Covert contrast in the acquisition of stop-/s/ sequences in Greek

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INTRODUCTION

- Children do not always progress abruptly from incorrect, neutralized productions to readily perceivable and transcribable phonological categories.
- Children may go through a stage of 'covert' contrast.
- ***Covert contrast***: A subphonemic difference between two sounds that is not perceptible to adults (e.g., *Macken & Barton*, 1980).
- Covert contrast for stops and fricatives has been reported in the literature, but there is little work on affricates and consonant clusters.
- Furthermore, there is limited work on covert contrast for languages other than English.

PURPOSE OF THE STUDY

- To look for covert contrast in word-initial stop-/s/ clusters and the affricate /ts/, both of which are late-acquired in Greek (*Panhellenic Association of Logopaedics*, 1995).

METHODOLOGY

[Participants]

- 19 monolingual Greek-speaking children (six 2-year-olds, seven 3-year-olds, three 4-year-olds, and three 5-year-olds).
- Typically-developing.
- Selected from a larger sample of 60 2-to-5-year-olds.
- Selected because they produced correct /s/ in singleton targets, but reduced stop-/s/ clusters and the affricate /ts/ to [s].
- Cluster reduction to [s] in stop-/s/ sequences was a common error pattern (*Syrika et al.*, 2007).
- 15 young native Greek-speaking adults from the same dialect region were also recorded in the same task.

[Task and Procedure]

- Word-repetition task.
- A picture and a digitized recording of the stimulus were presented simultaneously.
- The children were instructed to repeat the word that they heard.
- Children's repetitions were digitally recorded.

[Stimuli]

- 2-or 3-syllable real words with word-initial /s/, /ps/, /ts/, and /ks/ before each of the vowels /a/, /e/, /i/, /o/.
- All words were stressed on the first syllable.

[Analyses]

- Children's productions were transcribed by a Greek native speaker/phonetician (the first author) using the Praat waveform editor (*Boersma & Weenik, 2001*).
- For the productions of the 19 children analyzed, we paired productions of [s] in cluster reductions to correct /s/ targets in the same vocalic context.
- For example, [sa] in target /psaɾi/ (fish) was paired with the same child's correct production of /sa/ in target /savɾa/ (lizard).
- We examined the duration of the fricative [s] for both cluster reductions and correct productions of singleton /s/.
- We performed a spectral moments analysis to compare the fricative internal dynamics of productions of reduced [s] in stop-/s/ sequences to productions of correct singleton /s/.
- We measured spectral amplitude to compare the degree of sibilance of the fricative at different points in time.
- We applied the same analyses to the correct productions of singleton /s/ and stop-/s/ sequences produced by adults.

[Measurement Criteria]

Duration Analysis

- **Burst** (beginning of frication): the release of the stop closure.
- **Fricative end**: the first vocal pulse following a clearly periodic downswing of a wave cycle.
- For singleton /s/ and reduced [s], **fricative onset**: the onset of aperiodic high-frequency noise characteristic of voiceless fricatives.

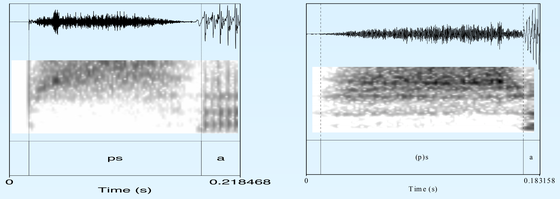

Figure 1: Alignment of fricative noise in a correct /ps/ cluster produced by an adult (left), and in a [s] for/ps/ substitution produced by a child (right).

Spectral Moments Analysis

- We calculated a series of seven spectra, over 10-ms windows starting at the stop burst or the beginning of the fricative, and space evenly over the duration up to the end of the fricative.
- We calculated mean frequency (centroid) for each spectrum.

Amplitude Analysis

- We calculated the peak amplitude in the spectrum (relative to minimum amplitude).

RESULTS: DURATION ANALYSIS ADULTS (For correct productions of singleton /s/ and stop-/s/ sequences)

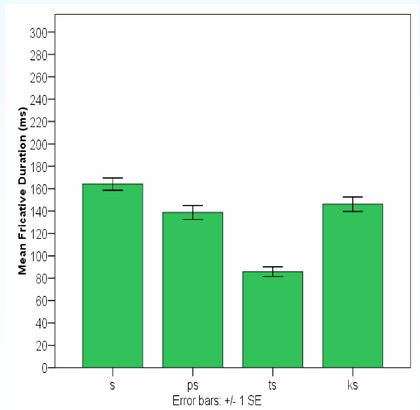

Figure 2: Average fricative duration (in ms) in correct productions of adults

- There is a significant effect of syllable structure on fricative duration.
- Fricative duration in singleton /s/ is longer than in /ps/-/ts/-/ks/.
- Fricative duration in /ps/ is similar to that in /ks/.
- Fricative duration in /ts/ is considerably shorter from that in /ps/ and /ks/.

RESULTS: DURATION ANALYSIS CHILDREN (For correct singleton /s/ and reduced [s] for stop-/s/ sequences)

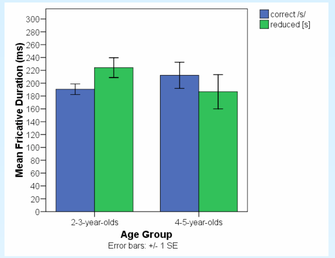

Figure 3: Average fricative duration (in ms) of correct /s/ and reduced [s] in 2-3 and 4-5 year-olds.

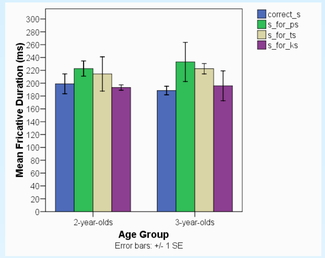

Figure4: Average fricative duration (in ms) of correct /s/ and reduced [s] by underlying place of articulation in 2 and 3-year-olds.

- There is a significant interaction between underlying syllable structure and age group for reduced [s] duration.
- Reduced [s] for underlying clusters is longer than correct singleton /s/ in 2-and 3-year-olds, but tends to be shorter in 4-and 5-year-olds.
- Reduced [s] is more variable than correct singleton /s/.
- Underlying place of articulation of the 'deleted' stop does not have a consistent effect on the duration of reduced [s].

RESULTS: SPECTRAL MEAN FREQUENCY (CENTROID) FEMALE ADULTS (LEFT) AND CHILDREN (RIGHT)

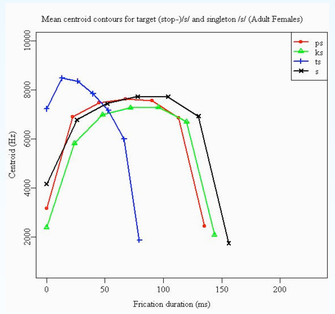

Figure 5: Mean centroid (M1) contours averaged across female adults

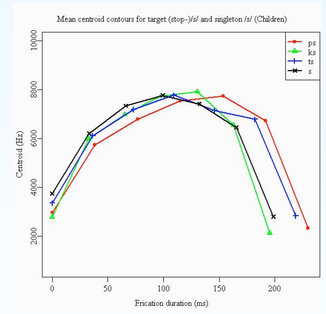

Figure 6: Mean centroid (M1) contours averaged across children

- **Adults:**
  - Target /ps/ and /ks/ have a lower centroid at fricative onset and target /ts/ has the highest centroid.
  - The affricate /ts/ has a clearly distinct pattern as compared to both singleton /s/ and stop-/s/ sequences /ps/ and /ks/.
- **Children:**
  - Reduced [s] for underlying stop-/s/ sequences shows a different pattern from the adults' correct productions in both the contour shape and fricative durations, especially for the affricate /ts/.
  - The centroid of underlying stop-/s/ sequences, and especially of /ps/and /ks/, is significantly lower from that of singleton /s/ (/ps/ vs. /s/: t(78)=1.8094, p=0.074; /ks/ vs. /s/: t(83)=2.2922, p=0.024).
  - This difference is primarily observed at fricative onset.
  - The lower centroid values suggest that target /ps/ and /ks/ are articulated at a more posterior constriction place as compared to target /s/ and /ts/.

RESULTS: SPECTRAL AMPLITUDE FEMALE ADULTS (LEFT) AND CHILDREN (RIGHT)

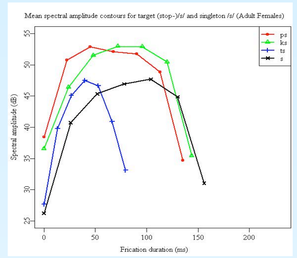

Figure 7: Spectral amplitude contours averaged across female adults

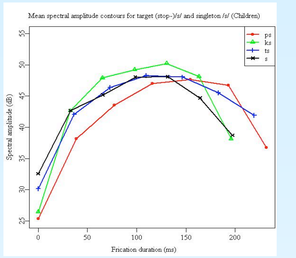

Figure 8: Spectral amplitude contours averaged across children

- **Adults:**
  - Target /ps/ and /ks/ have a higher spectral amplitude both at onset of frication and overall compared to that of singleton /s/ and /ts/.
  - The affricate /ts/ has a clearly distinct contour shape as compared to both singleton /s/ and stop-/s/ sequences /ps/ and /ks/, including a longer rise time and a shorter fricative duration.
- **Children:**
  - The spectral amplitude for target /ps/ and /ks/ is significantly lower as compared to that of target /s/ during the onset of frication (/ps/ vs. /s/: t(78)=3.5676, p<0.001; /ks/ vs. /s/: t(78)=4.1247, p<0.001).
  - This suggests that children are attempting to produce an initial stop before the fricative in an underlying stop-/s/ cluster, by making a less narrow constriction at onset, as compared to their productions of target singleton /s/.
  - A different pattern is observed for children as compared to the adults'.

CONCLUSION AND DISCUSSION

- Covert contrast was observed for Greek-speaking children who were perceived to neutralize stop-/s/ sequences to [s], suggesting the need to supplement transcription with acoustic analysis to better describe children's phonological knowledge.
- Future research will focus on a finer-grained analysis of the acoustic data, including an examination of individual subject data, as well as the perception of reduced stop-[s] sequences and singleton /s/ by Greek adult naïve listeners.

ACKNOWLEDGMENTS

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