Coarticulation of /s/ with following or preceding stops in Greek consonant sequences

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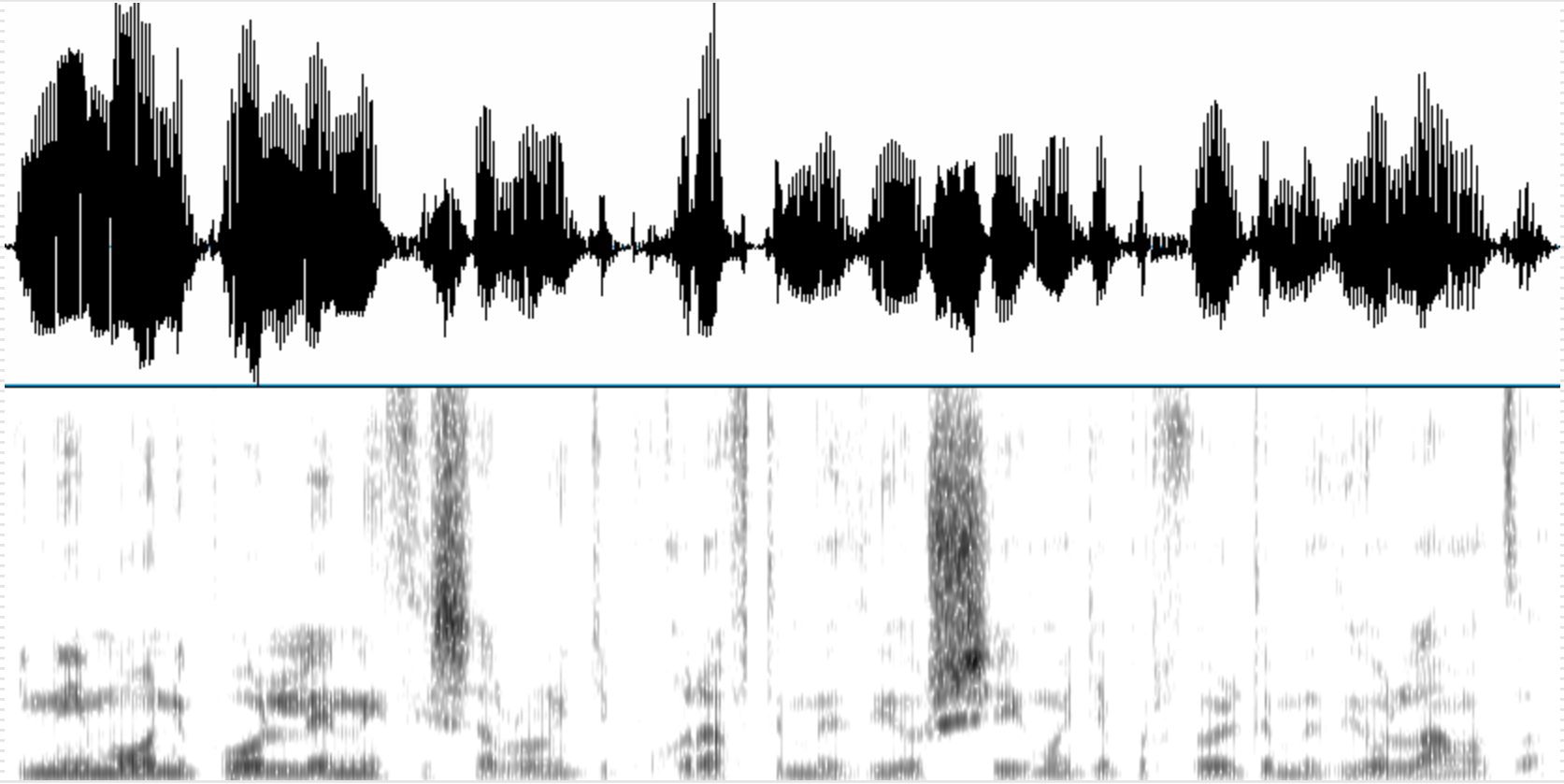
Introduction: The acoustic signal



Coarticulation in speech

- What is co-articulation?
  - An overlap in the articulation of sound gestures for consecutive segments of an utterance
- Why is it interesting?
  - Speech production: Describing coarticulation patterns across languages
  - Speech perception: Lack of invariance and the segmentation problem
  - Development of coarticulation in children and L2 learners

Coarticulation

- What we know
  - There are different types of coarticulation
  - Some coarticulation is physiological, and some is phonological (language-specific)
  - There is great variation in coarticulation
- What we don’t know
  - How to quantify coarticulation
  - How it develops in children and L2 learners
  - Little work on coarticulation in consonant clusters

Research Questions

- Examine coarticulation in consonant clusters
  - Are stop place cues present in the [s] in initial /s/-stop and stop-/s/ sequences in Greek?
  - Are these patterns similar to those that have been observed in English?
  - Do Greek children show the same patterns as the adults?
  - How can we quantify these dynamic features of fricative spectra?

Method: Participants

- Ten children at each of the following ages (2-,3-,4-, and 5-years), and 10 young adults (20-35 years) from Thessaloniki
- All participants passed a hearing screening, and had normal speech/language development
- All participants were part of a larger study investigating phonological development across languages

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Method: Stimuli

- Target (/sp/, /st/, /sk/, /ps/, /ts/, /ks/) placed in word-initial position in:
  - Two or three-syllable words with word-initial stress
  - Familiar to the children
  - Pictureable
- Each target paired with all possible vowel combinations of /i, e, a, o, u/.

Examples of stimuli

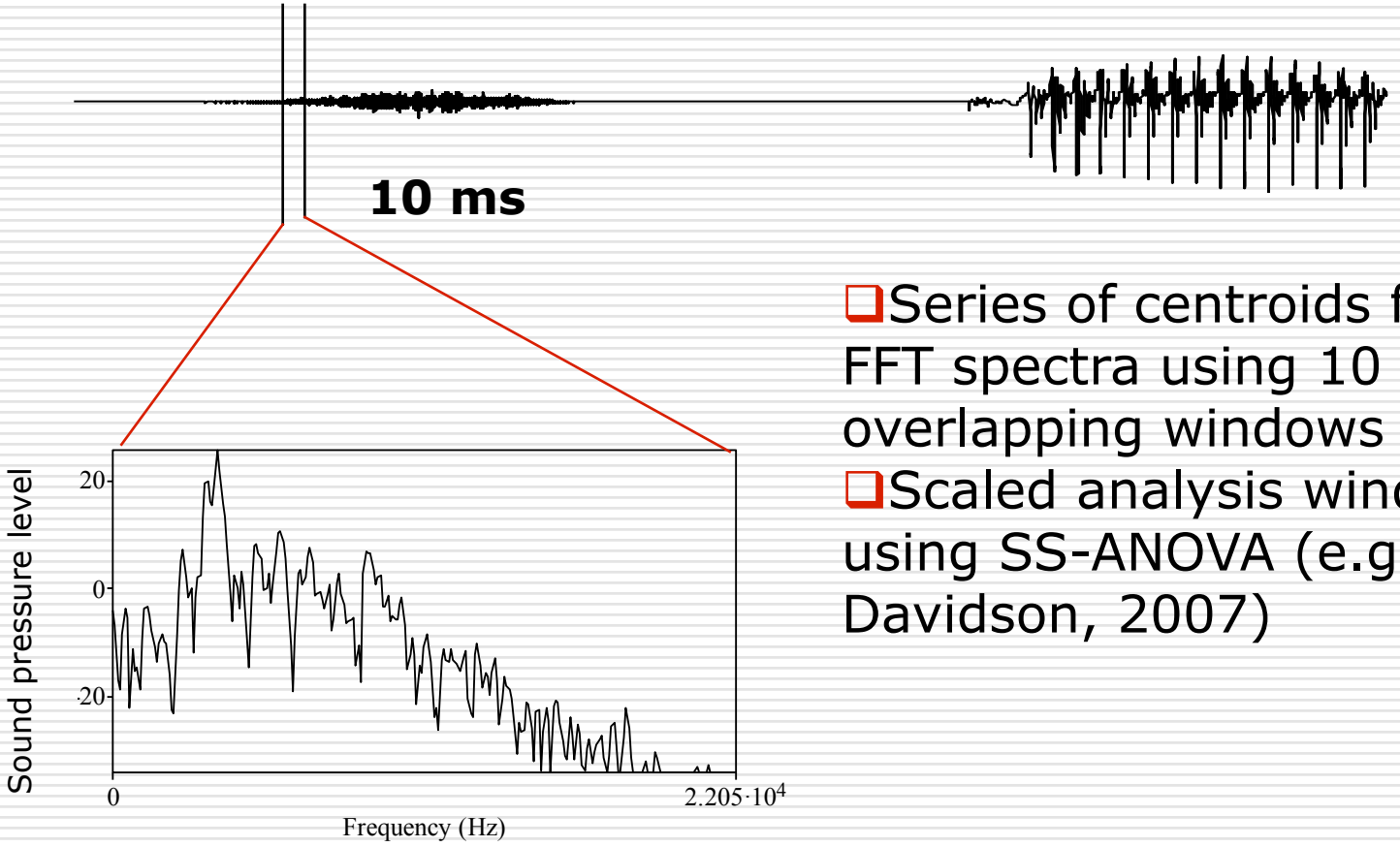
Method: Procedure

- A picture and an audio prompt were presented simultaneously
- Participants were instructed to repeat the word as they heard it
- Productions were digitally recorded

Method

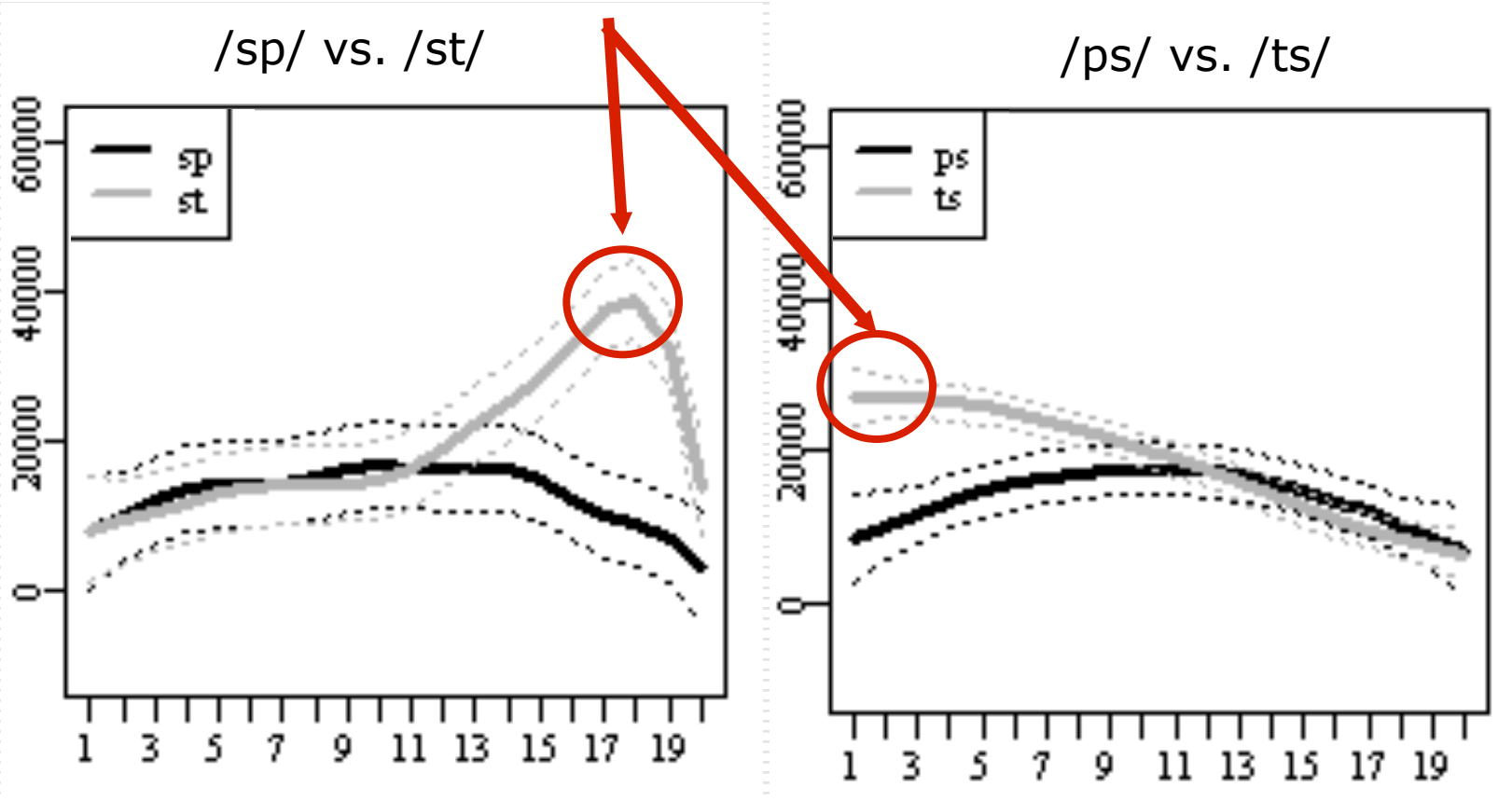
- Transcription analysis
  - Native-speaker transcription using Praat waveform editor
  - Initial consonant sequence was labeled
    - Correct
    - Incorrect
  - If incorrect, phonetic transcription of perceived error
  - Only correct productions analyzed in current study

Method: Acoustic analysis

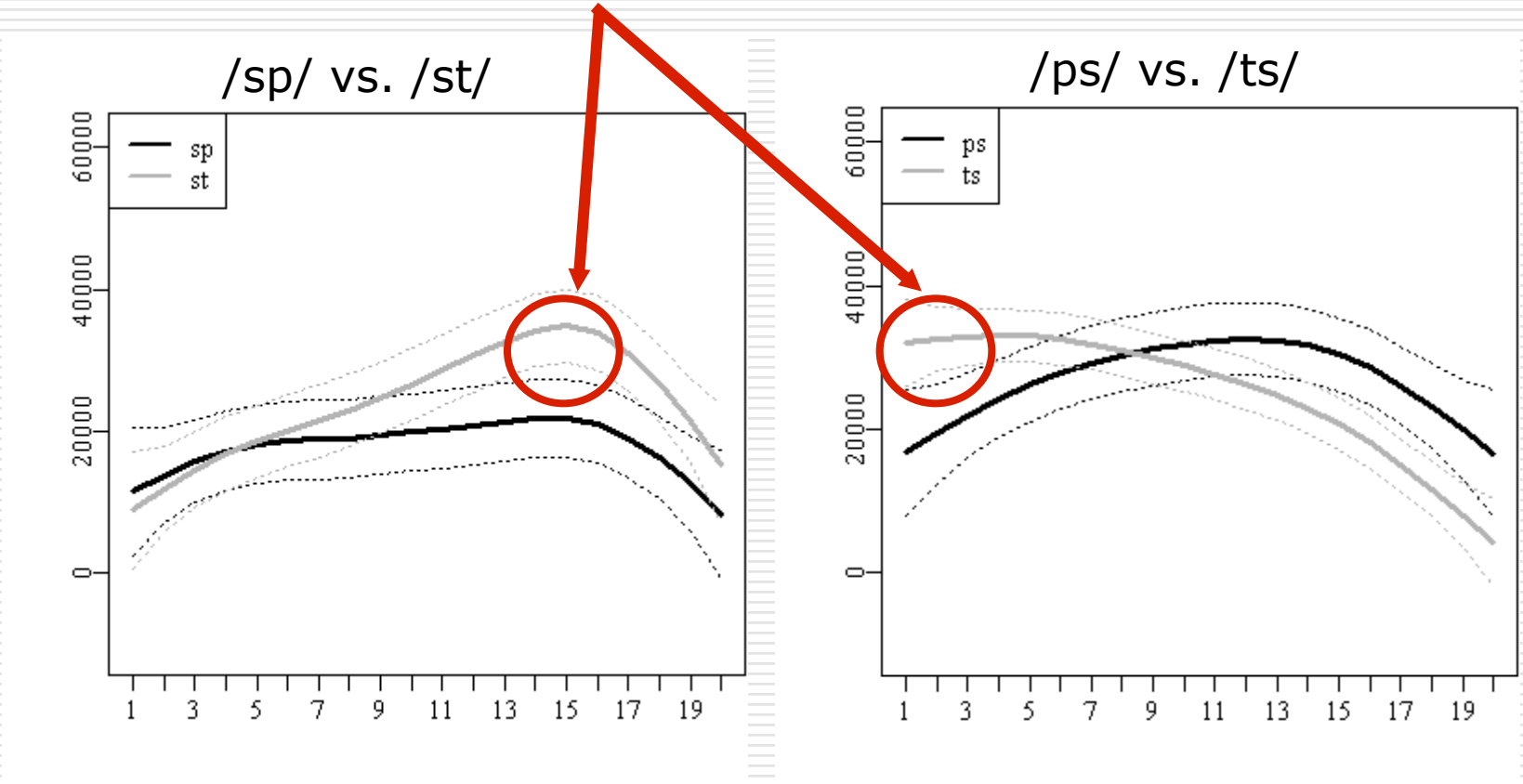


- Series of centroids from FFT spectra using 10 ms overlapping windows
- Scaled analysis windows using SS-ANOVA (e.g., Davidson, 2007)

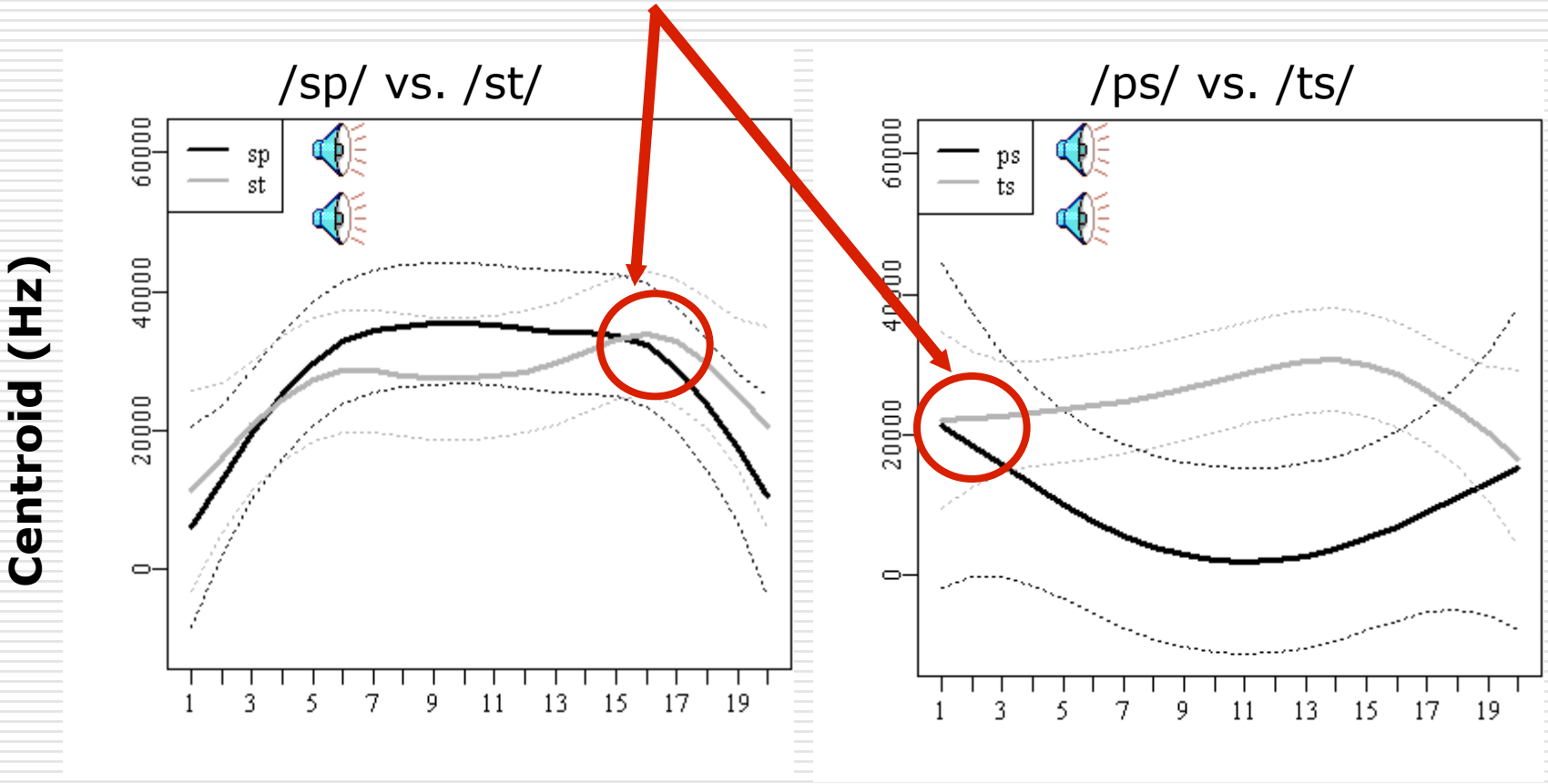
Results: Adults



Results: 5-year-olds

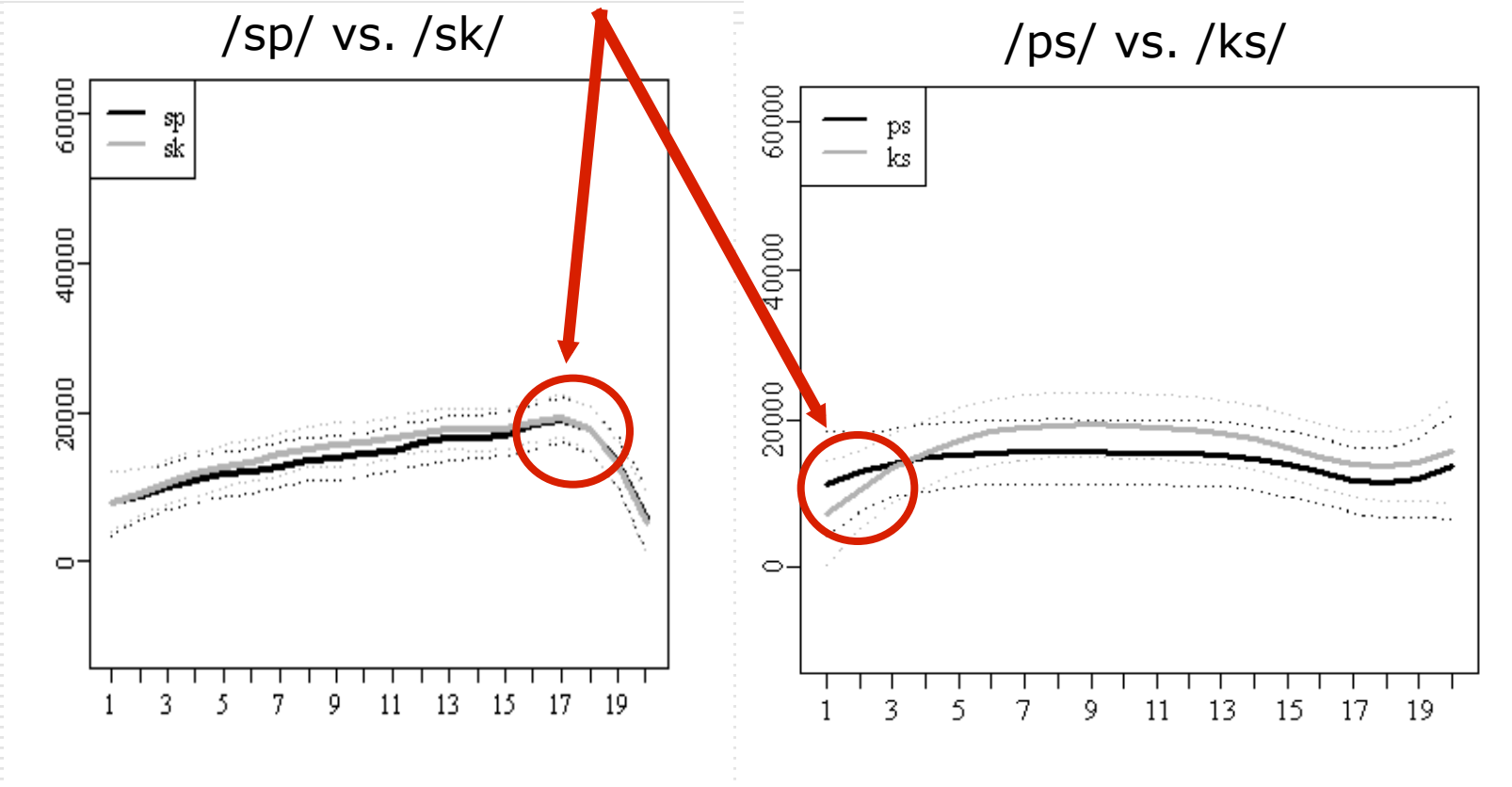


Results: 3-year-olds



Scaled frames of analysis windows

Results: Adults



Scaled frames of analysis windows

Results: Summary

- There was a significant effect of place:
  - Lower centroids for bilabials as opposed to dentals
  - Centroids for /sp/ and /st/ differed at the end of the trajectory.
  - Centroids for /ps/ and /ts/ differed at the beginning of the trajectory.
- Developmental patterns:
  - 4-and 5-year-olds showed adult-like coarticulation
  - Younger children did not.

Future directions

- Examine children's coarticulation in incorrect productions of clusters.
- Examine whether stop-/s/ and /s/-stop sequences differ in perceptual salience.
- Use a different analysis to describe coarticulation in clusters involving velars.

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