Production of Stop Consonants by Children with Cochlear Implants & Children with Normal Hearing

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Normal Hearing (NH)

- Who:
  - Individuals with no HL
- What:
  - Acoustic signal
  - Typically functioning auditory system

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Hearing Aid (HA)

- Who:
  - Mild – Profound HL
- What:
  - Amplified acoustic signal
- Pro:
  - Amplifies soft speech while reducing background noise
- Con:
  - May not benefit individuals with profound HL

www.samvednaclinic.com

Cochlear Implant (CI)

- Who:
  - Profound HL
- What:
  - Electrical signal
- Pro:
  - Replaces function of the cochlea when individual cannot benefit from a HA
- Con:
  - Degraded signal
  - Information is lost

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Cochlear Implants (NIDCD); Smith (1975); Todd, Edwards, & Litovsky (2011)

Current Literature

What we hear in the speech signal

1.) Temporal Contrasts

- Differences in **timing**
- Example: Distinguish between voiced and voiceless sounds - *time* vs. *dime*
- Easy to distinguish, even for CI users

2.) Spectral Contrasts

- Differences in **frequency** (Peak ERB)
- Example: Distinguish between voiceless sounds - *tea* vs. *key*
- Easy to distinguish with normal hearing, but degraded through a CI

Imperfections of Cochlear Implants

1.) Spectral Information is Lost

- Difficult to distinguish sounds that differ by spectral, not temporal, contrasts

2.) Delay in Hearing Experience

- Surgical procedure to receive CI
  - FDA approved at 12 months
  - Hearing age ≠ Chronological age

3.) Reduced Speech Intelligibility

- Lack of listening and speaking experience
- Increased need for early speech intervention
- Heavily studied with “s” and “sh”

Giezen, Escudero, & Baker (2010); Peng, Spencer, & Tomblin (2004); Todd, Edwards, & Litovsky (2011)

Gaps in Current Literature

- Majority of research on fricatives: “s” and “sh”
  - Findings: Children with CIs produce “s” and “sh” differently and less intelligibly than their peers with normal hearing

- Lack of research on voiceless stops: “t” and “k”

Hewlett (1987); Todd, Edwards, & Litovsky (2011)

Why is this important?

- “t” and “k” are typically acquired early in the development of speech
  - Stops are typically developed earlier than fricatives
- Less speaking and listening experience due to time of implantation
  - Earliest implantation = 12 months
- IPA transcription is categorical
  - Acoustic analysis shows fine-grained differences

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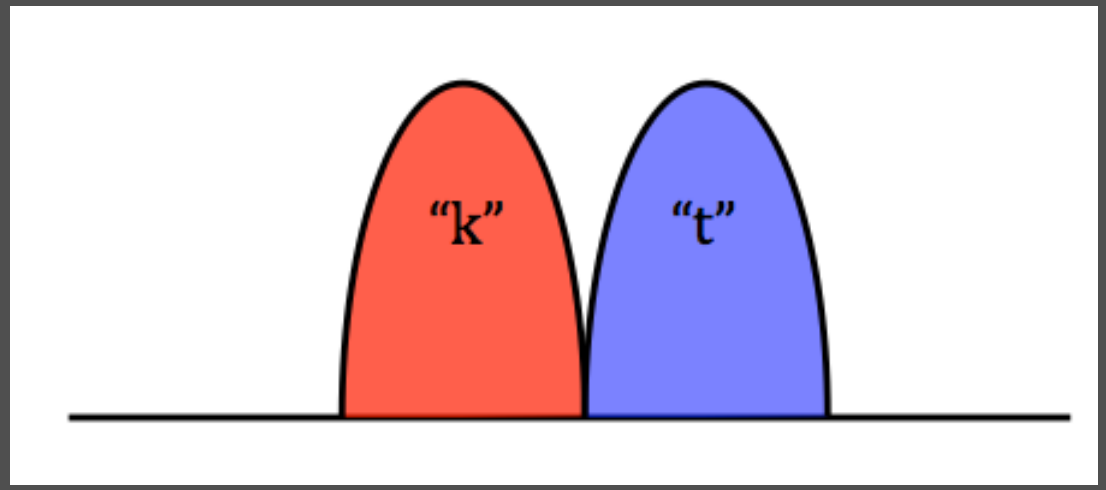
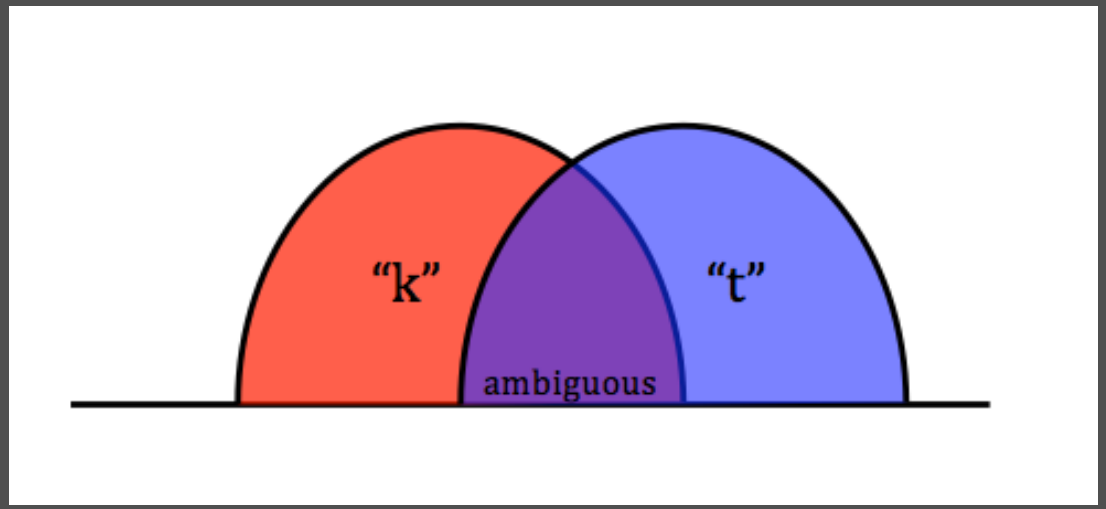
Hewlett (1987); Holliday et al. (2014); Tyler, Figurski & Langsdale (1993)

Robustness of Contrast (RoC)



More Robust



Less Robust

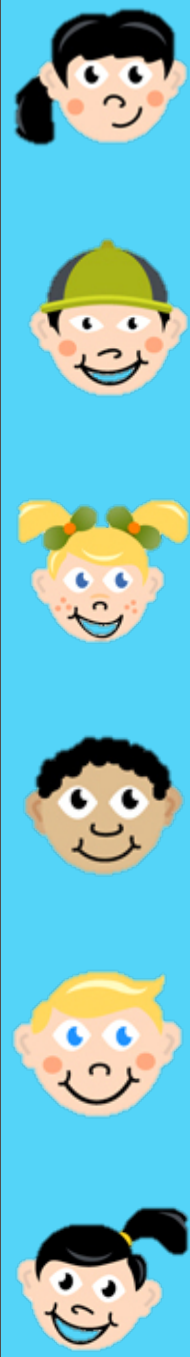
Research Questions

- Based on our perception using IPA transcription, are children with cochlear implants less accurate at producing “t” and “k” than their age-matched peers with normal hearing?
- Do children with cochlear implants have a lower robustness of contrast between the sounds “t” and “k” than age-matched children with normal hearing?

Participants

64 children; Monolingual speakers of American English

	Males:Females	Age in months m(SD)	*PPVT-4* m(SD)	Maternal Education
Cochlear Implant n=32	14:18	47.5(9.2) range = 31-65	n = 32 91.63(23.1)	High = 25 Mid = 6 Low = 1
Normal Hearing n=32	16:16	47.6(9.2) range = 31-66	n = 22 116.86(14.3)	High = 25 Mid = 6 Low = 1



Procedure

- Picture Prompted Real Word Repetition Task
- Stimuli: 15-18 “t”-initial and “k”-initial words
  - Followed by front and back vowel contexts
    - “kitty” (front vowel)
    - “comb” (back vowel)
    - “teddy bear” (front vowel)
    - “tooth” (back vowel)
  - “keep” vs. “coop”

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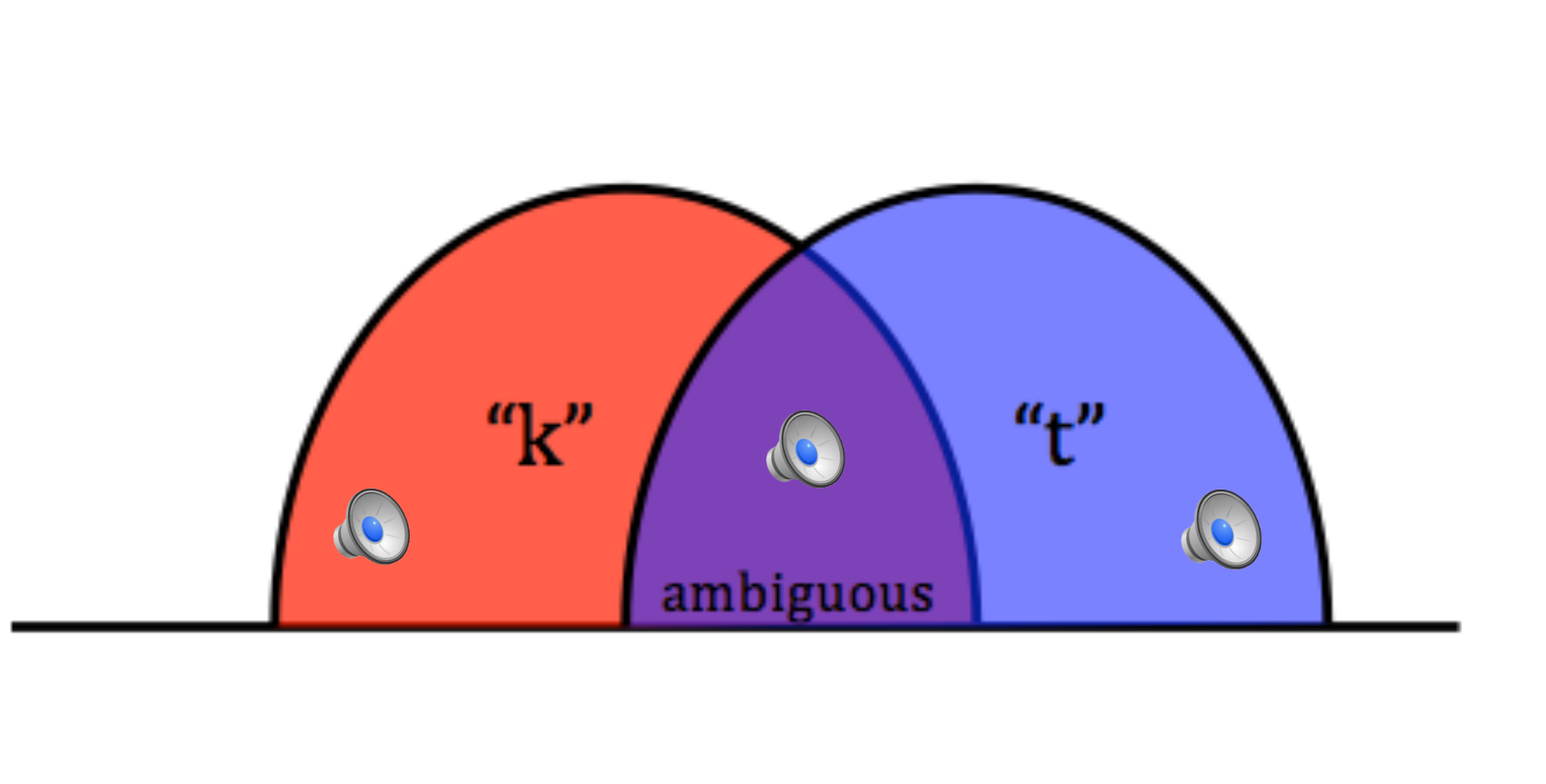
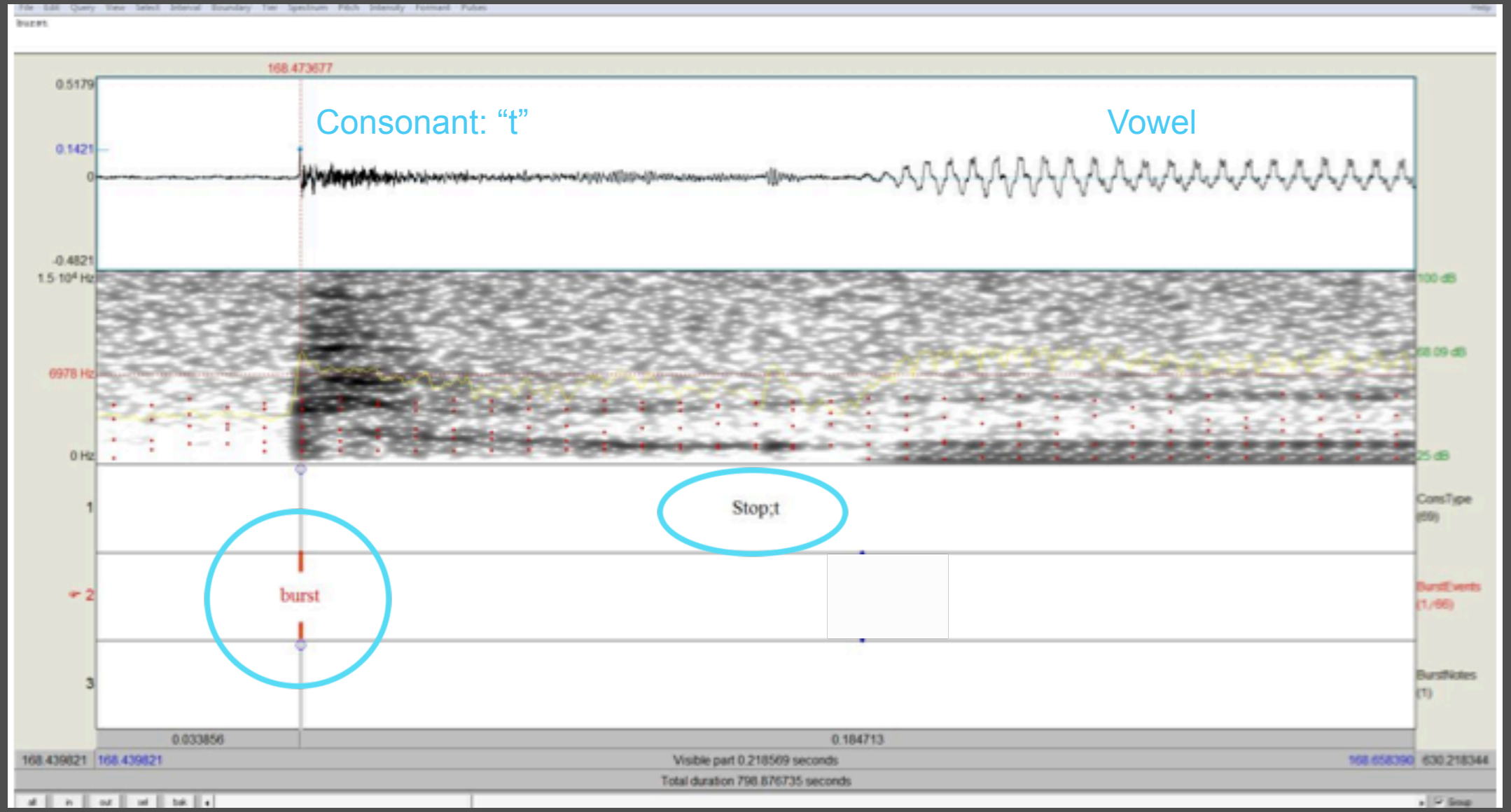
“tickle”

Coding: Transcription



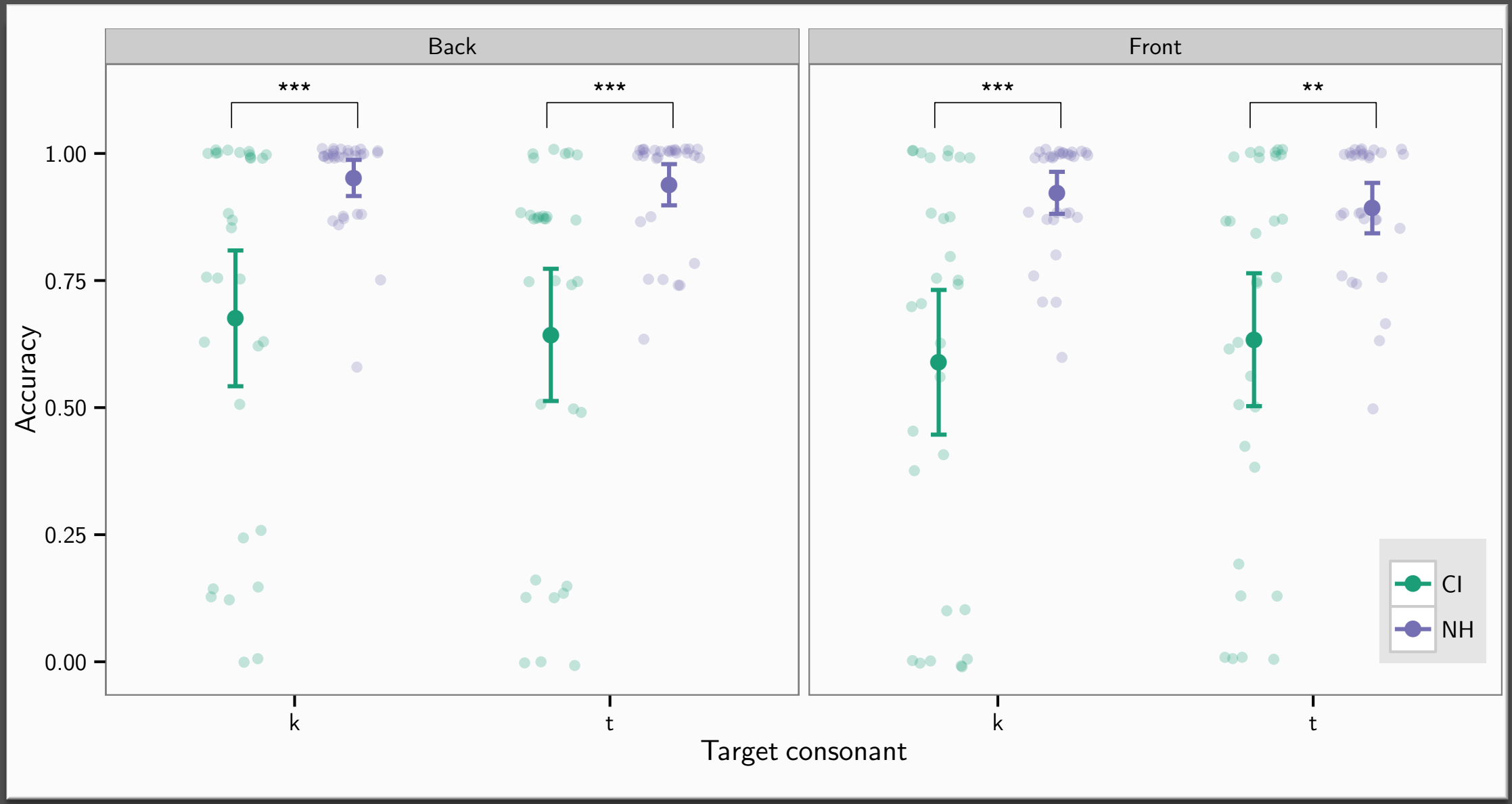
Coding in Praat



Data Analysis: Research Question #1

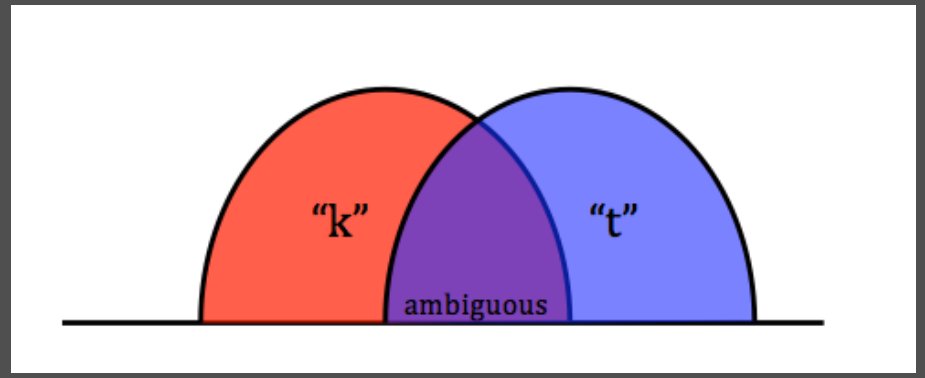
Based on our perception using IPA transcription, are children with cochlear implants less accurate at producing “t” and “k” than their age-matched peers with normal hearing?

Data Analysis: Research Question #1 (CA matches)

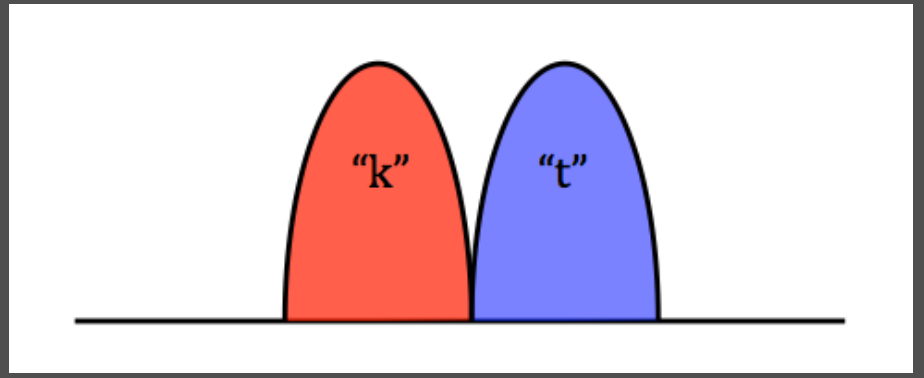


Data Analysis: Research Question #2

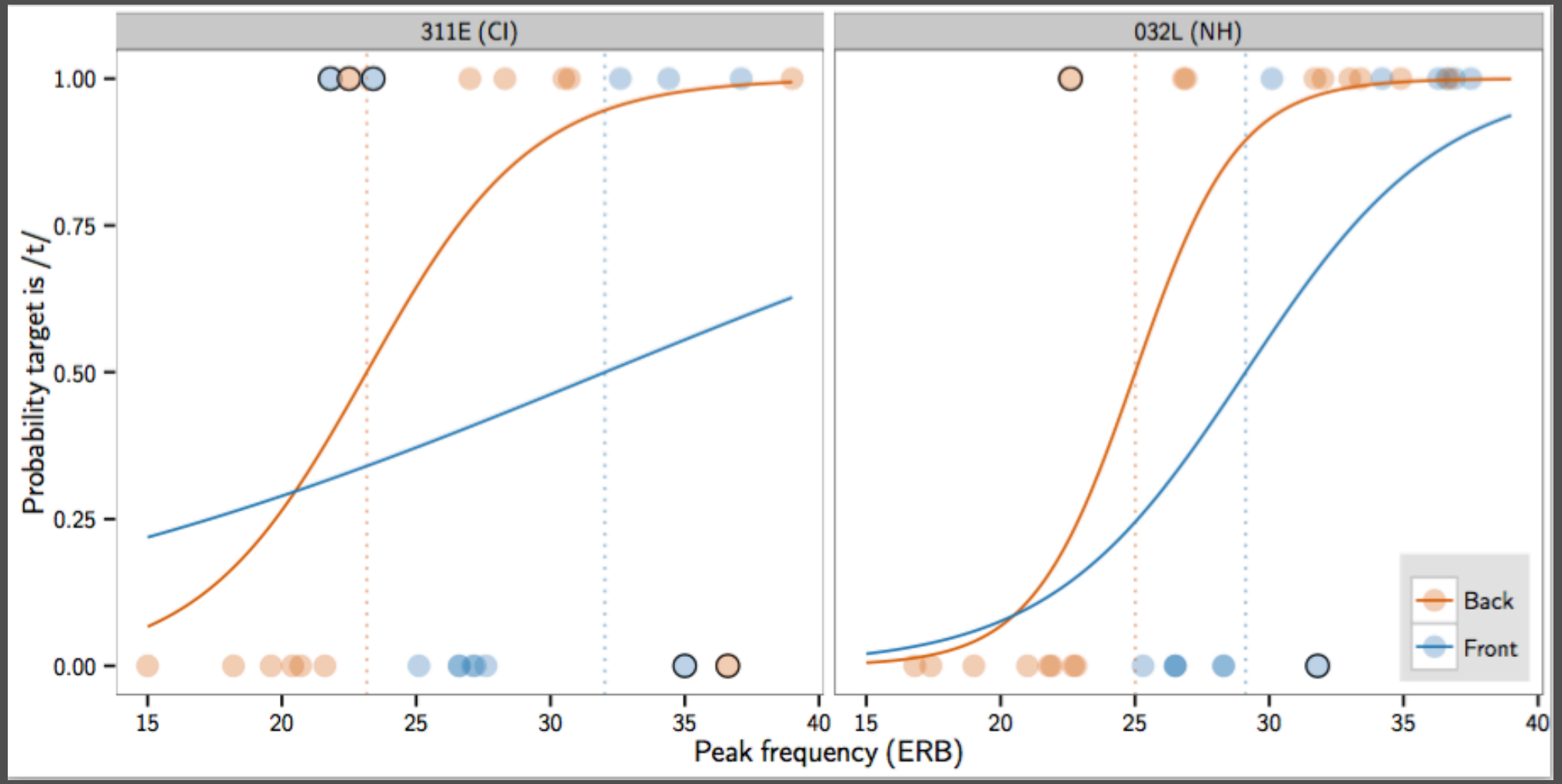
Do children with cochlear implants have a lower robustness of contrast between the sounds “t” and “k” than age-matched children with normal hearing?



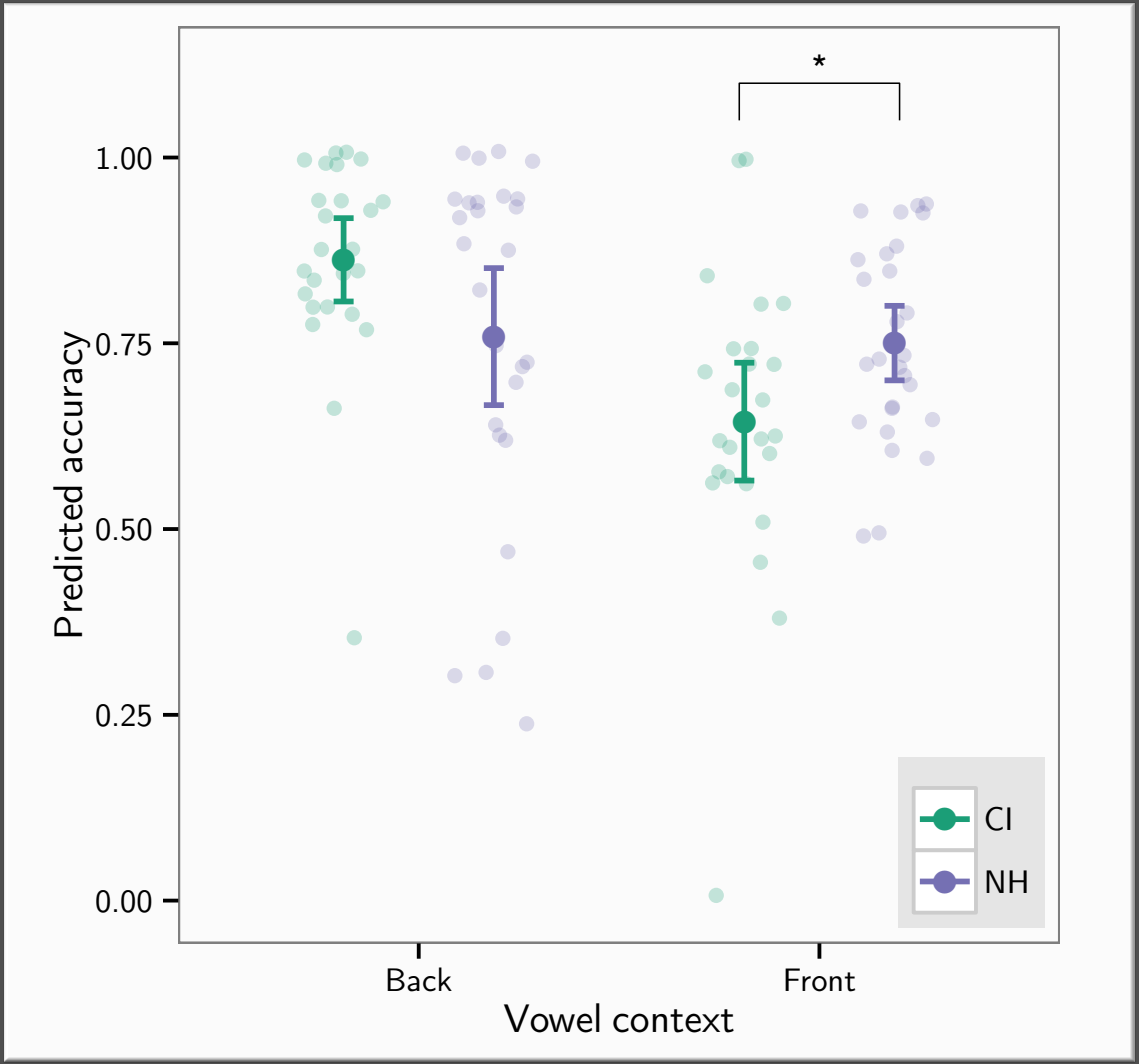
VS.



Robustness of Contrast



Robustness of Contrast



- Children with normal hearing have a significantly more robust contrast in front vowel contexts


fkx.dromhgg.top

Conclusions

- Based on IPA transcription, children with cochlear implants produced “t” and “k” significantly less accurately than their peers with normal hearing
  - Need for early intervention

- Based on acoustic analysis, children with cochlear implants produced a less robust contrast in front vowel contexts compared to children with normal hearing
  - Revealed fine-grained differences within productions that were perceived to be correct
  - Acoustic analysis supplements IPA transcription

Acknowledgments

Jan Edwards – Thesis Advisor; Principal Investigator of the Learning to Talk Research Lab

Allison Johnson – Ph.D. Student; Member of the Learning to Talk Research Lab

Pat Reidy – Post-Doctoral Associate in the Learning to Talk Research Lab

Members of the Learning to Talk Lab

Participants & Families

Research funded by:

Hilldale Undergraduate/Faculty Research Fellowship

Learning to Talk Grant from the National Institutes of Deafness and other Communication Disorders (NIH DC02932) – to Jan Edwards, Mary E. Beckman, and Benjamin Munson

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Thank You!