Production of dorsal place(s) of articulation by child and adult speakers of four languages

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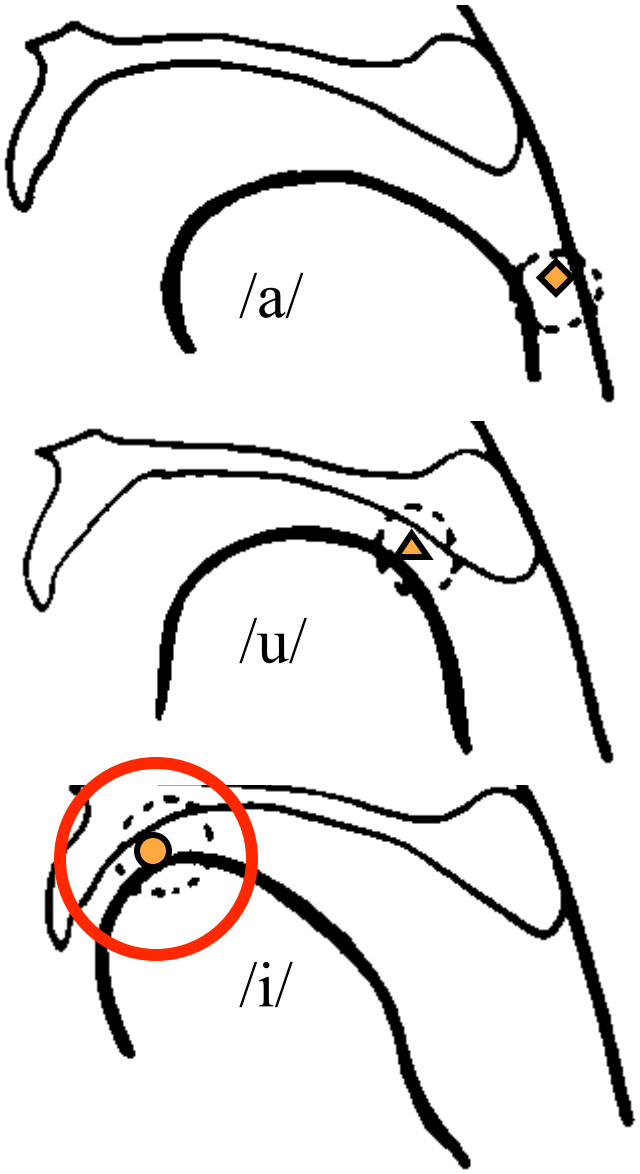
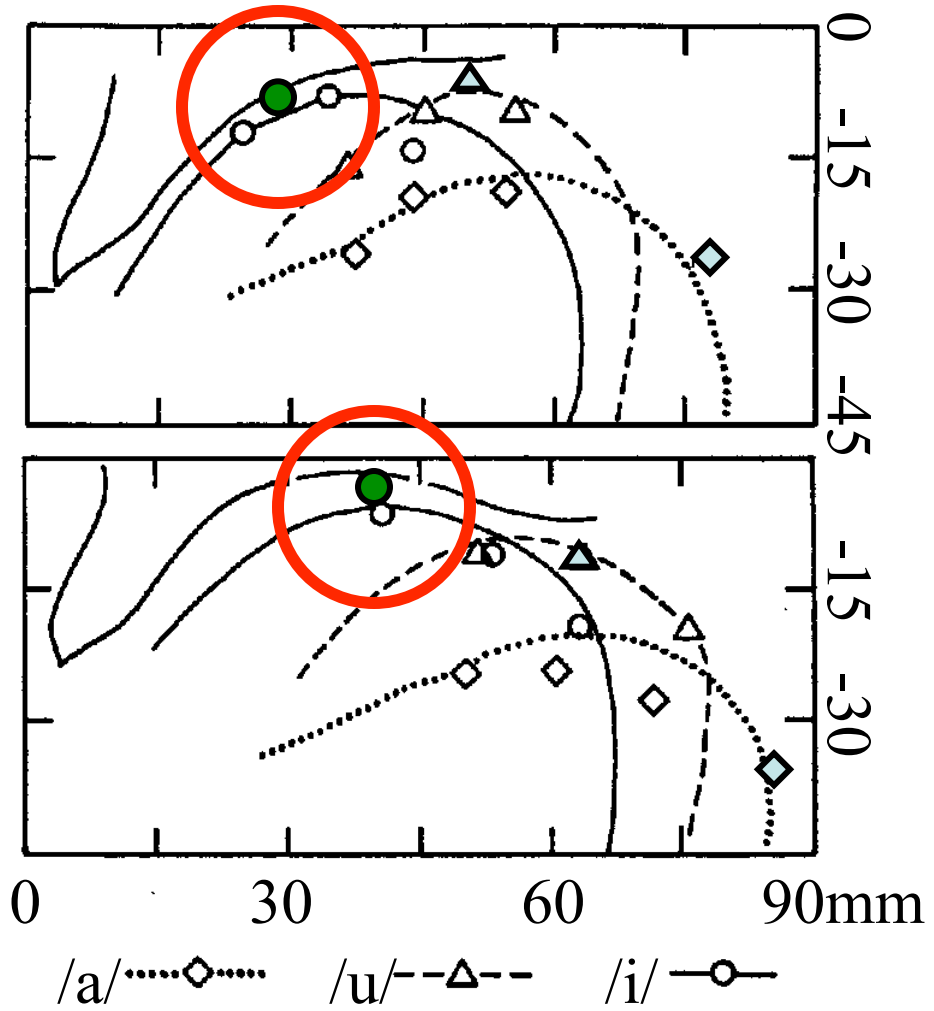
How should we characterize variation in the realization of dorsal stops?

- The /k/ of English *keep* and *coop* are produced with different places of constriction.
- Similarly, the Greek /kʲ/ in κύμα /kʲima/ "*wave*" has a different place of constriction than the /k/ in κουνέλι /kuneli/ "*rabbit*"?
- How do we characterize these differences?
  - Traditional analyses have argued for categorical descriptions such as "velar fronting" (Chomsky & Halle 1968)
  - Experimental studies have found a gradient effect of the following vowel's place of articulation (Keating & Lahiri 1991).



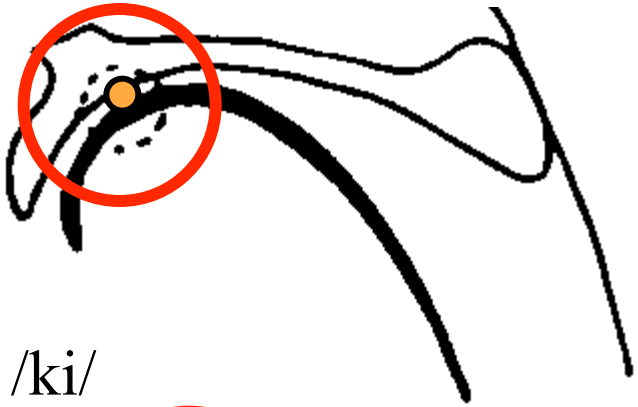
Japanese point vowels, from Wada, et al. (1969)

Both English speakers have a less front /i/ than the Japanese speaker's /i/.

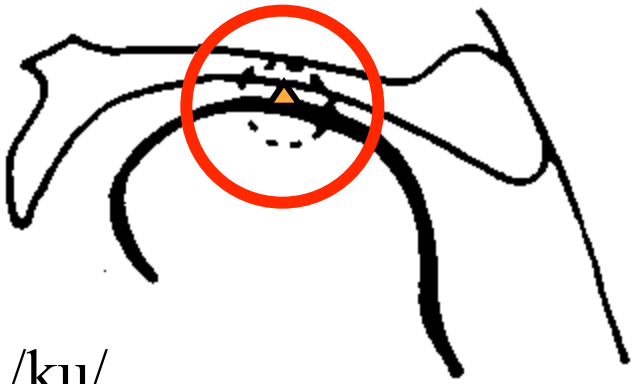


English point vowels, from Kent & Moll (1972)

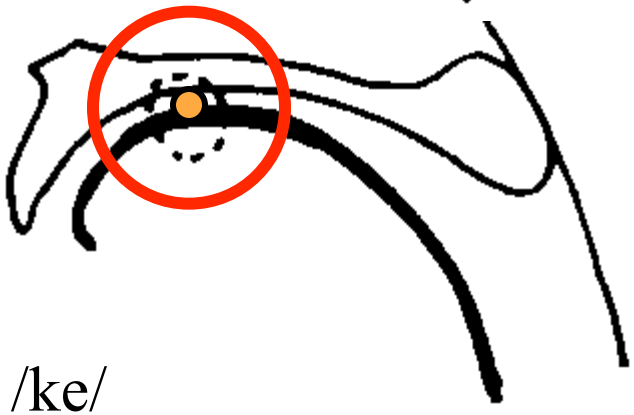
Place of constriction in Japanese /k/ shows a gradient dependency:



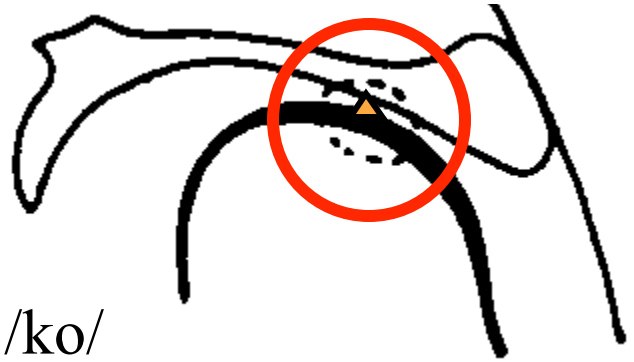
/ki/



/ku/



/ke/



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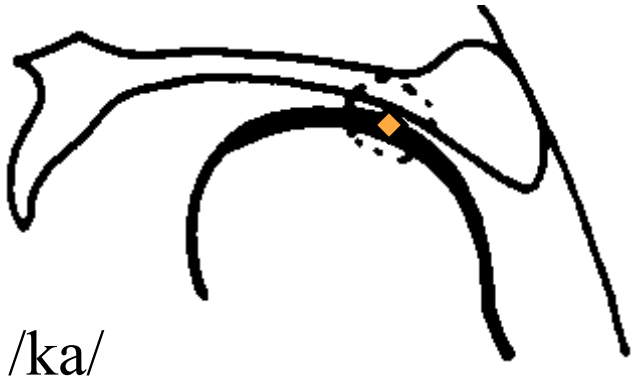


/ka/

Cineflourographic midsagittal views of Japanese /k/ before each of the five vowels (Wada, Yasumoto, Ikeoka, Fujiki, & Yoshinaga, 1969)

How do we examine this effect of vowel context on velar place of articulation?

- We need to look at velar stops cross-linguistically (e.g., Lahiri, et al. 1984; Sundara, 2005).
  - Both vowel space and constriction location may differ across languages.
- We need to effectively isolate the front cavity resonances of the burst.
  - Use smaller analysis window size (10ms vs. 20-45ms).
  - Use auditory spectrum rather than raw acoustics.
- We need to examine patterns of acquisition.
  - If there are language-specific differences in the effect of vowel context on velars in adult productions, then do we see these same effects in the productions of young children?

Questions of study

1. Is velar stop production dependent on the following vowel in a gradient or categorical way?
2. Are there cross-language differences in the effect of following vowel context on velar stop production for adults?
3. If so, then how do these cross-language differences influence acquisition patterns?

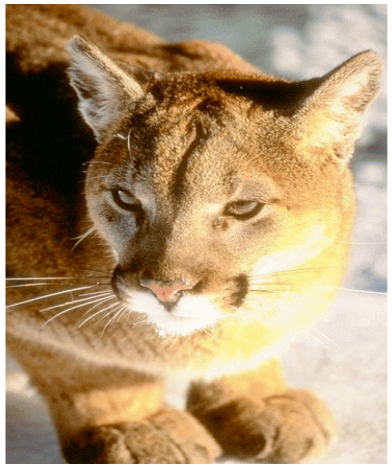
Hypotheses

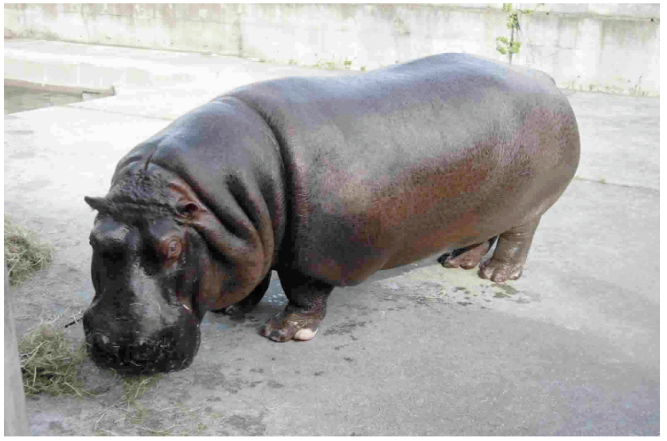
- The place of articulation for /k/ within a language will vary gradiently with the following vowel.
- These place of articulation differences will differ across languages because vowel quality differs:
  - Japanese and Greek /i/ are fronter than English /i/
  - Greek /u/ is more back than English /u/ (Chung, et al. 2008)
- Children's productions will gradually come to resemble those of the adults in the ambient language.
  - 2-year-old productions from different languages will be more similar to each other than to those of the adults of the ambient languages.

Method

- Single-word repetition task to elicit initial consonant productions in Cantonese, English, Greek, and Japanese before five vowels: /u/, /o/, /a/, /e/, and /i/.
- Ten typically-developing two- and five-year-olds (and ten adults) for each language were presented with pictures and digitized recordings of familiar real words.
- Children's repetitions were digitally recorded and transcribed by native-speaker phoneticians.
- Only tokens with correct productions of target consonants and vowels were included in the present analysis.

Stimuli examples



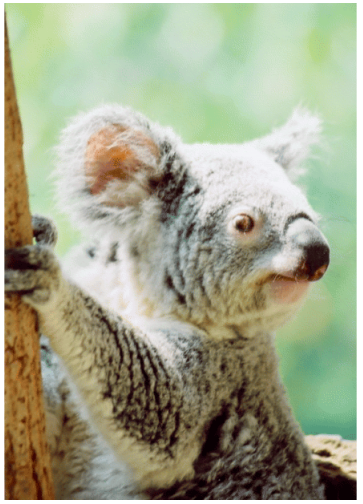


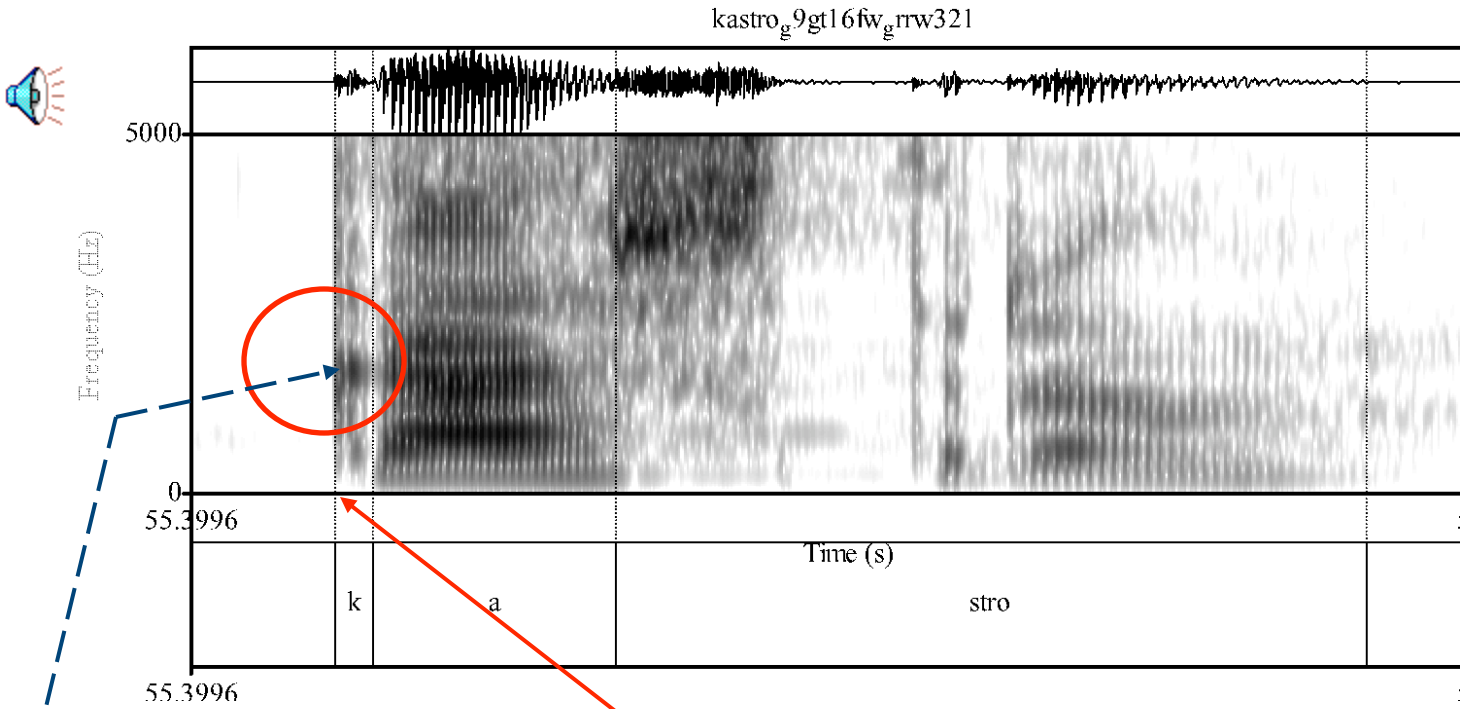
cougar

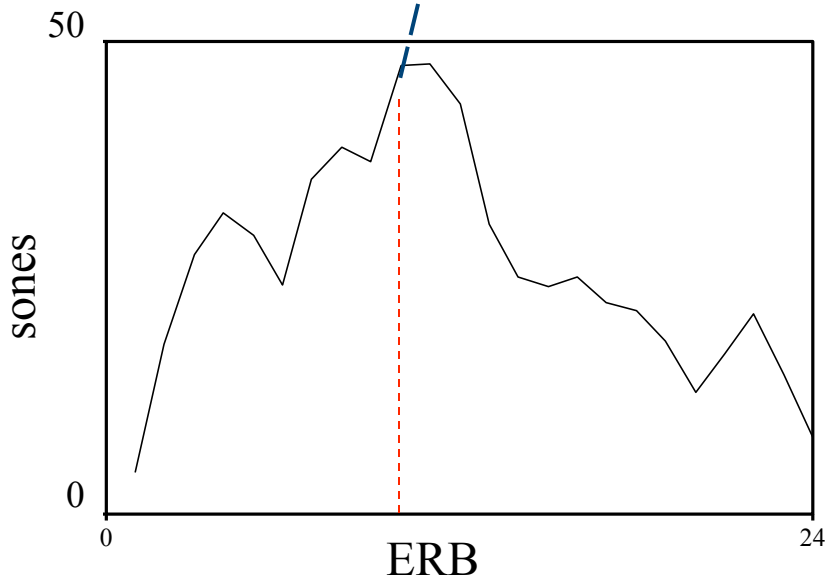
coat

[kaba]

[koara]

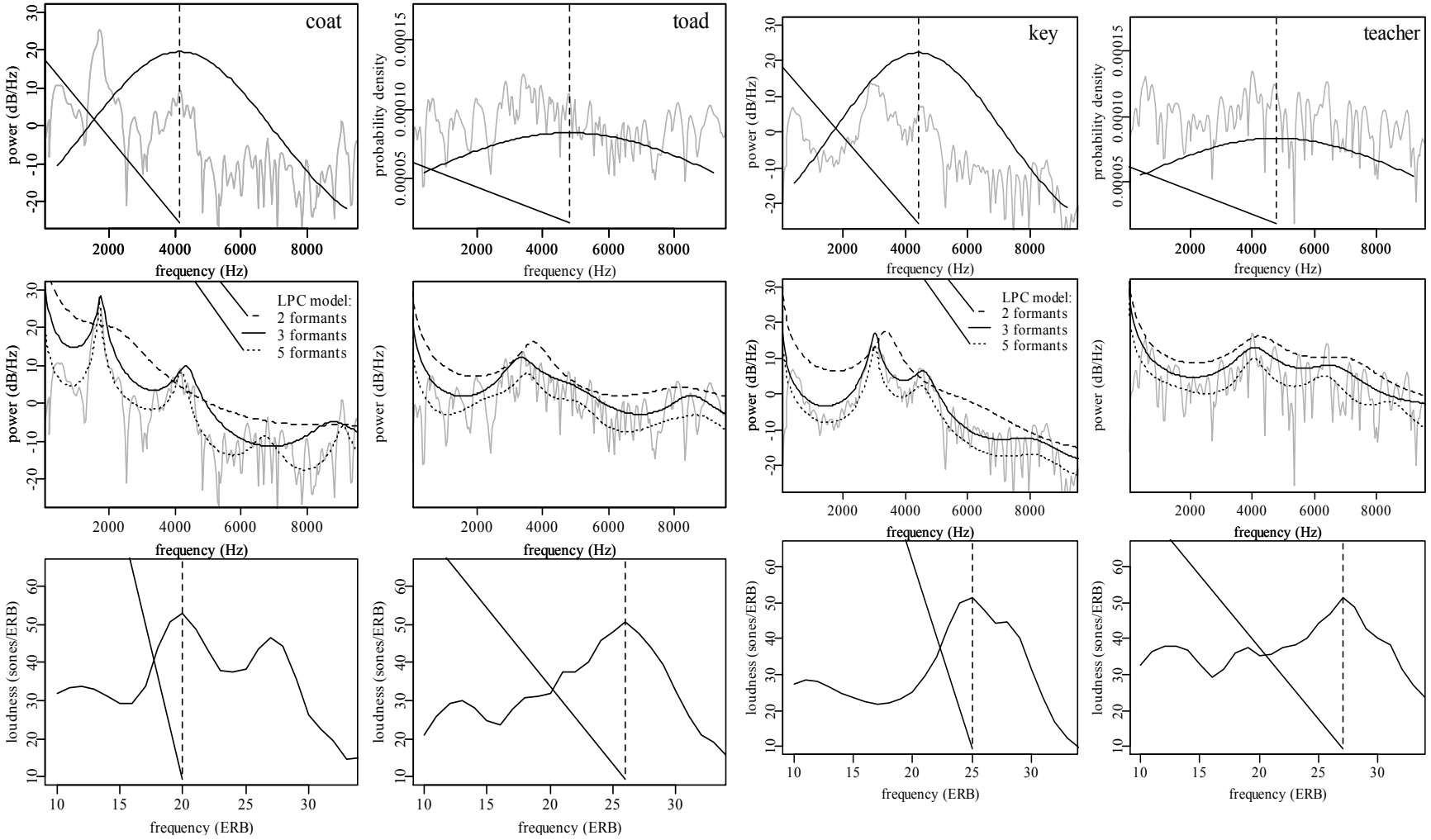


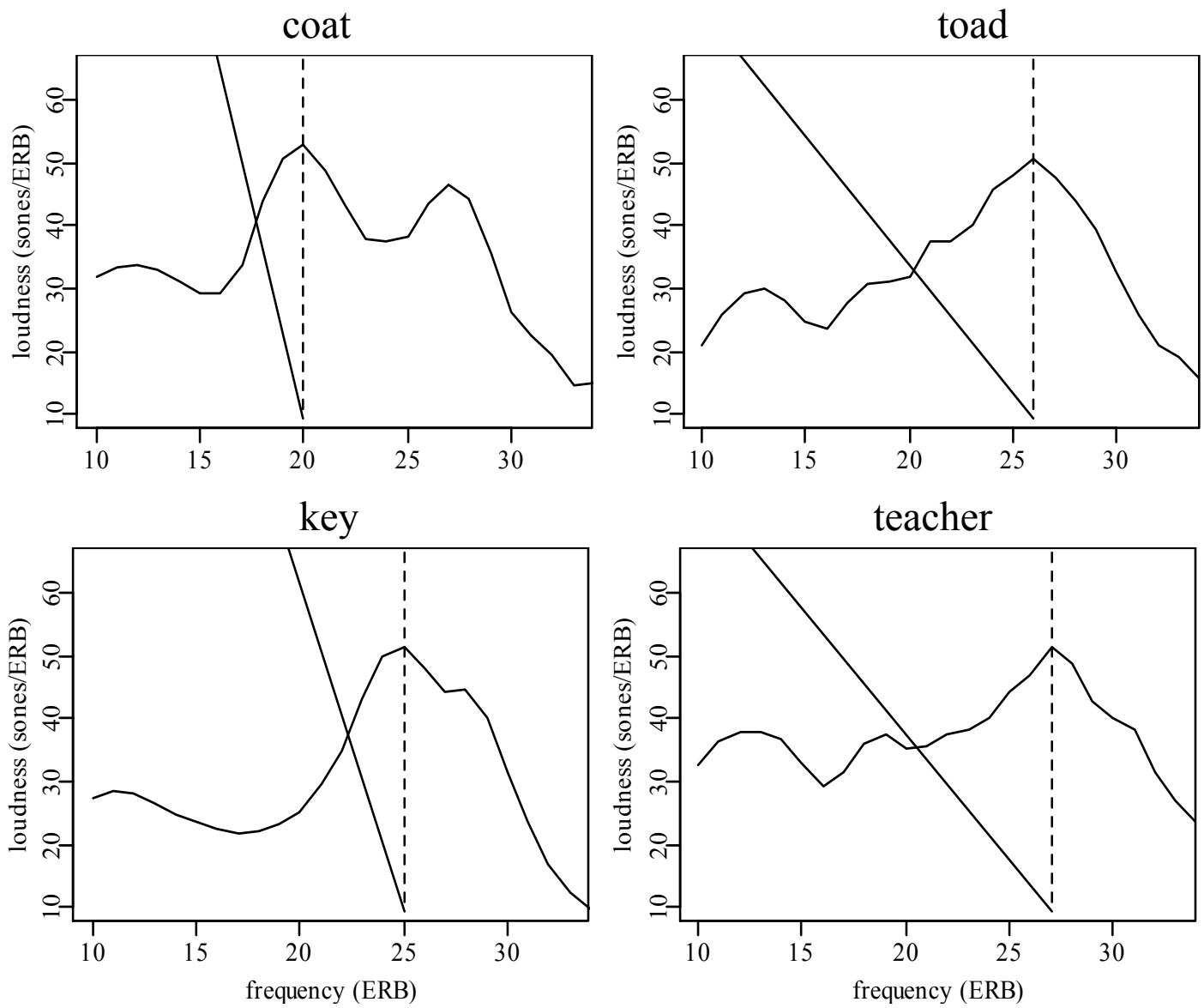




- Word-initial stops tagged for burst onset
- Spectra produced from 10-ms windows centered at burst
- Frequency of highest amplitude peak calculated for each burst

Auditory-based model of spectral analysis



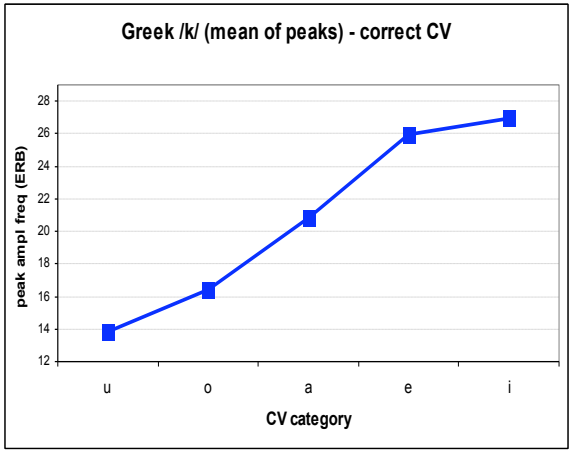

coat
toad
key
teacher
loudness (sones/ERB)
frequency (ERB)
10
15
20
25
30
10
20
30
40
50
60

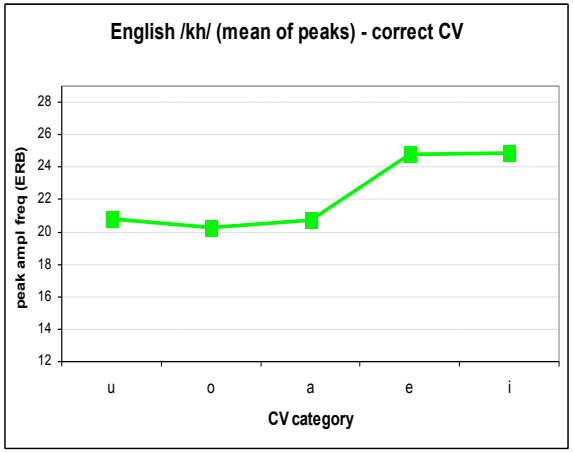
Psychoacoustic measure used

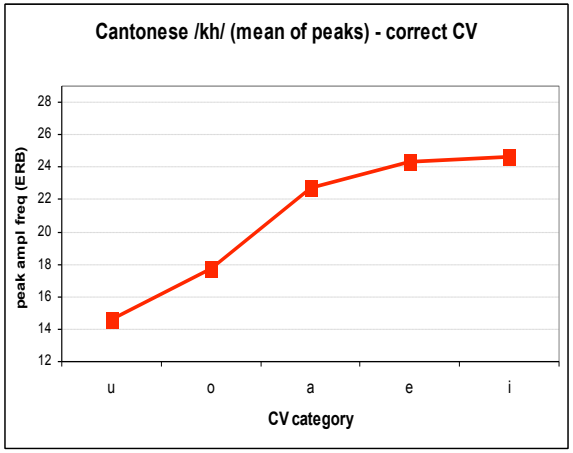
peak amplitude frequency (peak ERB) - acute/grave dimension

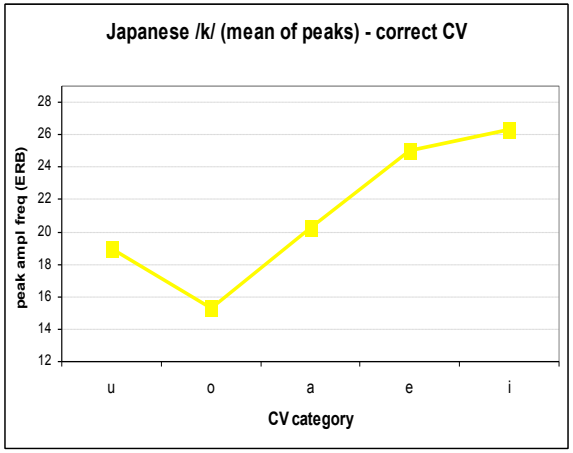
- the peak amplitude frequency, representing the point of highest specific loudness (measured in sones)
- higher frequency peaks= shorter front cavity (alveolars, front velars)
- lower frequency peaks= longer front cavity (back velars)

Results - adults



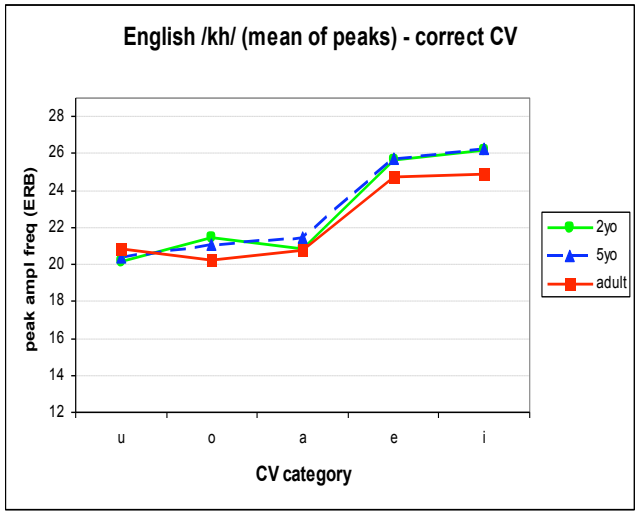


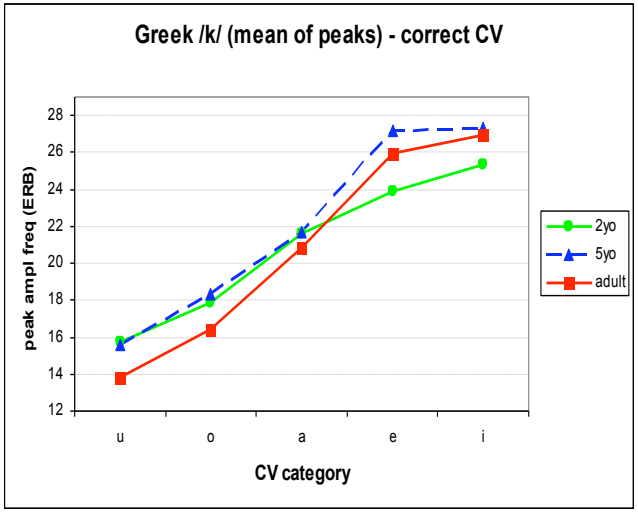


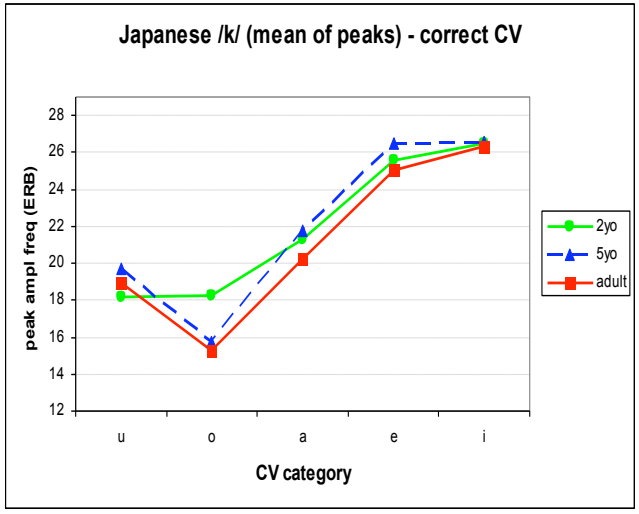


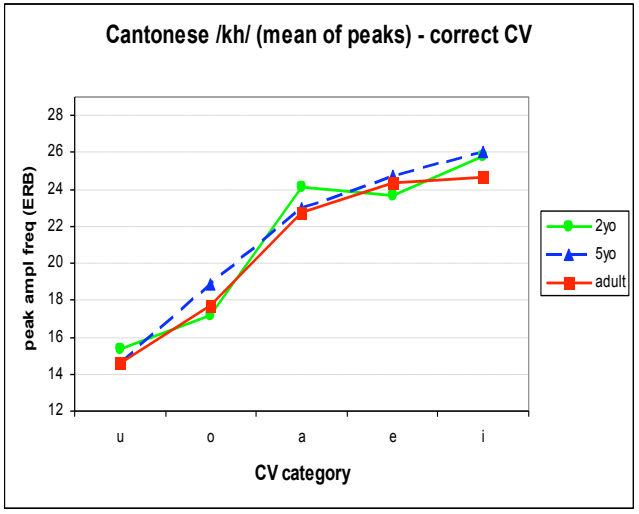
- In all languages except English, there was a gradient effect of vowel context on velar peak ERB values.
- Velars before /i/ have higher ERB values in Greek and Japanese, than in English and Cantonese.
- Back velars had considerably lower peak ERB values in Greek, Japanese, and Cantonese than in English.

Results – mean of peaks (by language)



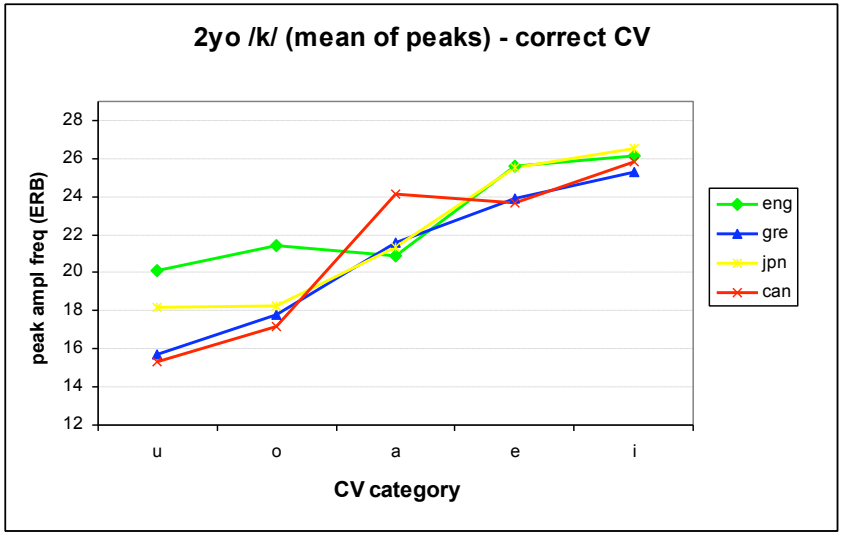


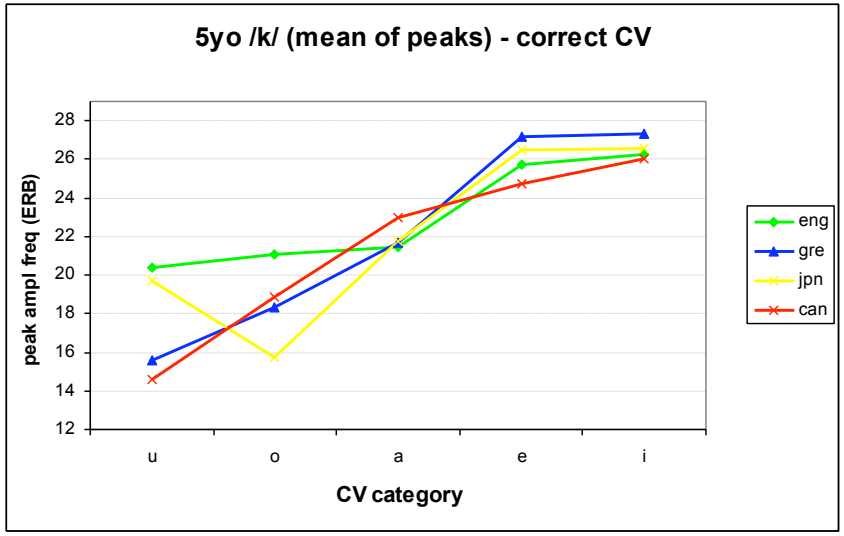


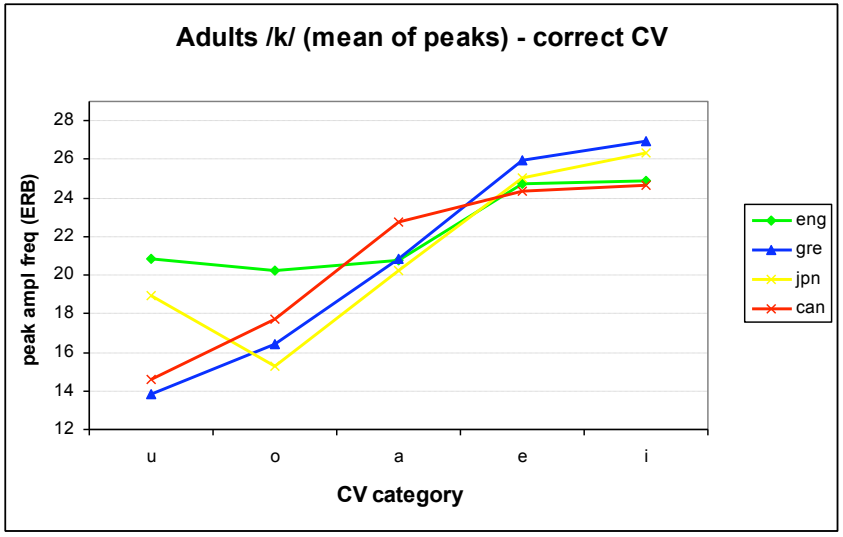


- Even 2-year-olds show language-specific effects of vowel context.
- However, Japanese 2-year-olds don't show a difference in peak ERB values for velars before /u/ and /o/.
- Similarly, the peak ERB values for velars before /i/ are not as extreme for Greek 2-year-olds.

Results – mean of peaks (by age)







- For adults, peak ERB values for velars before /i/ are higher for Japanese and Greek relative to English and Cantonese.
- However, for 2-year-olds there is no difference in peak ERB values for velars before /i/ across languages.

- For adults, peak ERB values for velars before /u/ are
- lower for Greek, Japanese, Cantonese relative to English.
- Even for 2-year-olds, this same pattern is observed.

Summary and Discussion

- In Greek, Japanese and Cantonese, vowel context has a gradient influence on the place of articulation of dorsal obstruents; in English, there's a categorical effect.
  - Gradient effect of vowel context seen even when only first 10 ms of stop is examined.
  - Why is the effect not gradient in English?
    - Perhaps because central vowels were not included in the corpus.

Summary and Discussion

- Effects of vowel context on velar stop production were language-specific.
  - Less back /u/ of English resulted in higher peak ERB values for velars before /u/ (relative to the other 3 languages).
  - More back /o/ relative to /u/ in Japanese resulted in lower peak ERB values before /o/ as compared to /u/ in Japanese.
  - More front /i/ of Greek and Japanese results in higher peak ERB values before /i/ (relative to English and Cantonese).

Summary and Discussion

- Children's productions were language-specific from early on, but still showed clear developmental trends.
  - As early as 2-year-olds, correct productions show ambient language influence.
    - Gradient patterns were seen in Greek, Japanese, and Cantonese; categorical pattern was seen in English.
    - Peak ERB values for /u/ were higher for English relative to the other 3 languages even for 2-year-olds.
  - However, developmental patterns are seen even for these correct productions.
    - Productions of Japanese 2-year-olds don't show difference in peak ERB values for velars before /u and /o/.
    - Language-specific differences not observed for peak ERB values for velars before /i/ for 2- or 5-year-olds.

Future directions

- Examine differences in place of articulation for alveolar vs. velar stops using auditory-based analysis.
  - Include measure of compact/diffuse dimension as well as acute/grave dimension.
  - Include CV formant transitions as well as burst.

Future directions

- Analyze both correct and incorrect productions.
  - Common error pattern in English for /k/ is [t] substitution.
  - Is this same error pattern observed across languages?
  - Is this error pattern categorical or gradient?

Future directions (maybe omit)

- Examine perception of stop bursts across languages
  - How is front /ki/ of Greek and Japanese perceived by English and Cantonese listeners?
    - Anecdotal evidence suggests that very front /ki/ of Greek-speaking children is perceived as correct by Greek listeners, but as [ti] by English listeners.

Acknowledgments

- Co-PIs: Mary Beckman and Ben Munson
- Lab colleagues: Tim Arbisi-Kelm, Hyunju Chung, Eden Kaiser, Eunjong Kong, Fangfang Li, Sarah Schellinger, Asimina Syrika, Kari Urberg-Carlson
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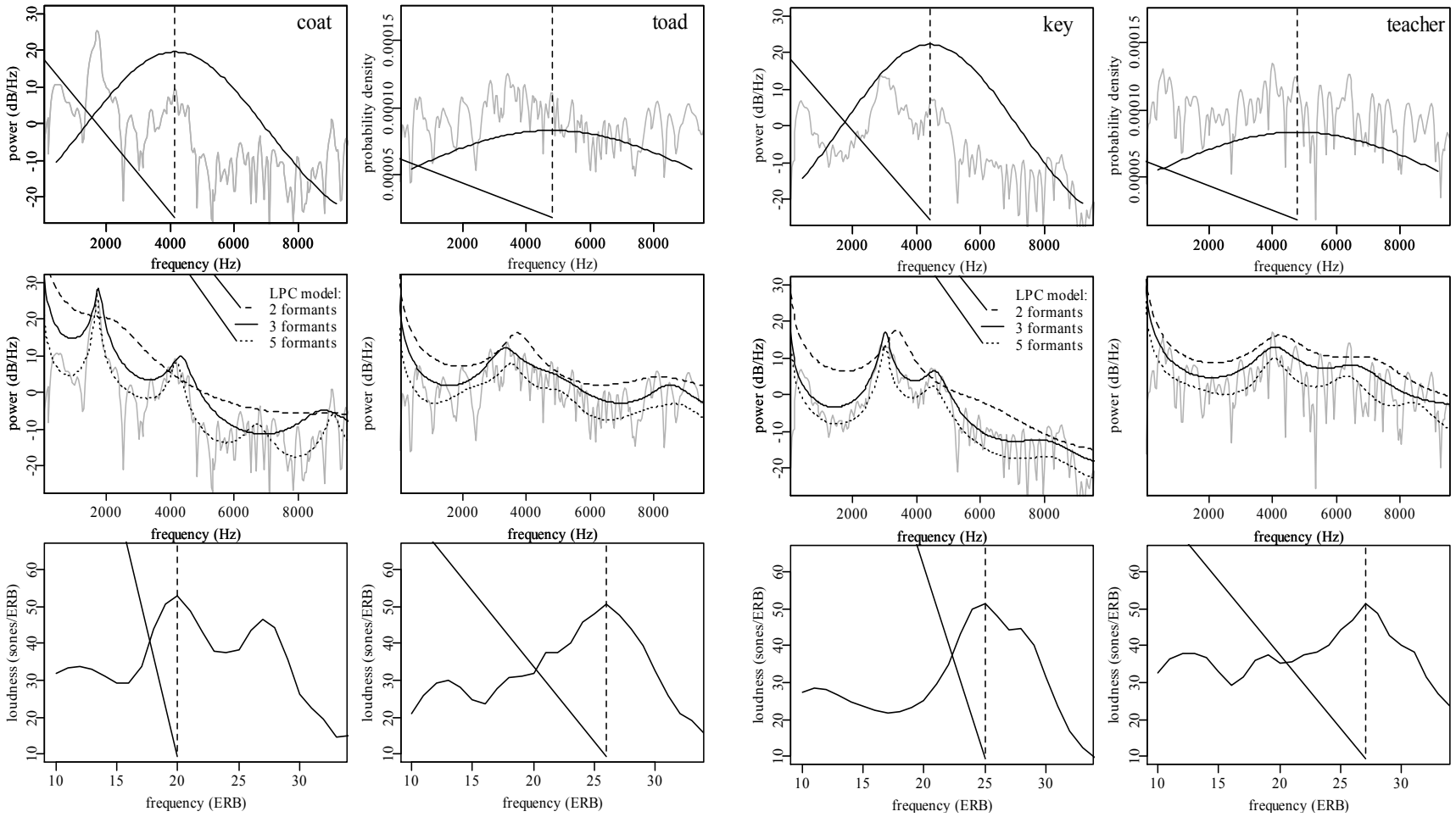
- Support from NIDCD Grant 02932 and NSF Grant BCS-0729140 to Jan Edwards
- Participation of the children and cooperation from their parents

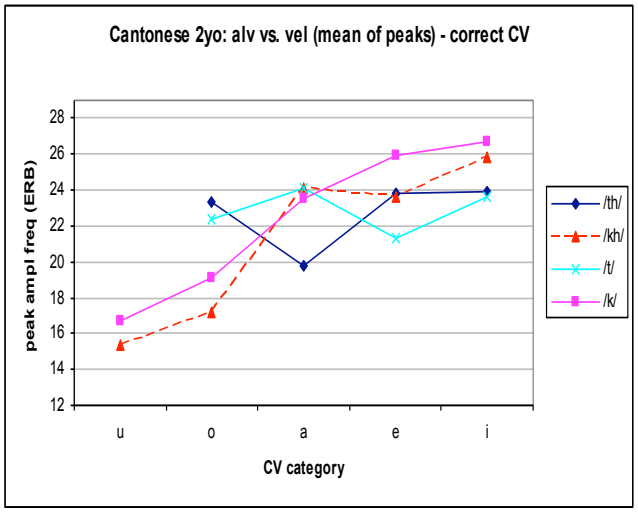
For all of which, a heartfelt:

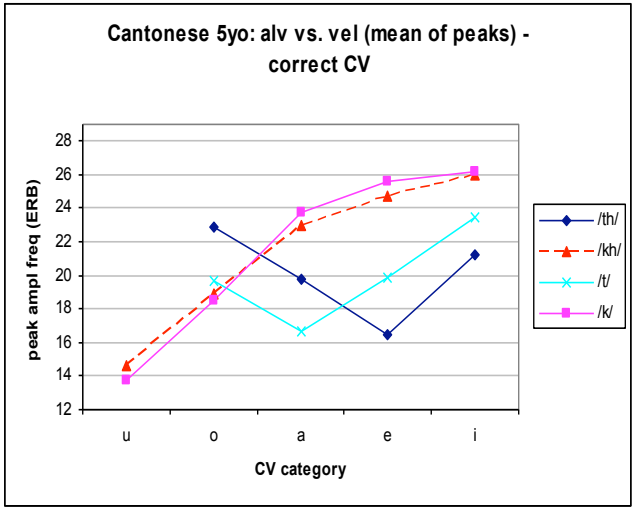
謝謝　　thank you　　ευχαριστώ πολύ　　ありがとう

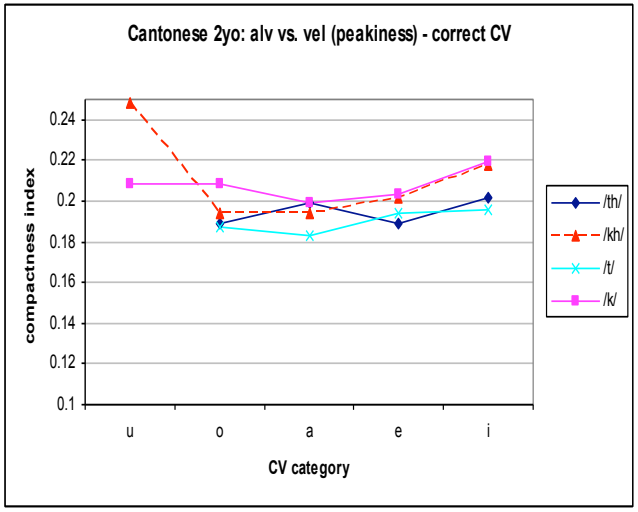
Auditory-based model of spectral analysis

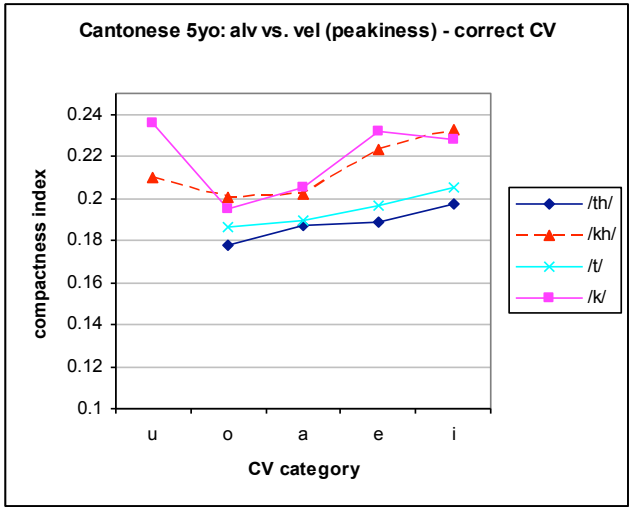


Results - Cantonese

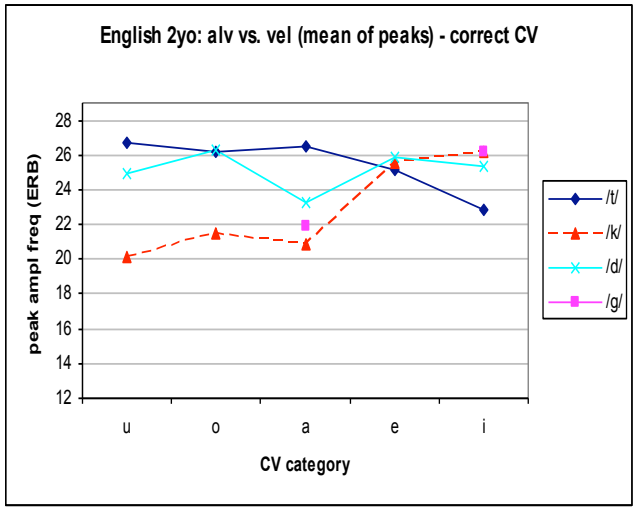


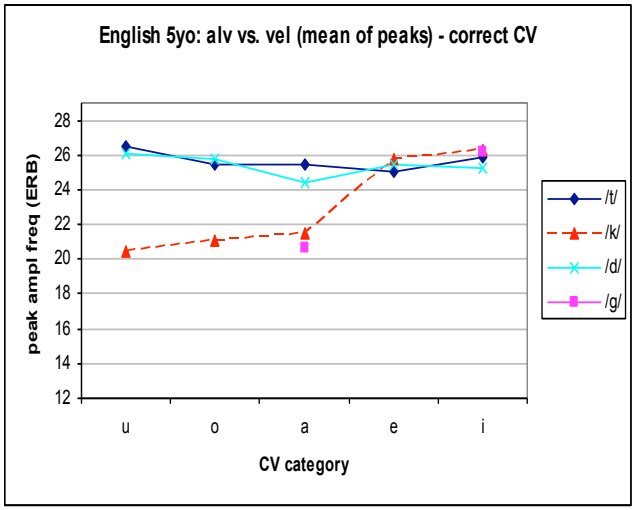


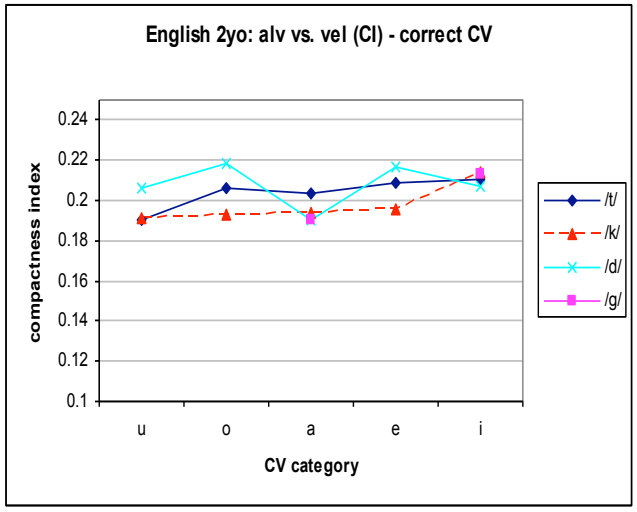


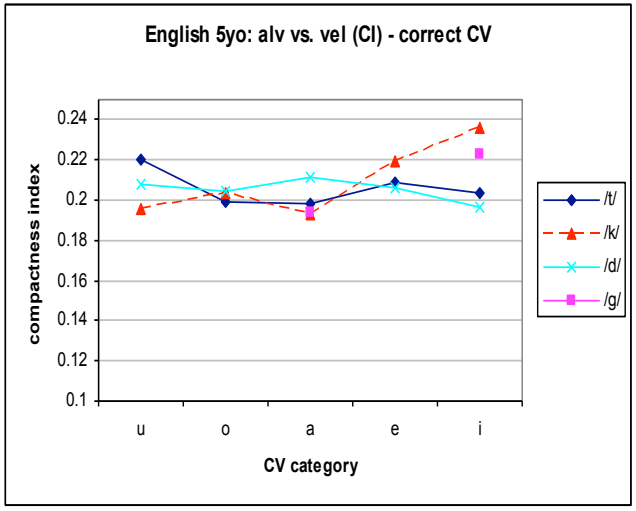


Results - English

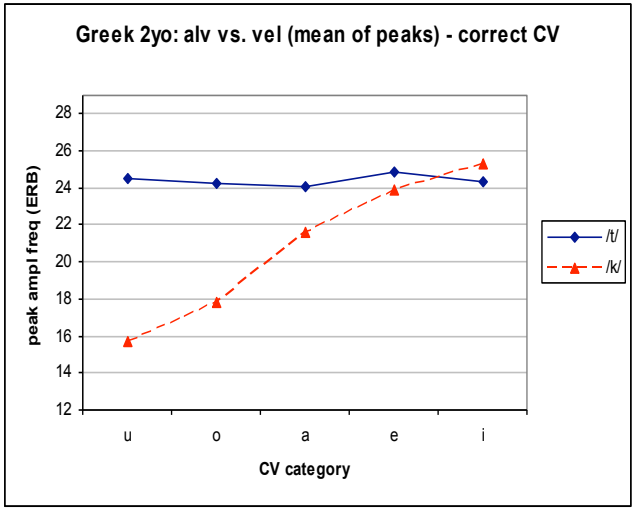


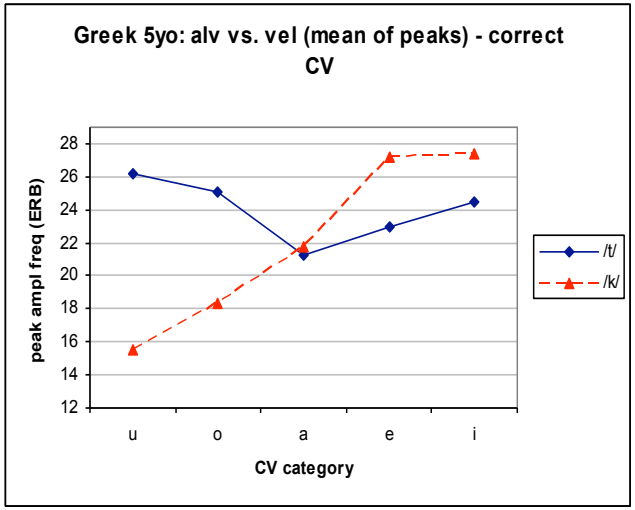


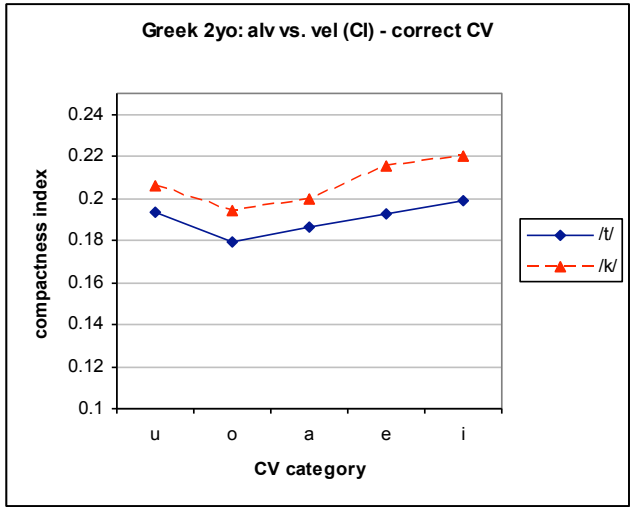


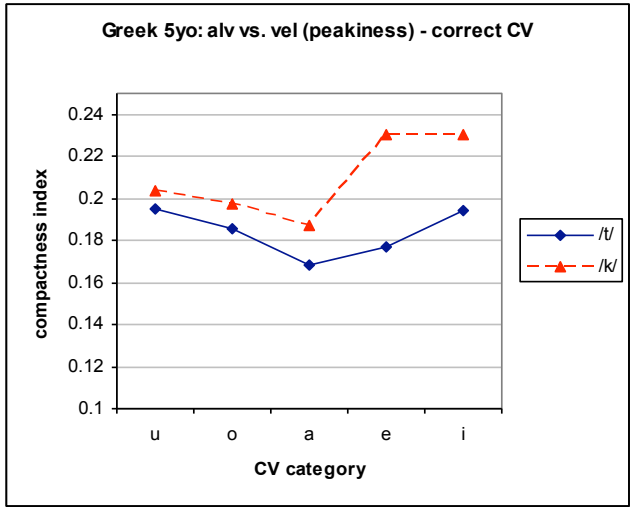


Results - Greek









Results - Japanese