Holistic lexical storage: Coarticulatory evidence from child speech

Meg Cychosz, University of California, Berkeley

mcychosz@berkeley.edu | github.com/megseekosh

Background

- Adults and children appear to decompose morphologically complex words
  - Children are productive on the wug test & frequently overgeneralize (e.g. *goed*)
- But children may not always break words down into morphemes and phonemes
  - Children often coarticulate more than adults, perhaps because they represent speech in syllables or whole words [1, 2, 3]
  - There are processing and repetition advantages for frequent multiword collocations [4, 5, 6]

Could children's coarticulatory patterns reveal how they represent complex words? [7]

Predictions

1. If children represent words more holistically, they will coarticulate **more** than adults at **morpheme boundaries.**
2. If adults parse speech segmentally, they will coarticulate **more within** morphemes than **across** morpheme boundaries.

Speech Community

- Mid-size town in south Bolivian highlands
- Bilingual speakers of South Bolivian Quechua & Spanish
  - South Bolivian Quechua is a highly agglutinating language with 200+ morphemes
- Children attend school from age 4 and are taught in Spanish
- Children speak Quechua at home, but do not learn to write it
- Women under 30 and children are/will be literate in Spanish

Participants

- 40 bilingual South Bolivian Quechua-Spanish speakers
  - 30 children (age 5-10), 10 female adults

Task

- Picture-prompted word elicitation task
  - 32 common nouns (*cow, flower*)
- Small, plastic bug placed on top of picture

- Children asked "*Where is my bug?*" to elicit noun+locative combination (e.g. "*On the cow.*")
- Each word contained sequence [ap] either:
  - Within morpheme (e.g. ***papa*** 'potato')
  - Between morpheme (e.g. ***waka-pi*** 'cow-LOCATIVE')

Analysis

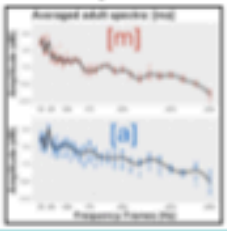
- Coarticulation measured between [a] and [p] across and within morphemes
- Tiny vocal tracts make adult-based coarticulatory measures unreliable
- Coarticulation = difference between Mel-frequency log magnitude spectra averaged over adjacent phones [8]:

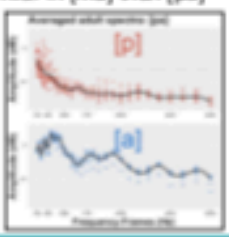
$$d_{ap} = \sqrt{\Sigma\left(\bar{x}_a - \bar{x}_p\right)^2}$$

where d = distance between [a] and [p]

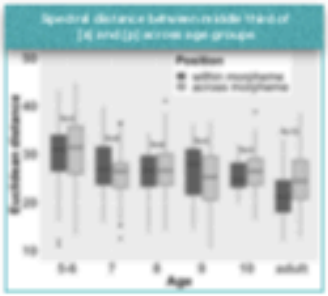
Results

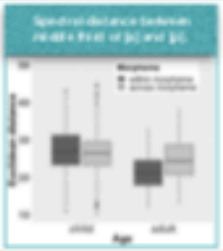
Coarticulation measurement visualized:
Mean spectra are more similar in [ma] than [pa]






```
Euclidean distance ~ Morphological_environment*Age
+ Word_duration + (1|word) + (1|speaker)
```





- Word duration controls for speaking rate
- Averaging over **entire** [a] and [p] phones did not show different coarticulatory patterns by age
- Averaging over **middle thirds** of [a] and [p] showed significant interaction of **Morphological environment*Age**

Conclusions

- Adults **coarticulate more within morphemes** than between
  - Highly-practiced articulatory routines within words
- Children **do not distinguish** by morpheme environment,
  - This suggests more holistic representations of complex words
  - Age effect only found when averaging spectra over middle third of phone
- Next steps: look at additional morphemes
  - Look at effects by lexical item
  - Look at effects by bilingual language dominance (quantified using daylong audio recordings of naturalistic speech)

Research funded by Tinker Field Research, UC Berkeley Student Technology Fund, and Oswalt Documenting Endangered Language grants, and Raymond H Stetson Scholarship in Speech Science, to MC. Thank you to the participating families for their time, involvement, and unending patience. Additional thanks to Keith Johnson, Sharon Inkelas, and Jan Edwards for feedback and guidance. Presented at the 2019 International Congress of Phonetic Sciences.

Paper ID: 469