

# Spoken word recognition of children with cochlear implants

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BUCLD 2017

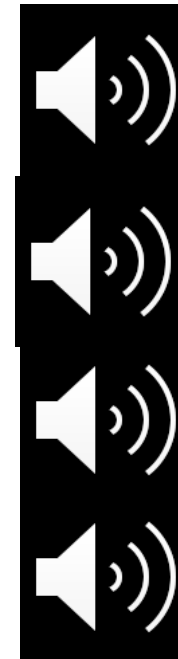
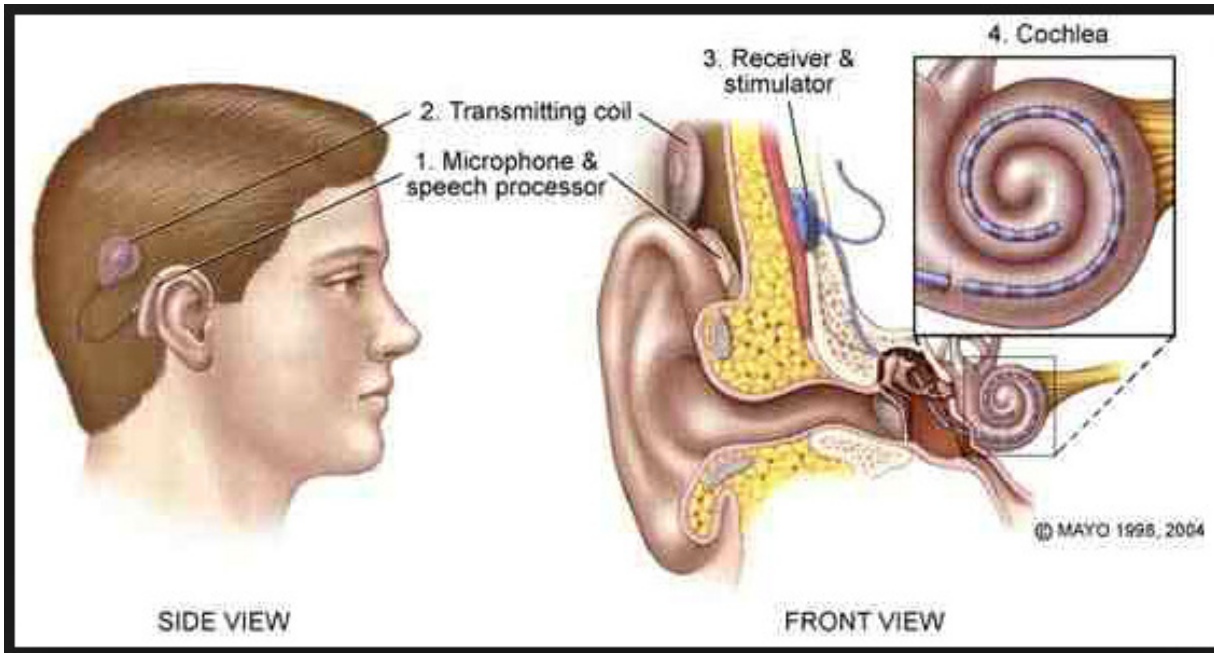


learning  
to talk



# Cochlear Implants

- Appropriate for individuals with severe or profound hearing impairment.
- Replaces acoustic hearing with an electrical signal.
- Pros: Children who are prelingually deaf do *much* better with a cochlear implant than with hearing aids.
- Cons: Signal is impoverished, especially for spectral information.



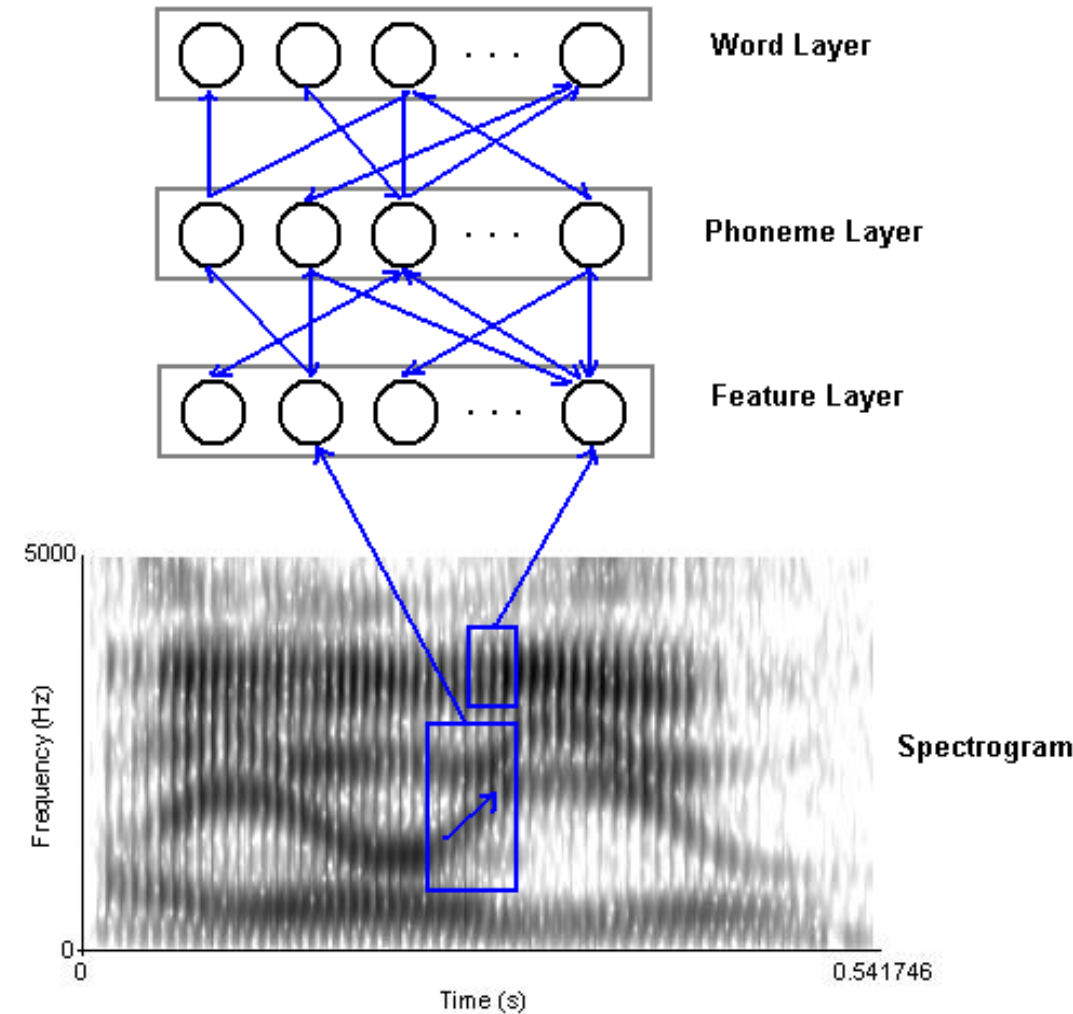
# Spoken language development in children with CIs

- Much better than children with hearing aids but not as good as children with normal hearing (NH)
- Why?
  - Early language deprivation
  - Impoverished signal



# Spoken word recognition in adults

- Mapping speech onto words
- Generally effortless, automatic in adults
- Key features
  - Perceptual encoding of signal.
  - Cascading activation of sub-lexical and lexical units.
  - Competition among candidate words.
  - Integration of semantic and syntactic cues.
- What about children?

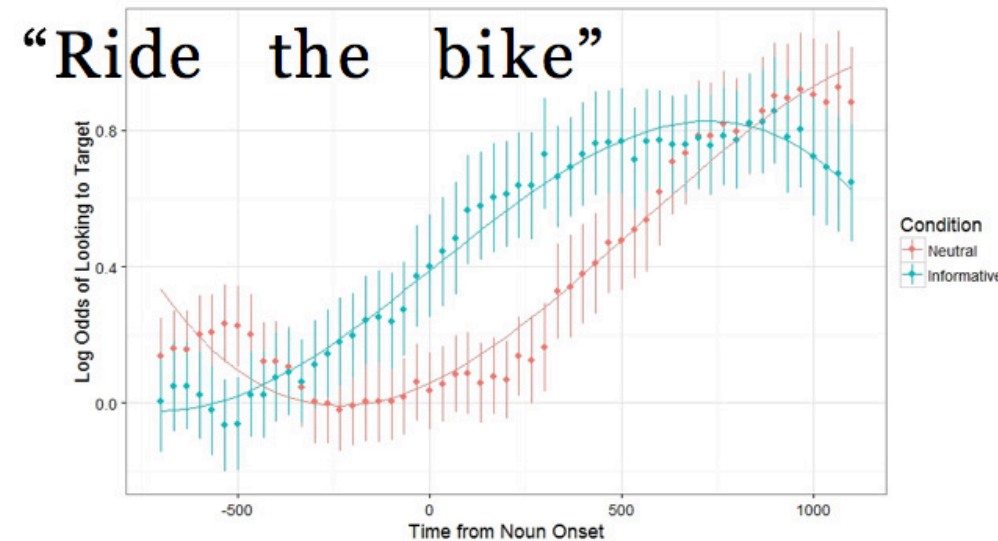


Schematic of TRACE model

<https://commons.wikimedia.org/wiki/File:TRACE.PNG>

# Spoken word recognition in children with normal hearing

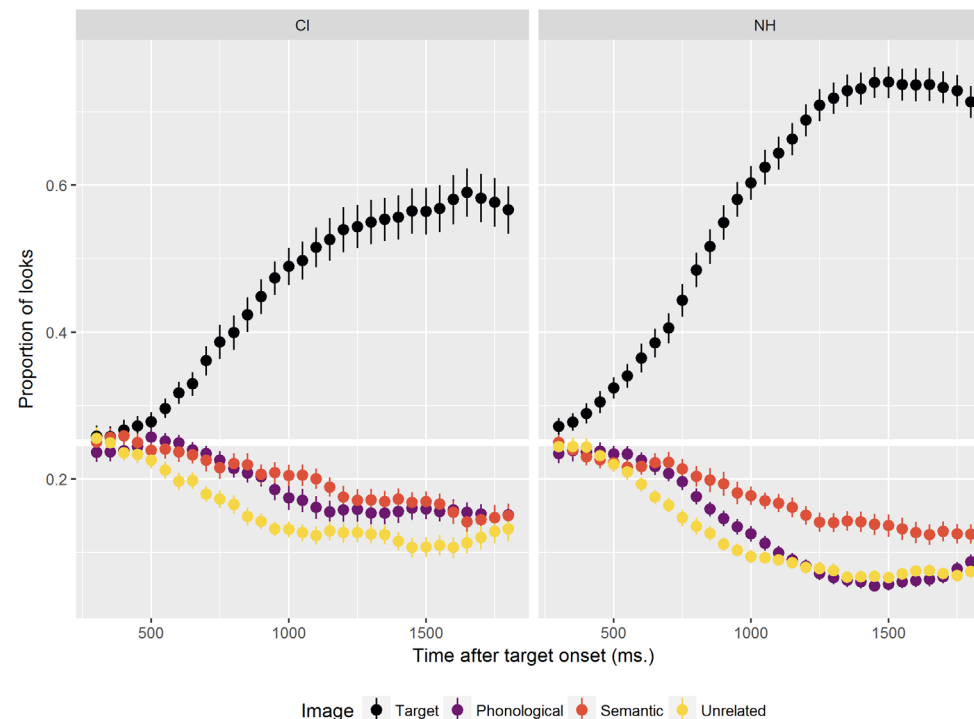
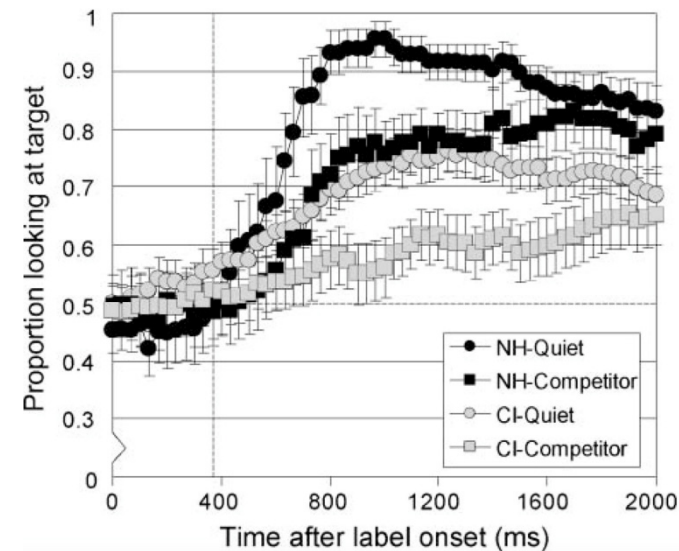
- Remarkably adult-like.
- Recognize words incrementally. (Swingley et al., 1999; Fernald, Swingley, & Pinto, 2001)
- Use semantic information. (Venker et al. 2016)
- Use information from neighboring words. (Lew-Williams & Fernald, 2007; Mahr et al., 2015)
- Sensitive to sublexical differences (Swingley & Aslin, 2000; White & Morgan, 2008; many other mispronunciation studies)
- What about children with cochlear implants?





# Spoken word recognition in children with CIs

- Children with CIs recognize familiar words more slowly and less accurately (Grieco-Calub, et al., 2009; Edwards & Mahr, 2017)
- Preschoolers with CIs take longer to reject phonological competitors (Edwards & Mahr, 2017).



# Mispronunciation experiment

- Based on White and Morgan (2008) and Law and Edwards (2015)
- See two pictures: Familiar and unfamiliar object
  - Matched for animacy
- Hear a prompt to look at one of the images:  
*Find the dog!*
- Three different conditions
  - Correct productions of familiar words
  - Mispronunciations of familiar words
  - Nonwords





See the dog! *or*  
See the tog!

Correct productions and  
mispronunciations of familiar words

- Child never heard both *dog* and *tog* in same block of task
- Onset mispronunciations



See the vafe!

Nonwords

- Encourage fast referent selection
- Disambiguation



# Questions and hypotheses

- Are children with CIs less sensitive to sublexical differences relative to children with NH?
  - Children with CIs will be *less* sensitive than children with NH to mispronunciations.
- Can vocabulary size differences account for differences in spoken word recognition between children with CIs and children with NH?
  - Group differences will still be observed in the mispronunciation condition and possibly the nonword condition.
  - Vocabulary size differences will account for group differences in the correct production condition.



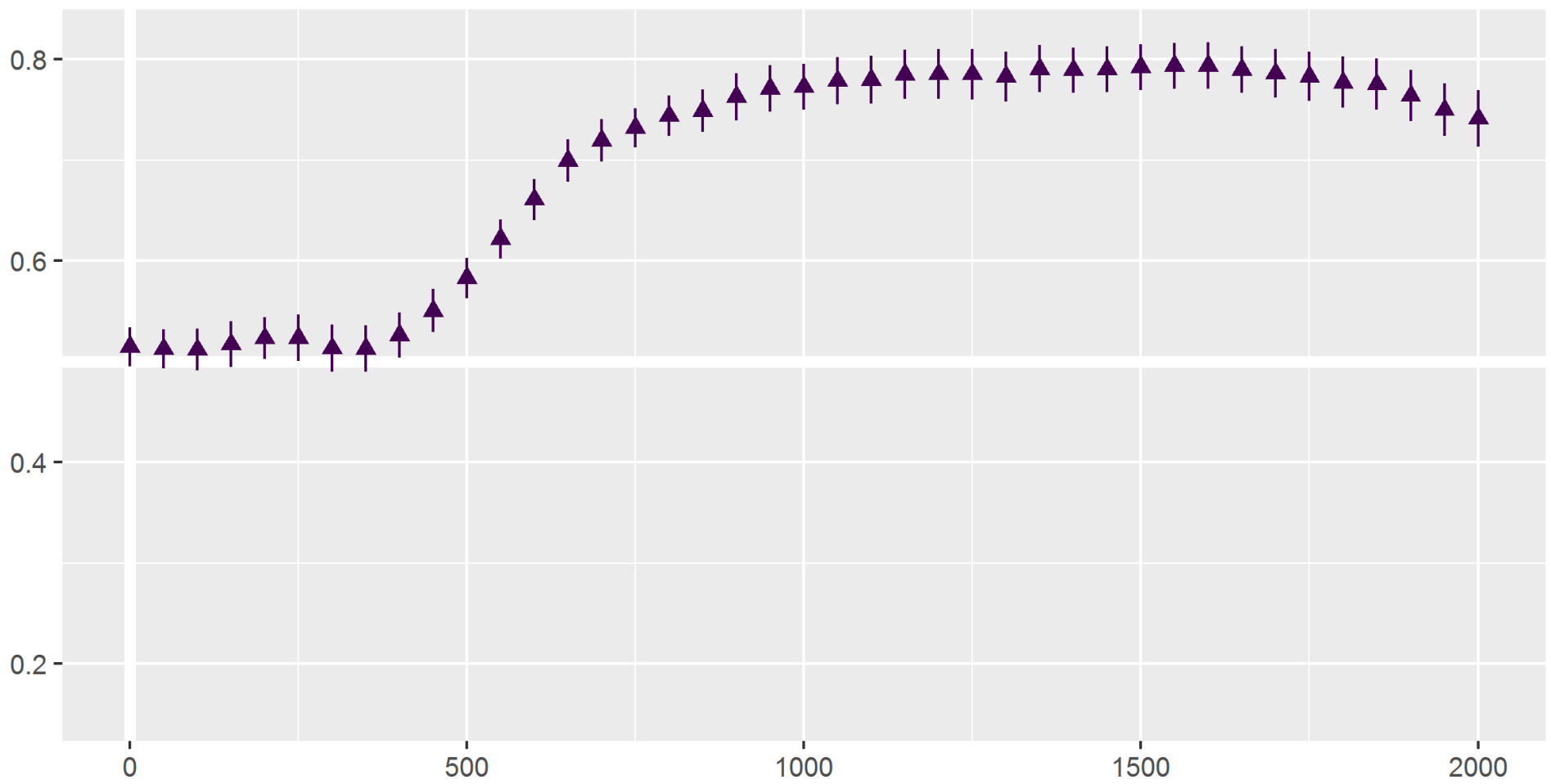
# Participants

- 25 children with cochlear implants (CI) (15 females, 10 males)
- 25 children with normal hearing (NH)
- Matched for age, sex, maternal education level, number of visits.
- 37 sessions per group

Group	Age in months mean (SD)	Maternal Education n = 25	Vocabulary (EVT-2) mean (SD) Standard: 100 (15)
CI	51 (9) Range = 34–66	High school diploma = 2 Some college/2-year degree = 5 College or Graduate degree = 18	97 (19) Range = 46–131
NH	51 (9) Range = 36–66	High school diploma = 2 Some college/2-year degree = 5 College or Graduate degree = 18	117 (12) Range = 88–134

Group ● Cochlear implant ▲ Normal hearing      Child hears ● Real word ● Mispronunciation ● Nonword

Proportion of looks to familiar object



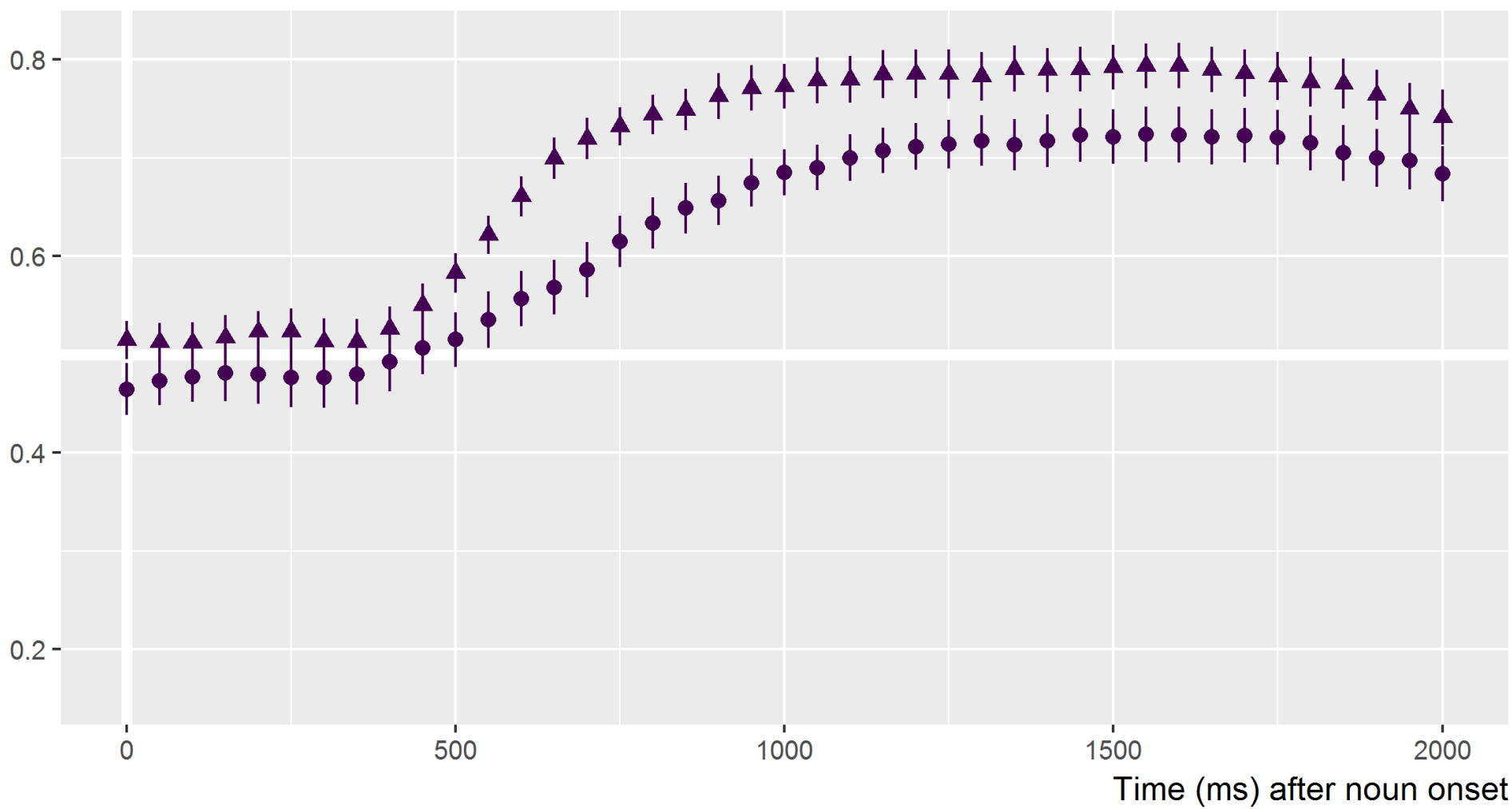
Time (ms) after noun onset

Mean ± SE

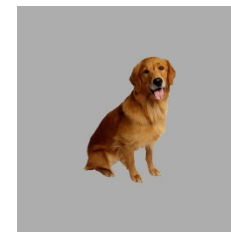


Group ● Cochlear implant ▲ Normal hearing    Child hears ● Real word ● Mispronunciation ● Nonword

Proportion of looks to familiar object

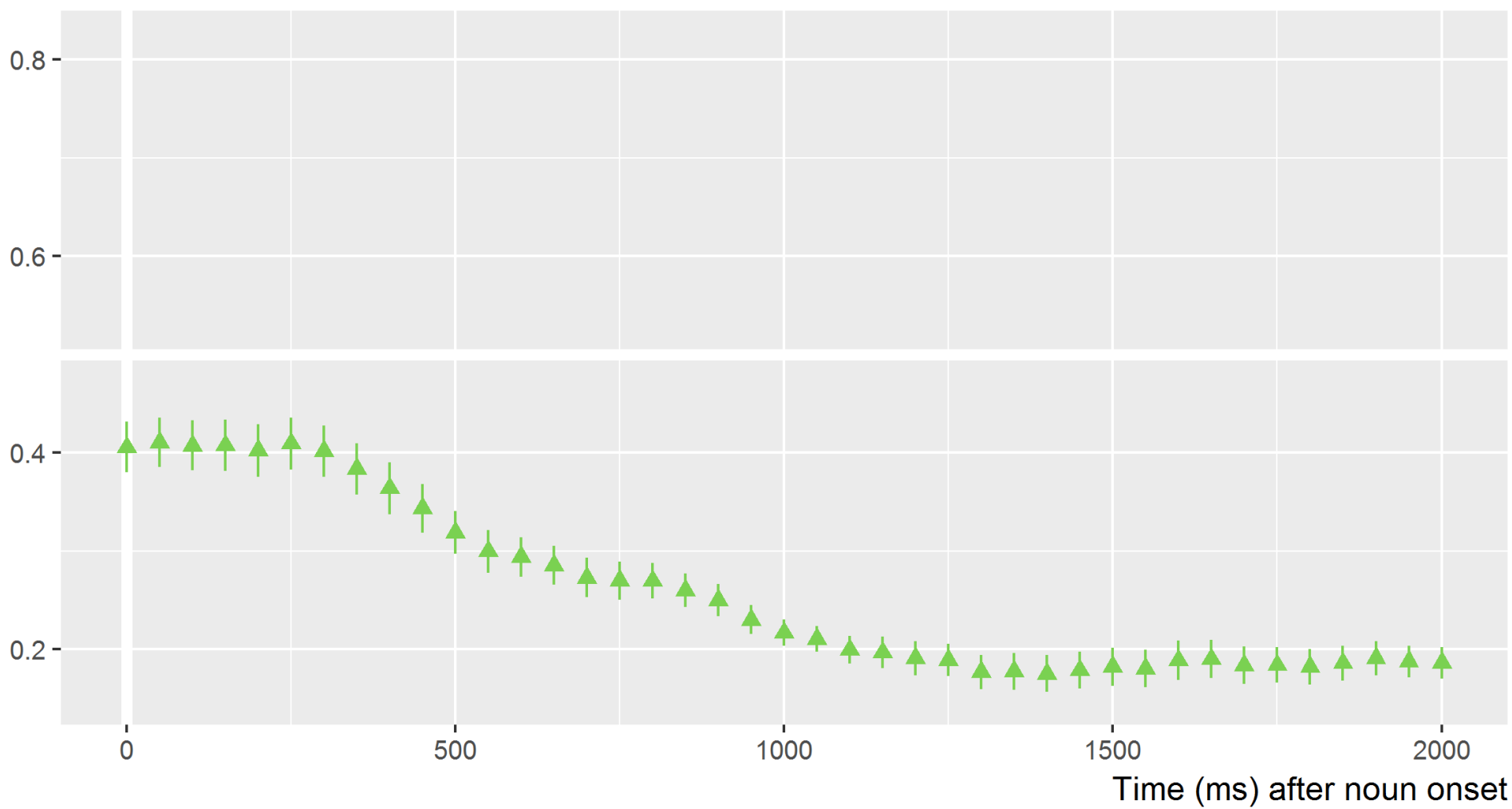


Mean ± SE

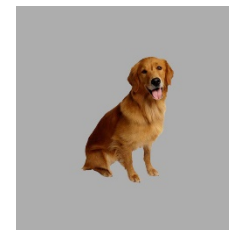


Group ● Cochlear implant ▲ Normal hearing      Child hears ● Real word ● Mispronunciation ● Nonword

Proportion of looks to familiar object



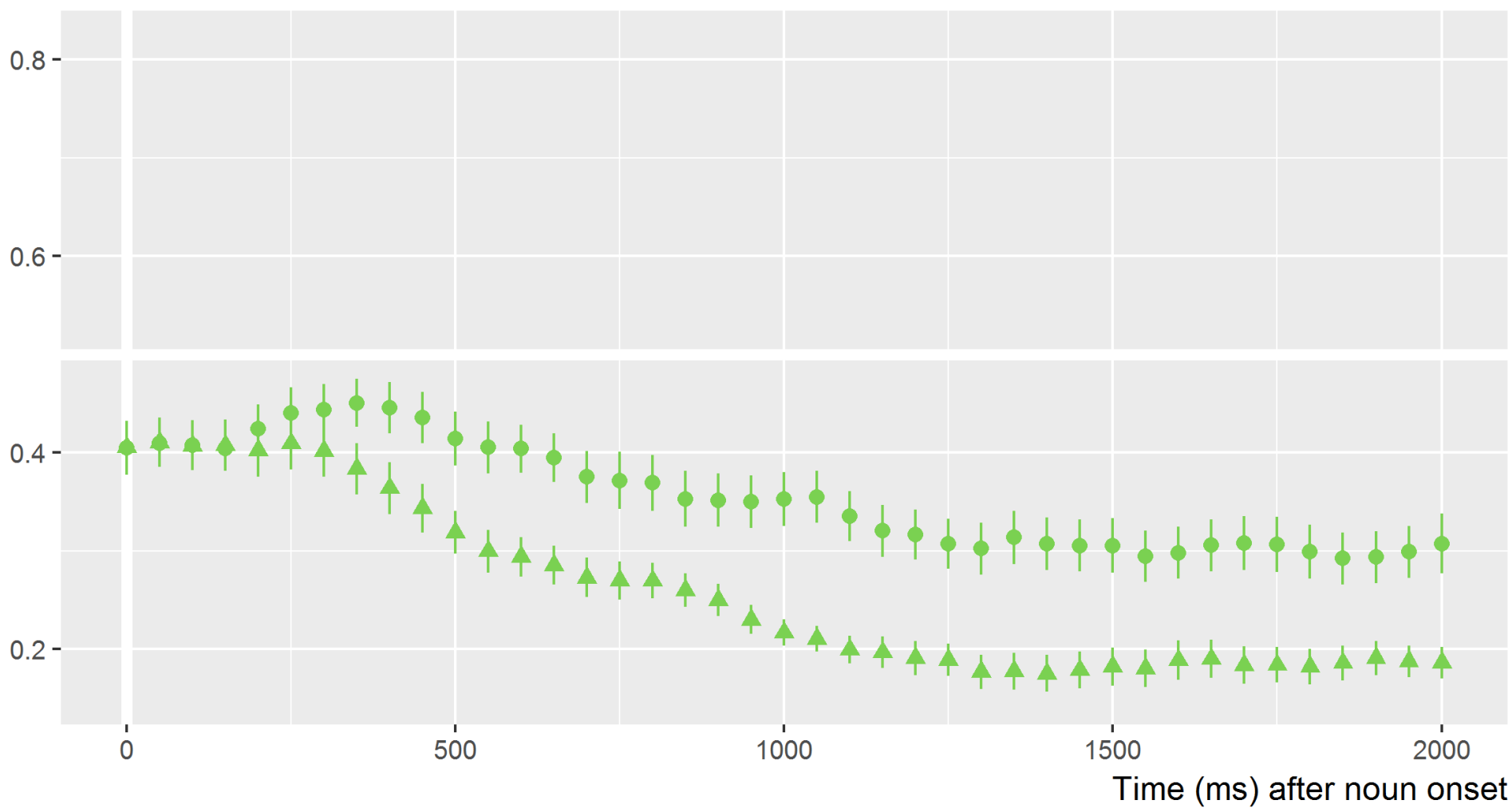
Mean ± SE



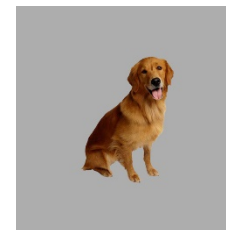


Group   ● Cochlear implant   ▲ Normal hearing   Child hears   ● Real word   ● Mispronunciation   ● Nonword

Proportion of looks to familiar object

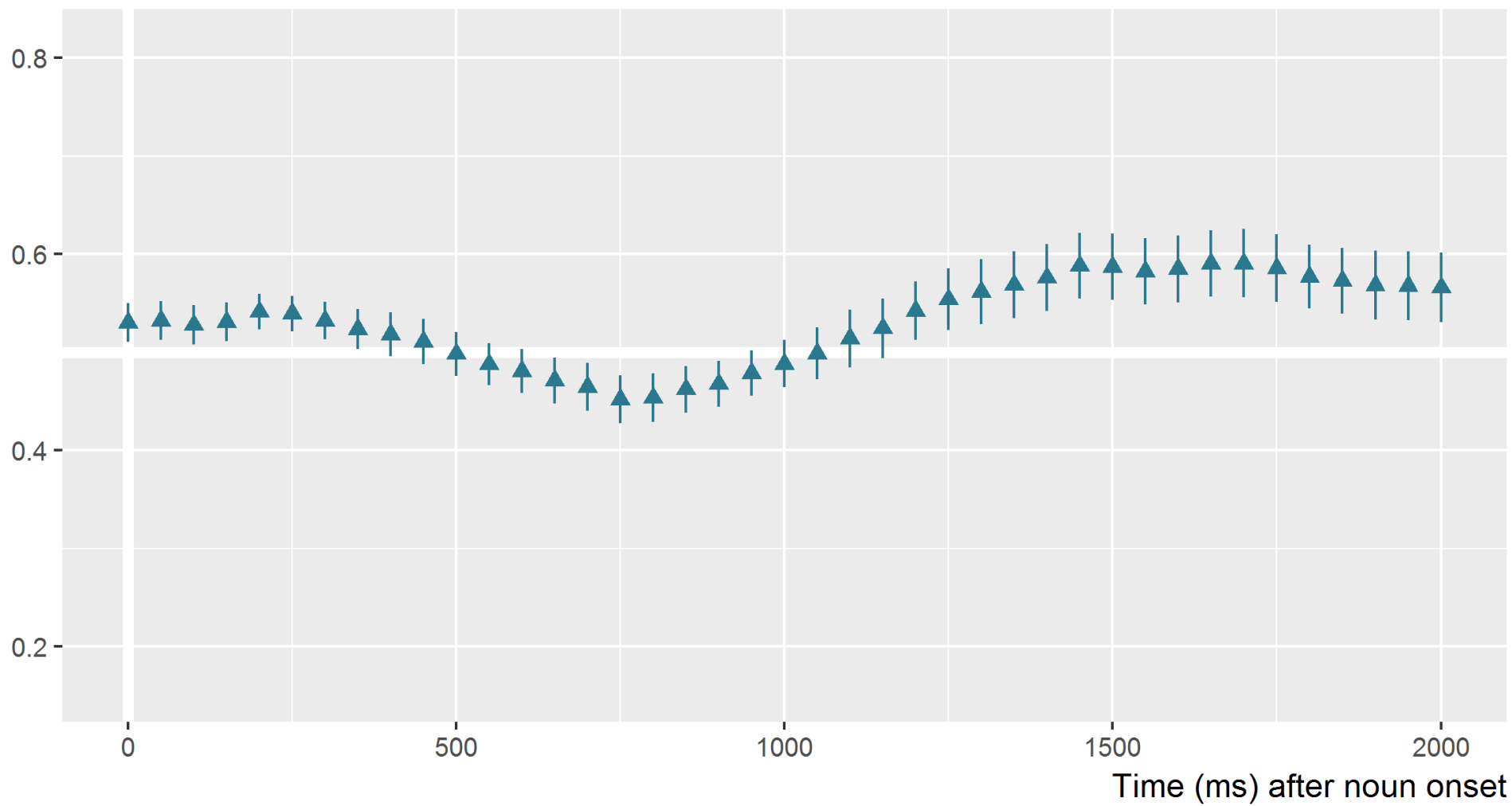


Mean  $\pm$  SE

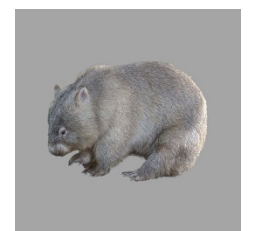


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Proportion of looks to familiar object

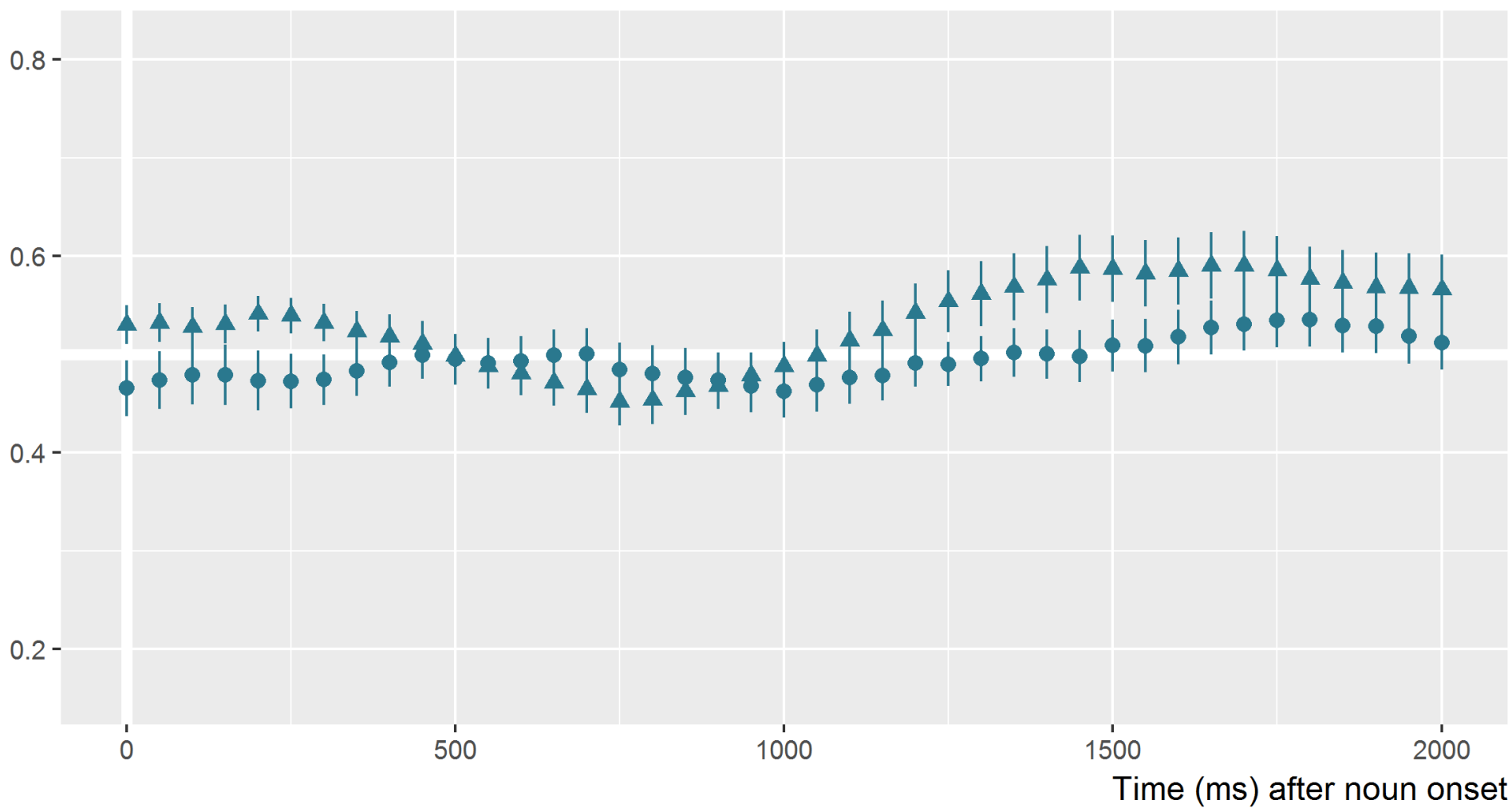


Mean ± SE

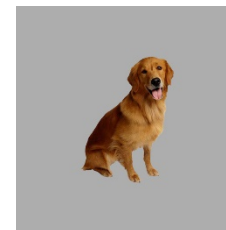


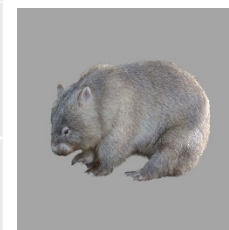
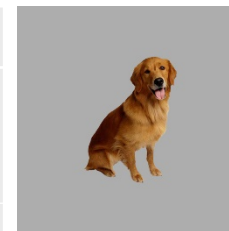
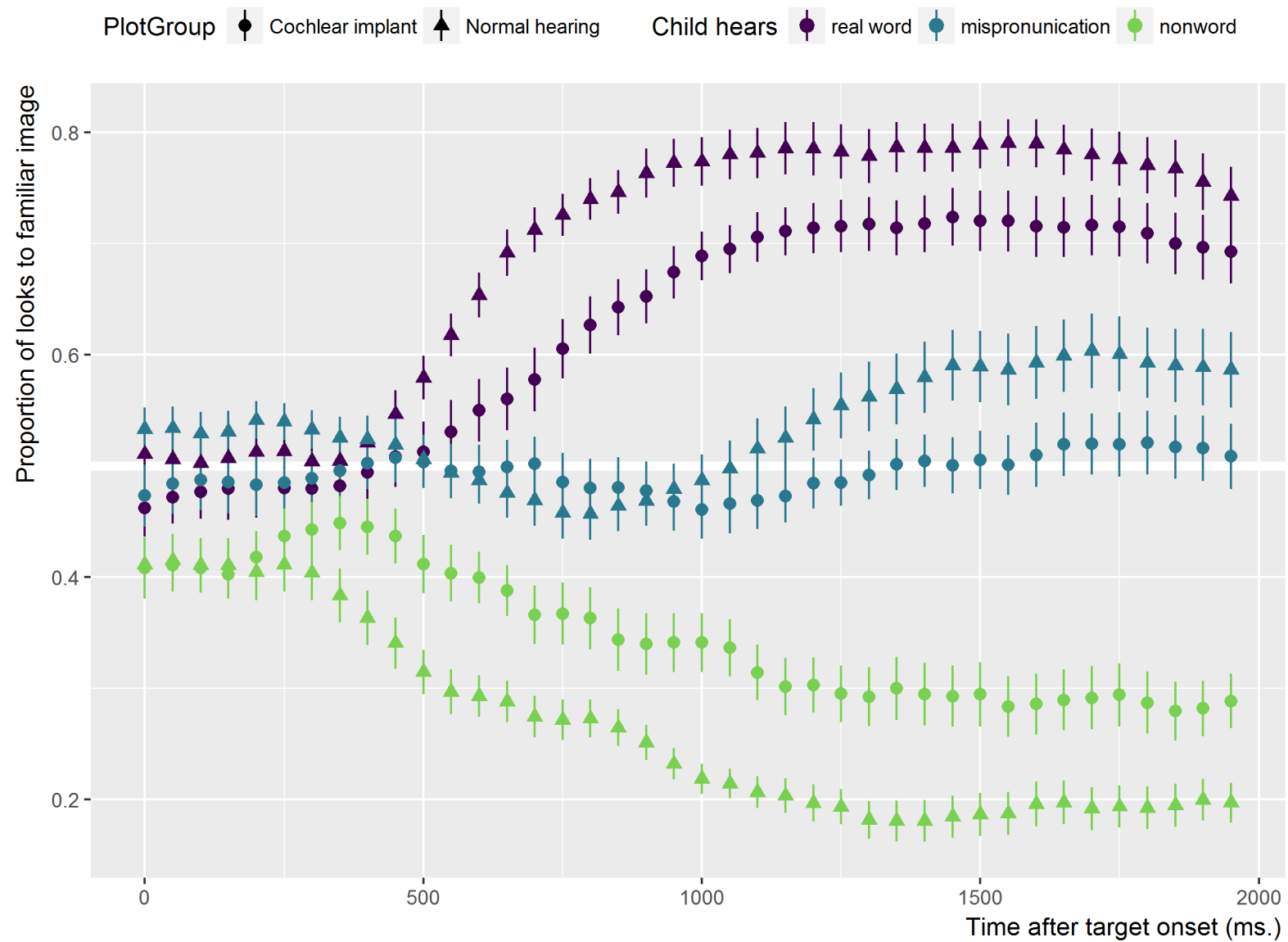
Group   ● Cochlear implant   ▲ Normal hearing   Child hears   ● Real word   ● Mispronunciation   ● Nonword

Proportion of looks to familiar object



Mean  $\pm$  SE





# Clear differences between groups

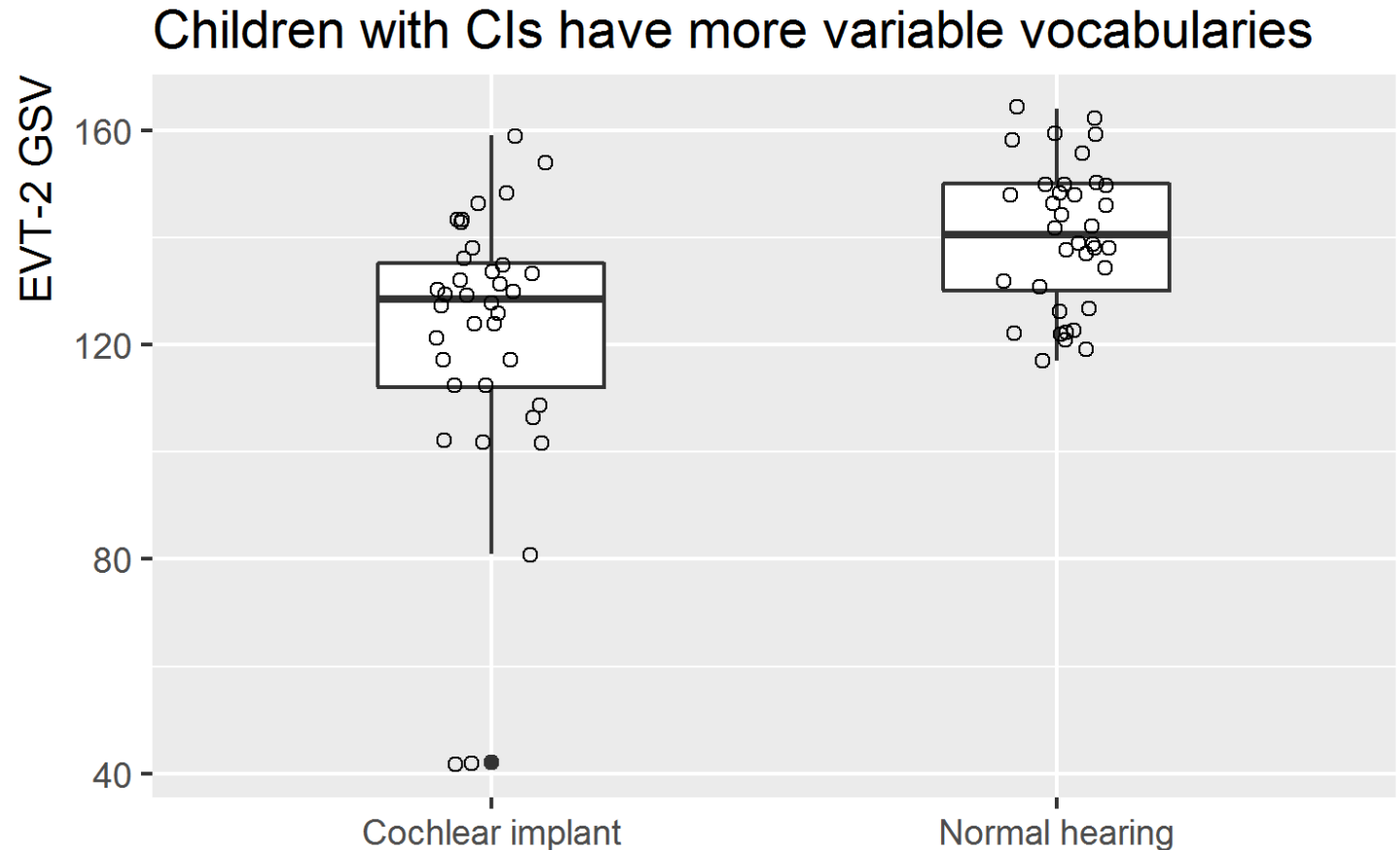
- Children with CIs relative to children with NH are:
  - Slower and less accurate in correct productions.
  - Less accurate in nonword condition.
- What about the mispronunciation condition?





# Groups differ in vocabulary size and range

- Perhaps the group differences just reflect differences in vocabulary size?
- Include Vocabulary and Vocabulary \* Time effects.
- Include Vocabulary x Group interactions

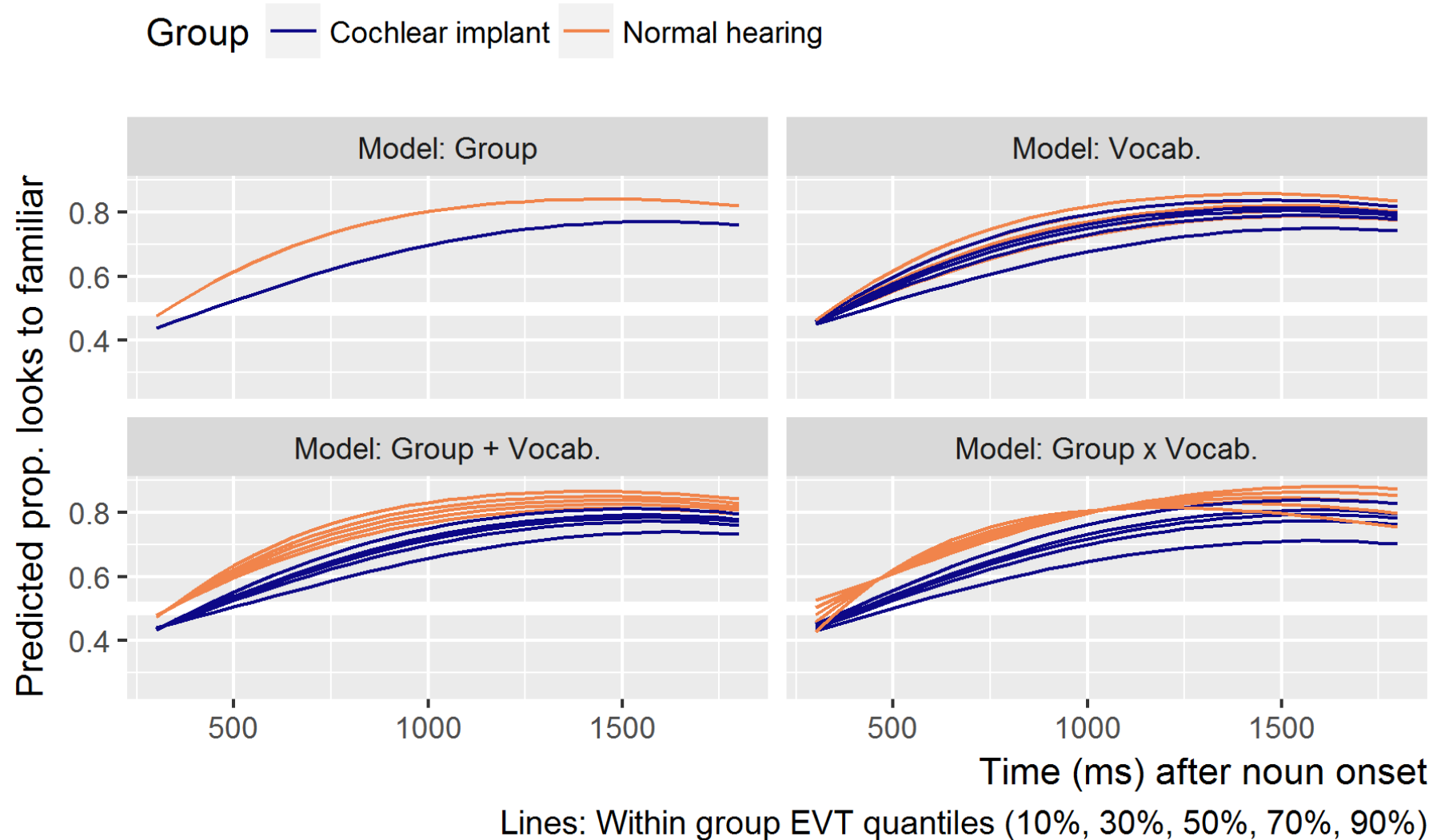


# Growth curve analysis (Mirman, 2014)

- Logistic mixed-effects model of data from 250ms to 1500ms
- Looks to familiar object as a function of Time
  - $\text{Log Odds} \sim 1 + \text{Time}^1 + \text{Time}^2 + \text{Time}^3$
- Allow random Time slopes for Child
- For the current analyses, fit separate models for each Condition
- Do we see effects of?
  - Group *and/or*
  - Vocabulary (EVT2-Growth Scale Values) *and/or*
  - Group x Vocabulary Interaction

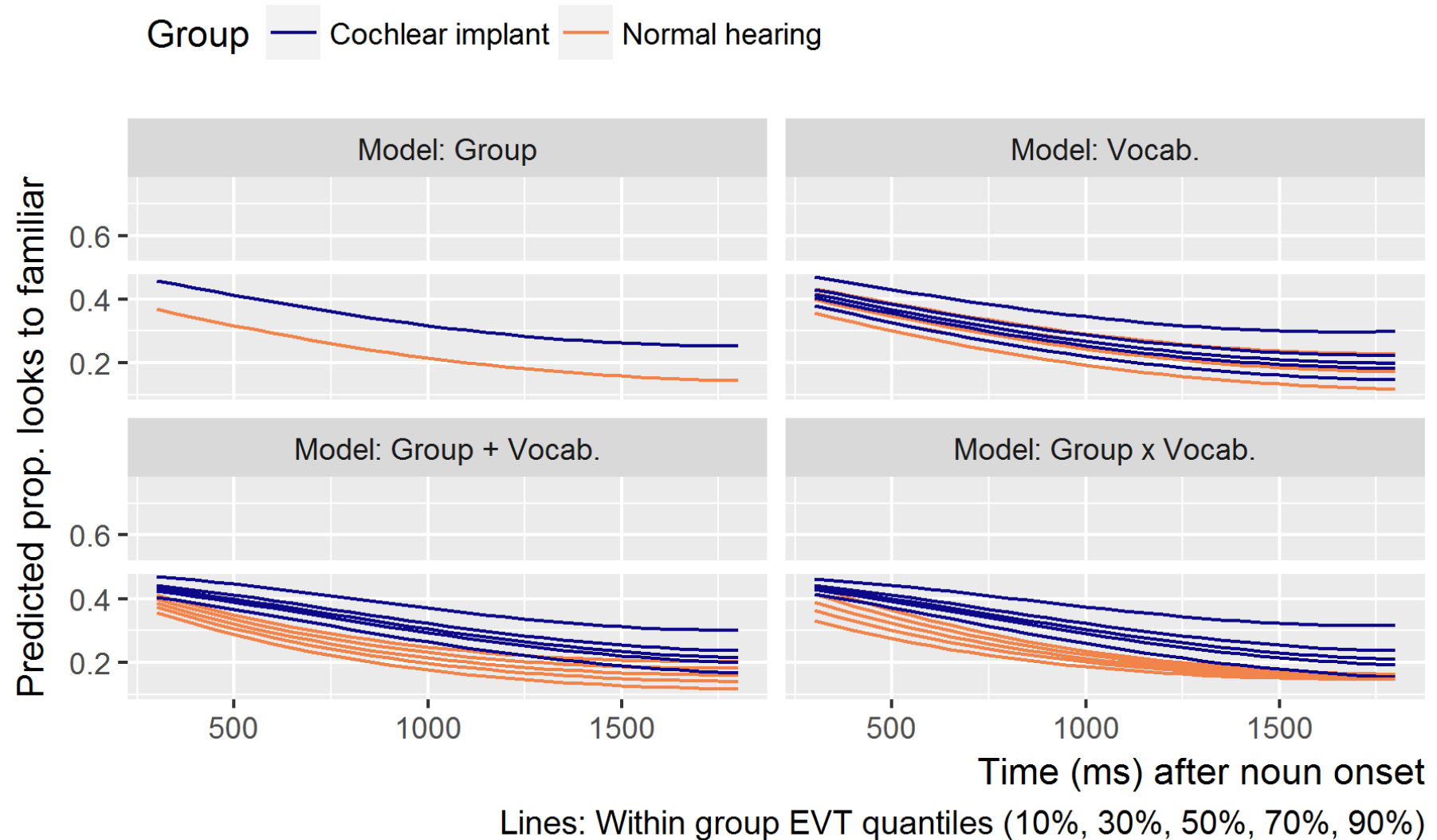
# Correct production condition

- Significant effect of Group.
  - Children with CIs are less accurate.
- Significant effect of Vocabulary.
  - Larger vocabulary predicts faster looks and greater accuracy.
- Significant Vocabulary x Group interaction



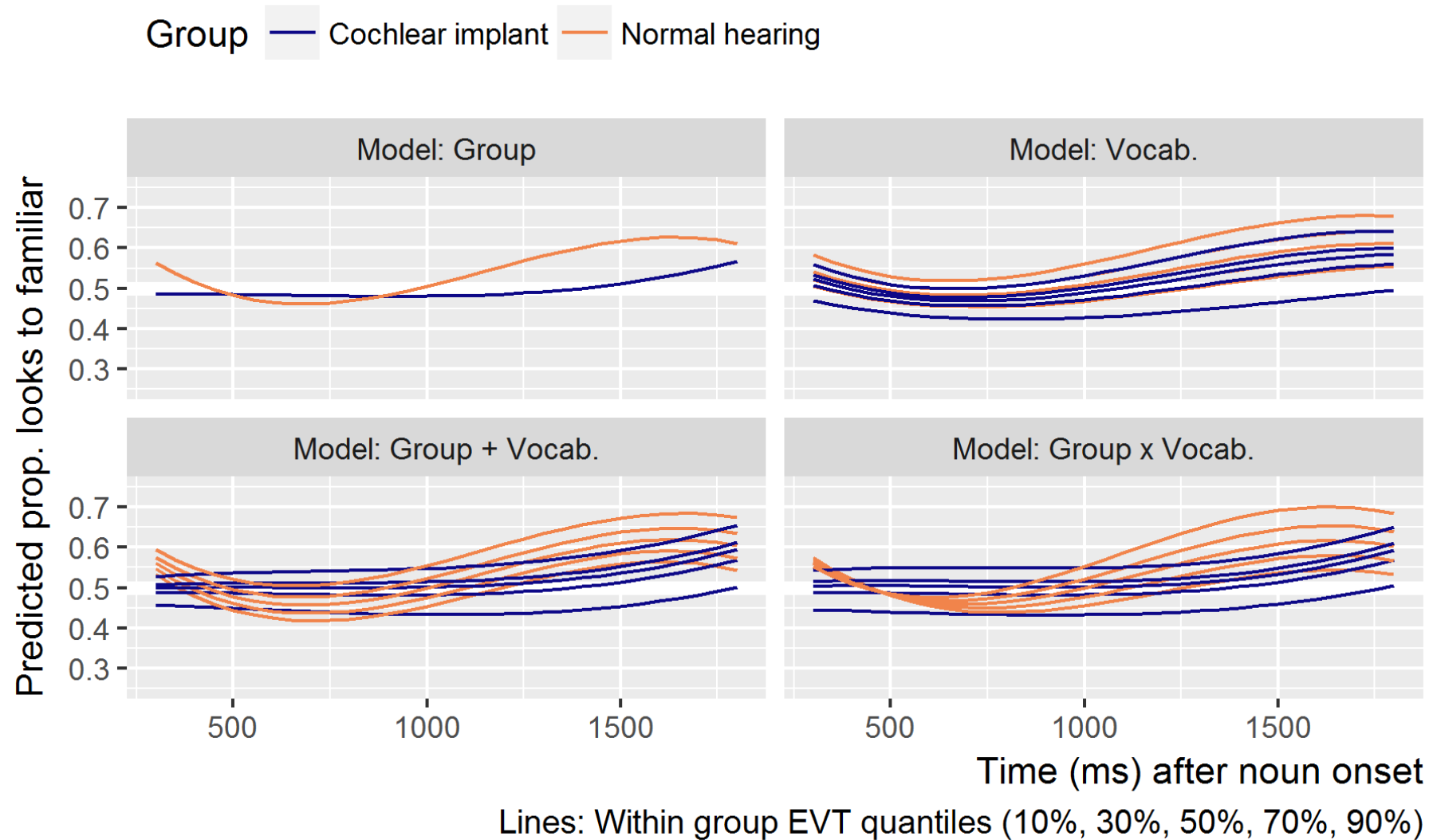
# Nonword condition

- Significant effect of Group.
  - Children with CIs are less accurate.
- Significant effect of Vocabulary.
  - Larger vocabulary predicts faster looks and greater accuracy.
- Group x Vocabulary is *not* significant.



# Mispronunciation condition

- Significant effect of group.
  - Shape of curve is different for the two groups.
- Significant effect of Vocabulary.
  - Larger vocabulary predicts greater accuracy.
- Group x Vocabulary is *not* significant.





# Discussion

## Predictions:

- ✗ • Children with CIs will be *less* sensitive than children with NH to mispronunciations.
- ✗ • Vocabulary size differences will account for group differences in the correct production condition.
- ✓ • For nonword and mispronunciation conditions, group will be significant even after vocabulary size is included in the model.



# Discussion

- It's difficult to reconcile these two findings:
  - Sensitivity to sublexical differences
  - Group differences on correct productions even after vocabulary differences are taken into account.
- Do some of the group differences reflect different processing strategies by children with CIs to compensate for the impoverished signal?





# Acknowledgements



- Other *Learning To Talk* PIs: Mary Beckman and Ben Munson
- Research team (at UW): Nancy Wermuth, Ruby Braxton, Nicole Breunig, Michelle Erskine, Megan Flood, Allie Johnson, Kayla Kristensen, Franzo Law II, Michelle Minter, Alissa Schneeberg, Tatiana Thonesavanh
- Funding sources: NIH and NSF
- Participation of the children and cooperation from their parents



# Interested in this research?

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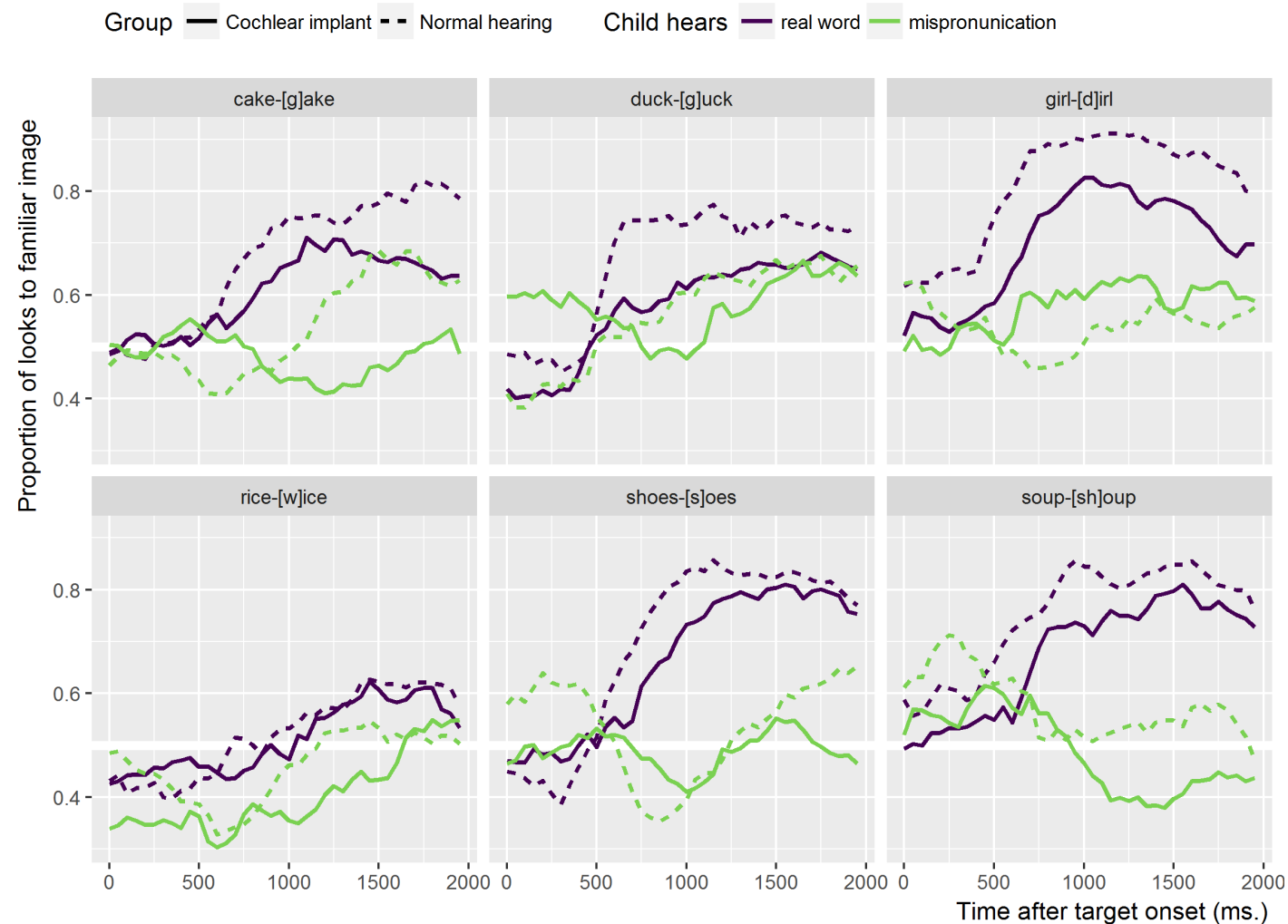
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**DEPARTMENT OF HEARING  
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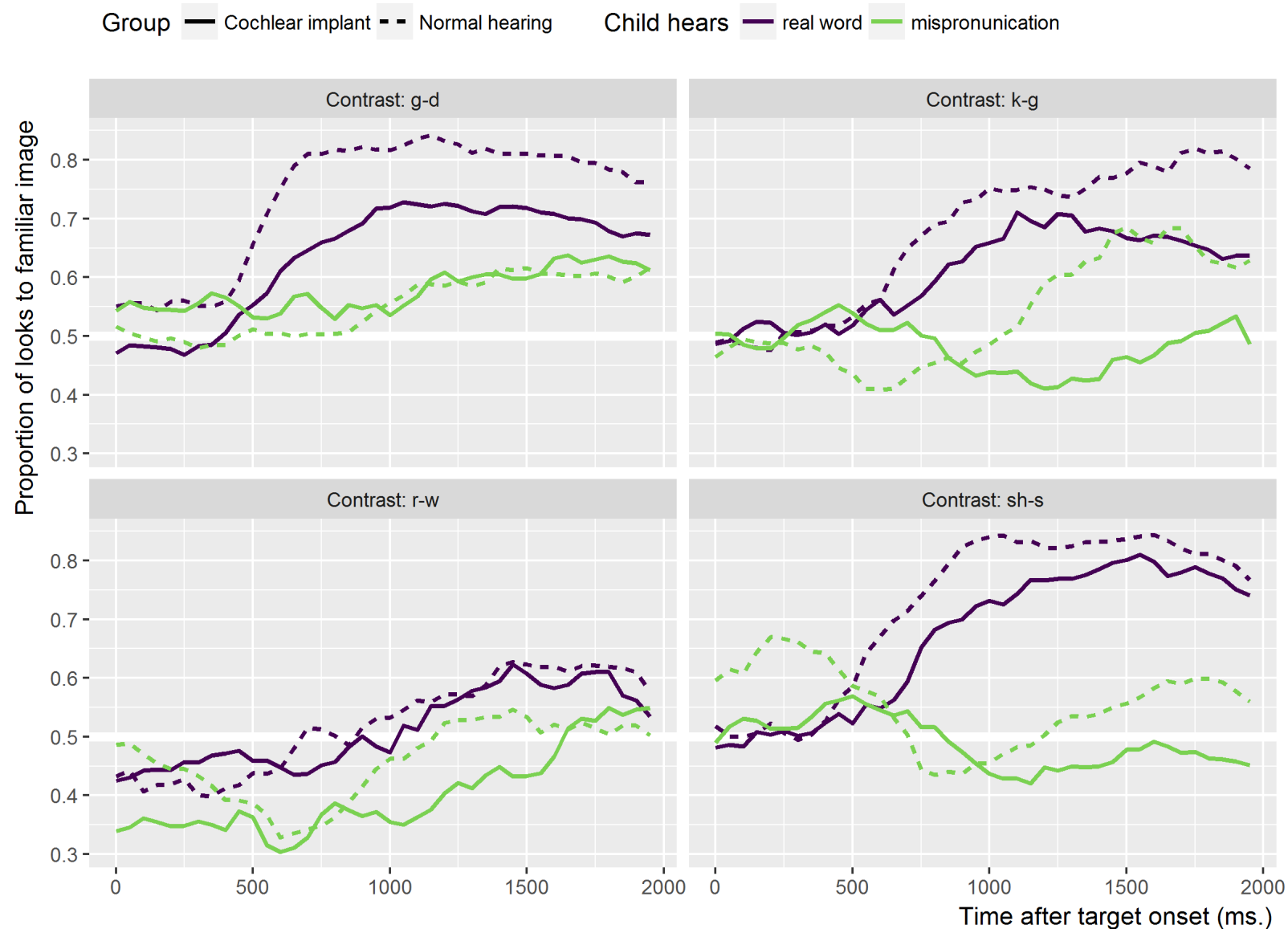
# Results by item



/k/ vs. /g/: voicing contrast (temporal)  
/s/ vs. /ʃ/: place contrast (spectral)  
/d/ vs. /g/: place contrast (spectral)  
/r/ vs. /w/: place and manner



# Results by contrast



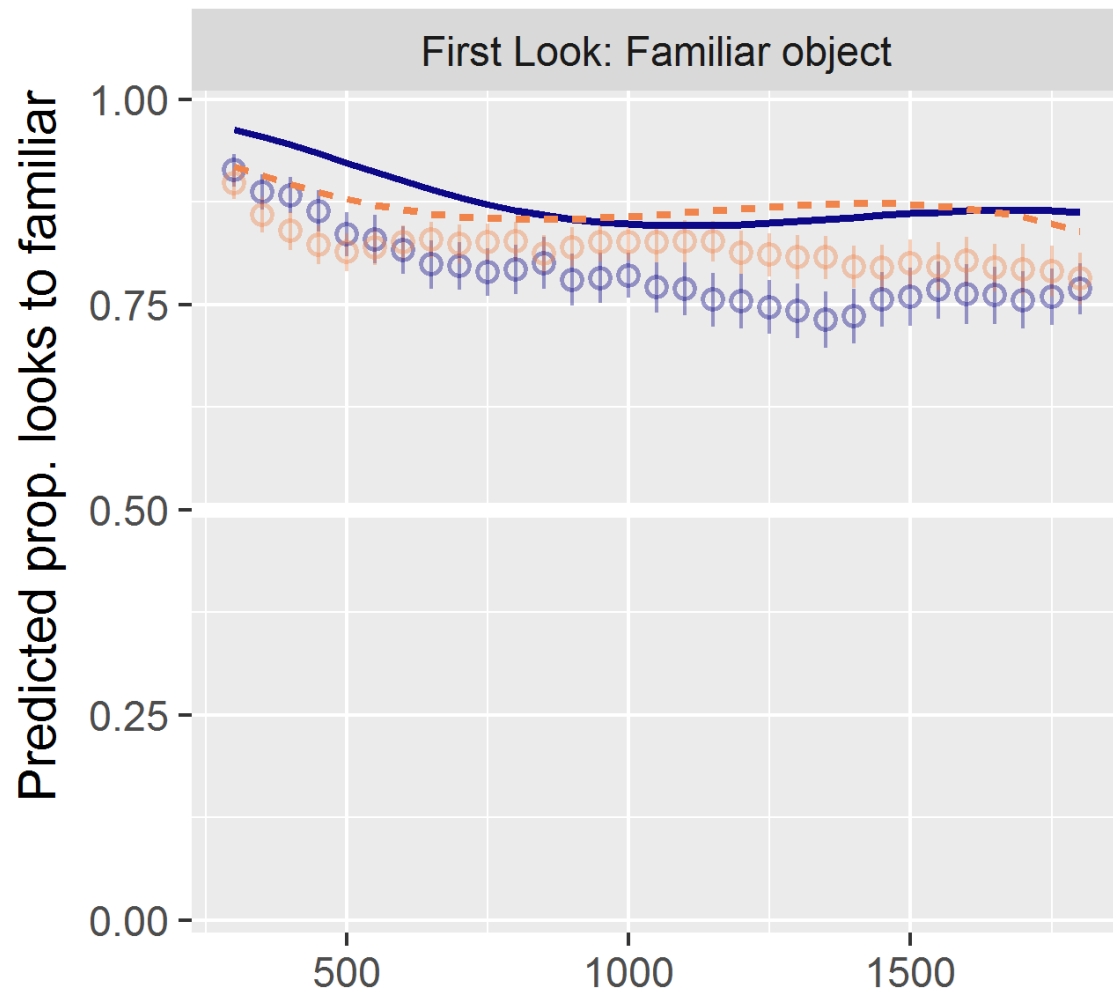
/k/ vs. /g/: voicing contrast  
/s/ vs. /ʃ/: place contrast  
/d/ vs. /g/: place contrast  
/r/ vs. /w/: place and manner

# Exploratory findings on mispronunciations

- On this two image task, a child could be fixated on the familiar or unfamiliar image during the start of the noun
- These would demand different behaviors
  - Switching
  - Staying

Group  Cochlear implant  Normal hearing

Real  
words





Time (ms) after noun onset

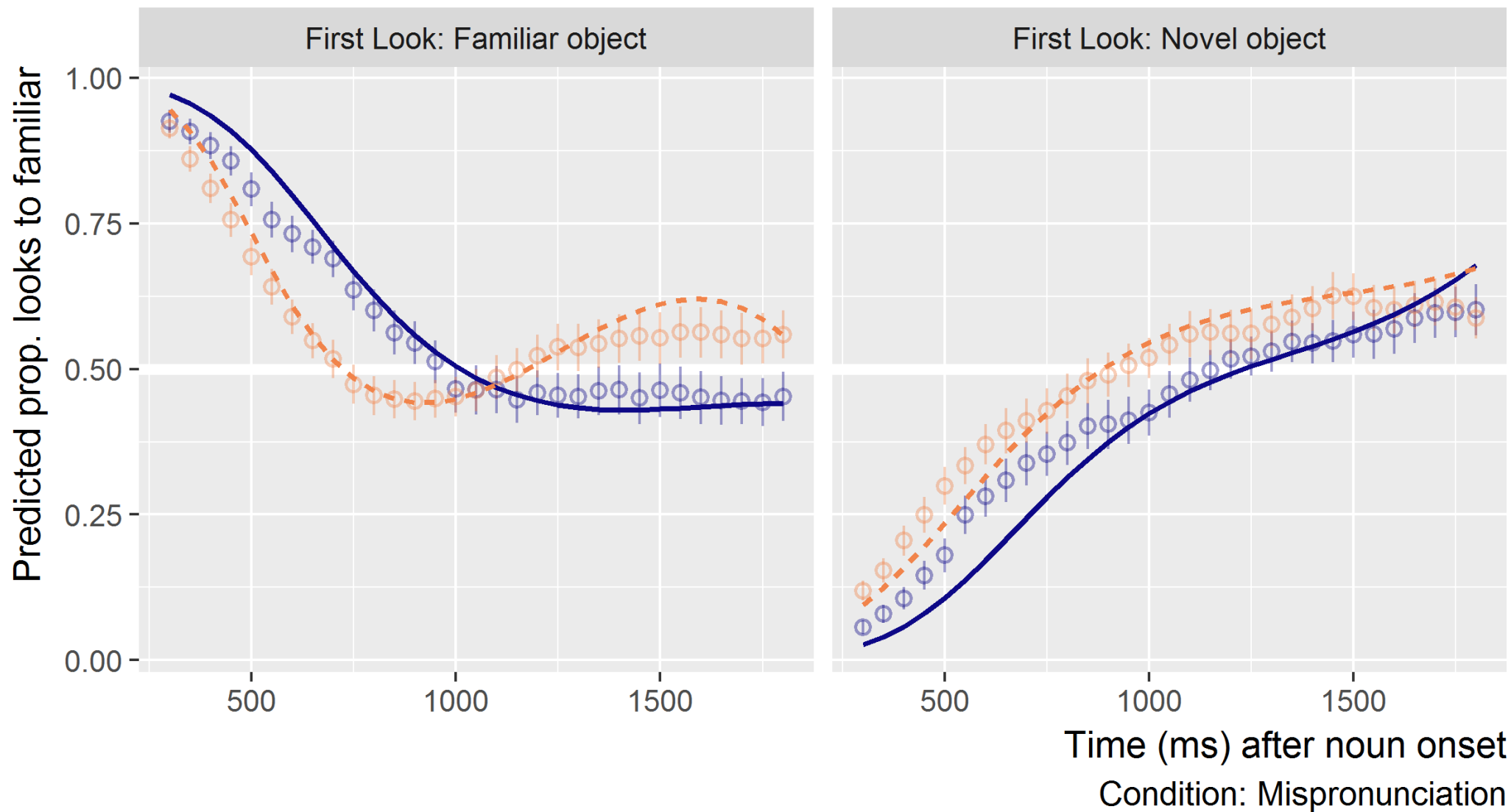
Condition: Real word

Staying

Switching

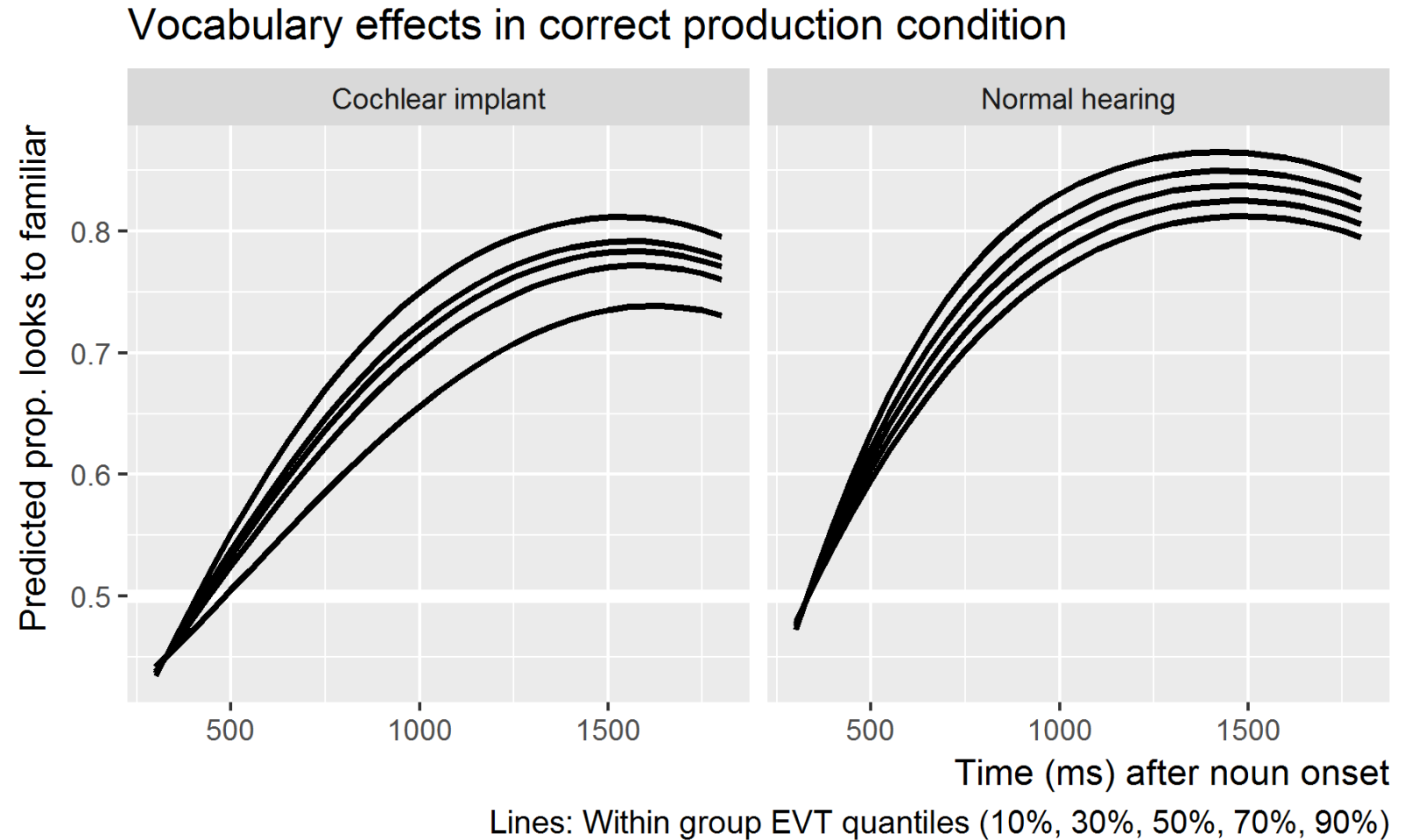
Group  Cochlear implant  Normal hearing

MPs



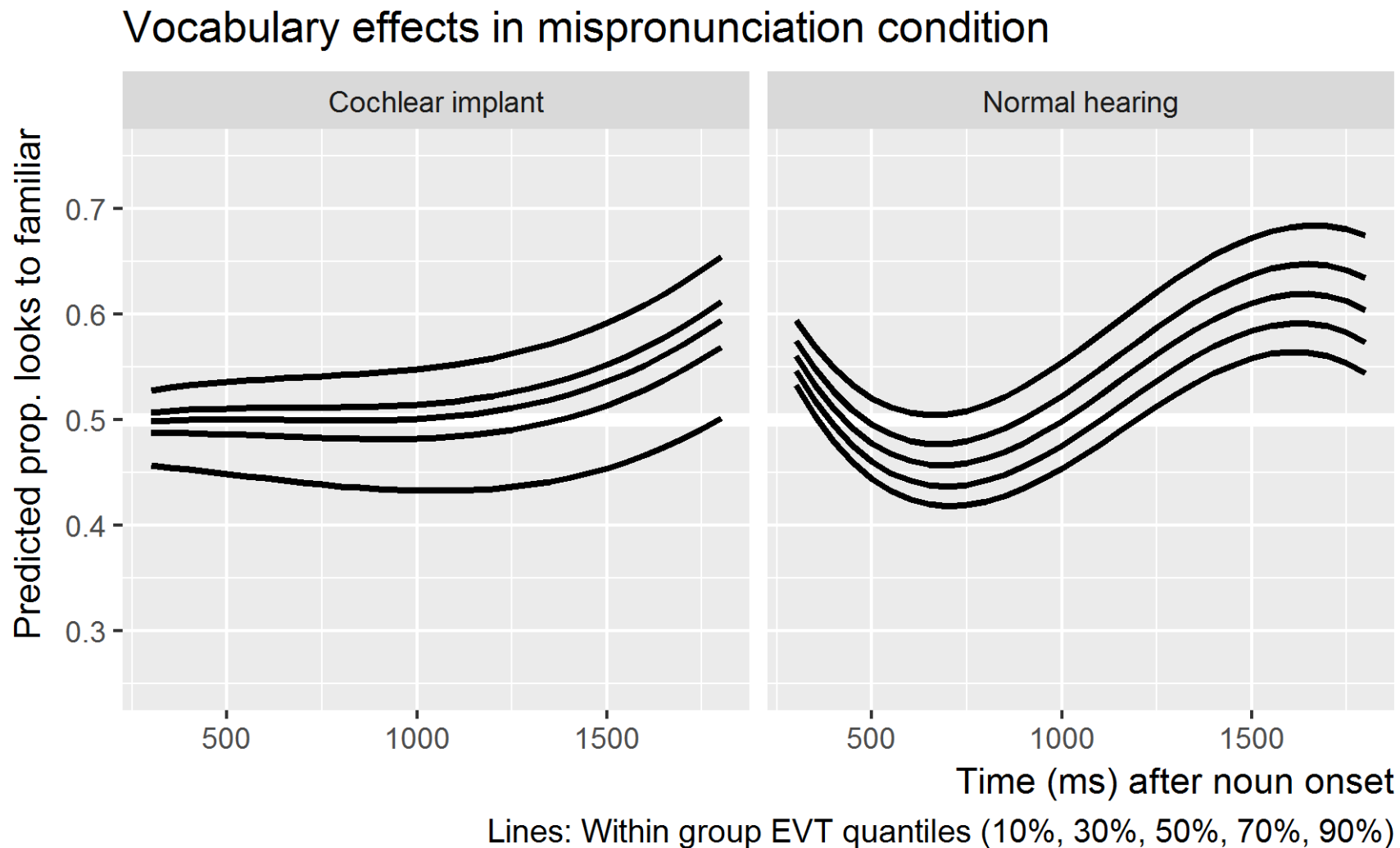
# Correct productions

- Significant effect of Vocabulary
- Larger vocabulary predicts faster looks and greater accuracy
- Vocabulary x Group interaction



# Mispronunciations

- Children with CIs *are* sensitive to mispronunciations.
- Looking pattern is different for the two groups.
- Effect of Vocabulary is similar for the two groups:
  - Significant intercept difference.



# Nonword condition

- Significant effect of Vocabulary
- Larger vocabulary predicts faster looks and greater accuracy

