# Audiological and Demographic Factors that Impact Phonetic Categorization by Cochlear Implant Users

Sarah Colby, Michael Seedorff, & Bob McMurray

Department of Psychological & Brain Sciences Department of Otolaryngology – Head and Neck Surgery University of Iowa

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# **Residual Hearing & Cls**

- Wide variety of CI configurations
  - Electric-only: unilateral and bilateral
  - Acoustic + Electric: bimodal (contralateral residual hearing) or hybrid (ipsilateral residual hearing)
- Generally beneficial to preserve acoustic hearing (when possible)
  - Improvements to monosyllabic word recognition (Dorman, 2008)
  - Improved speech recognition in noise (Dorman & Gifford, 2010; Gantz et al., 2005)
- Two problems:
  - Evidence for an A+E benefit
  - What is the acoustic hearing providing?

# What is the evidence for an A+E benefit?

- Studies often rely on within-subjects comparisons
  - A+E vs. E-only
  - Problem: A+E is the more familiar listening configurations
- Between subject comparisons in their normal hearing configurations are more rare.
  - Many demographic factors are confounded with device type (age, experience, etiology of deafness, etc).

#### What does residual acoustic hearing provide?

- Acoustic hearing offers a mix of cues:
  - Prosody
  - Segmentation
  - Pitch

- Suprasegmental information
- Does it actually provide cues for phoneme and word discrimination?
  - Measures that precisely target phoneme categorization could reveal a direct benefit.

#### What does residual acoustic hearing provide?

- McMurray, Farris-Trimble, Seedorff, & Rigler (2016) investigated speech categorization by Acoustic+Electric and Electric-only
  - Need to adapt to uncertainty to successfully recognize speech, categorization tasks can probe this

## **Speech categorization**

Stop voicing: low-frequency voicing cue expected to be transmitted through acoustic hearing

/b/

Frication: high-frequency spectral cue expected to be transmitted through CI







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## Adaptation to uncertainty

- Ton of variability
- Slope of responses
- Transform data so that boundary is the same across participants



# Adaptation to ambiguity



CI users have shallower slope than NH No difference between A+E and E-only CI groups

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(McMurray, Farris-Trimble, Seedorff, & Rigler, 2016)

# Adaptation to Ambiguity

Fricatives 1 \*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\*\* 0.8 0.6 0.4 ······ Control - CI: Electric only 0.2 — CI: Acoustic+Electric boundary \*\*\*\*\*\*\*\*\*\*\* -2 2 5 -3 -1 4 Fricative Place rStep ( $\int \rightarrow s$ )

> CI users have shallower slope than NH A+E CI group shallower than E-only CI group

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(McMurray, Farris-Trimble, Seedorff, & Rigler, 2016)

# Adaptation to ambiguity

- Surprisingly, A+E performed poorer than E-only with fricative categorization (McMurray, Farris-Trimble, Seedorff, & Rigler, 2016)
  - Maybe A+E listeners don't always fully adapt to their CI
- Bimodal listeners with poorer residual hearing show a greater bimodal benefit (Mok et al., 2006)
  - Could be over-relying on their acoustic hearing

## **Current study**

- How does residual acoustic hearing impact adaptation to phonetic ambiguity?
- Does ability to deal with acoustic ambiguity relate to clinical speech outcomes?

# **Current study**

- Categorization of stop voicing & fricative continua
  - 5 continua x 8 steps x 5 repetition/step x 2 contrasts
  - bear-pear, self-shelf
- CNC word recognition, AzBio sentence recognition



## **Current study**

- Large sample to capture variety of device configurations
  - Age, device experience

Group	N	Mean age (SD)	Mean device experience (SD) in years
Electric-only			
Unilateral	18	58.5 (11.2)	12.8 (9.1)
Bilateral	23	57.0 (13.2)	7.8 (5.2)
Acoustic + Electric			
Bimodal	43	60.4 (10.0)	3.4 (3.4)
Hybrid	25	62.5 (10.2)	2.0 (1.6)
Single-sided deafness (SSD)	27	54.3 (12.4)	2.9 (1.7)
Total Sample	136		

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# Analyses

- Differences between hearing configurations
  - Add groups
  - Add model

## **Voicing Categorization**

Acoustic+Electric CI users have steeper categorization than Electric-only



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#### **Fricative categorization**

SSD participants have steeper categorization

No broad group differences



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# Analyses

• Differences between hearing configurations

• Demographic factors

## **Voicing Categorization**



Older CI users have shallower stop-voicing categorization

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## **Fricative categorization**



Electric-only CI users with longer device experience have steeper categorization

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# Analyses

• Differences between hearing configurations

• Demographic factors

• Residual hearing

# **Residual acoustic hearing**

Hybrid CI users with better PTA are worse at fricative categorization.

No effect of PTA for voicing categorization in any group.



# **Interim Summary**

- A+E listeners have sharper stop voicing categorization, less clear for fricatives
- Older CI users have shallower stop voicing categorization
- Longer device experience sharpens fricative categorization
- Within Acoustic+Electric listeners, individuals with better residual hearing are worse at fricative categorization
  - Largely driven by participants with ipsilateral residual hearing

# **Relationship to speech outcomes**

- Does sensitivity to phonetic ambiguity relate to clinical assessments of word and sentence recognition?
- Calculated slope for each participant and each contrast (voicing & frication) MAYBE A TINY FIGURE?
- Test accuracy ~ categorization slope + hearing configuration

## Word recognition



Electric-only users with steeper categorization slopes have better word recognition ANIMATE ME!!!!!

#### **Sentence recognition**



Electric-only CI users with steeper categorization slope have better sentence recognition scores

#### Sentence recognition in noise



CI users with steeper categorization slope have better sentence recognition in noise scores

# **Speech categorization & outcomes**

- Why the differing results in A+E and E-only listeners?
- A shallow slope isn't necessarily a bad thing
  - Gradiency is thought to preserve flexibility (Kapnoula et al., 2021; McMurray et al., 2009)
  - Might be adaptive for A+E listeners
- In this paradigm, shallow slope could be gradient categorization or noisy
  - Need something that can capture continuous responses: Visual Analogue
    Scale



# Summary

- Residual acoustic hearing is beneficial for categorizing voicing, but not frication
  - A+E listeners might not be fully adapting to their implant, and thus not gaining as much benefit
  - Listeners with better residual hearing may be over-relying on their acoustic hearing and are missing out on import cues to frication
- Age and device experience matter for perceiving different contrasts
  - Age attenuates voicing categorization
  - Device experience impacts fricative categorization
- Speech categorization is related to clinical outcomes
  - In noise, listeners with sharper categorization perform better
  - Need continuous measure to disentangle gradiency vs. noise

# Thank you!

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