

# Articulatory and acoustic changes in pre-adolescent and adolescent childrens' production of /s/ and /ʃ/: A case study in Hungarian



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## Introduction

- Fricatives are among the latest acquired speech sounds [e.g. 1, 2, 3] ⇨ the constriction needs precise articulatory maneuvers [4, 5].
- The acoustic contrast of /s/ and /ʃ/ was different of the adults' samples even in 7 year-olds [6]
- Similar acoustic contrast but larger variability in 14 years-olds than in adults [7]
- Similar acoustic and articulatory contrast of /s/ and /ʃ/ in 10-12 years-olds than in adults BUT: larger variability in CoG of /ʃ/ in the second half of its duration [8]
- Larger coarticulatory resistance in /s/ [9], but lower in /ʃ/ [10] in 6;3-9;9 years-olds, than in adults.
- Present study: longitudinal (2 years, 4 times) study of two children. Hypotheses: (i) The contrast is present already in the first recordings (7;5 and 11;0 years), but not in all measures. (ii) The contrast appears in more features in the last recordings.

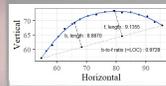
## Participants, material, methods

- One girl: 7;5, 7;11, 8;5,8, one boy:11;0, 11;6, 12;0, 12;5, adult control: 43 ys ⇨ No speech or hearing deficit, typical development, monolingual Hungarian subjects
- 81 V<sub>1</sub>C<sub>1</sub>V<sub>1</sub>C<sub>1</sub>V<sub>1</sub> nonsense words, read aloud twice in random order
- Ultrasound recording of midsagittal tongue contour (Articulate Instruments Ltd.) & Beyerdynamic TG H56 omnidirectional microphone on the headset + 16 bit, 44.1 kHz sampling



Present analysis: V = /v a: e i u /, C = /s ʃ/

- labeling: automatic [11] & manual correction in Praat [12]
- Measurements on 3 points: at the time point of the closest ultrasound images to 0%, 50%, 100% of the C & in total duration
- Analyzed features:
  - LOC<sub>2-1</sub> [13]: ratio of b and f lines (n: distance between the start & end point of the tongue curve; b, f: distance between the 1/3 and 2/3 of n and the tongue curve)
  - CoG, SD, skewness, kurtosis ⇨ start, mid, end point



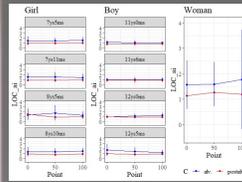
## Statistics

- R [14]: ANOVA (aov) & MANOVA separated for speakers
- Factors: C, age – for children, point – where applicable
- Dependent: CoG, SD, skewness, kurtosis (in both ANOVA & MANOVA), LOC<sub>2-1</sub> (only ANOVA)
- Separated for speakers; dependent variables: LOC, CoG, SD, skewness, kurtosis; factors: (i) woman: C & measurement point (in the case of the point measurements), (ii) children: C & age & measurement point (in the case of the point measurements)

## References

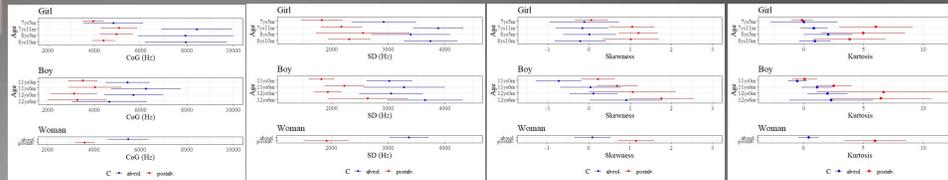
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## Results



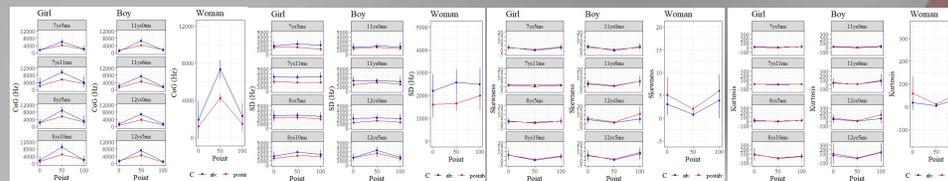
LOC<sub>2-1</sub>:

- Although the boy is older, the contrast of the 2 Cs are less clear until the 4<sup>th</sup> recording in his speech, while in the girl's it is apparent already in the 1<sup>st</sup>. The speech organs grow continuously but not linearly and not following the same curve. Therefore the articulation to achieve the same target may cause changes during speech acquisition that are not linear with age.
- Larger variability in the adult's speech might appear due to coarticulatory effects that were found to be different in children's and adults' speech samples [9,10].



### Spectral moments measured in the total duration:

- In the adult woman's pronunciation the contrast of /s/ and /ʃ/ was apparent in all 4 spectral moments.
- In the girl's pronunciation the contrast of /s/ and /ʃ/ varied across the age in all spectral moments measured in the total duration: it was not apparent in the first recording, but it was from the second.
- In the boy's pronunciation the contrast of /s/ and /ʃ/ appeared in CoG, SD and skewness in all four recording sessions, while in kurtosis only from the third recording session. The values changed across the four recording sessions.
- In some measures the contrast is apparent in the first recording, but is not in latter ones.



### Spectral moments measured at three measurement points:

- In the adult woman's pronunciation the contrast of /s/ and /ʃ/ was apparent in all 4 spectral moments. The presence of the contrast in the CoG varied across the measurement points: it appeared in the midpoint measurements.
- In the girl's pronunciation the contrast of /s/ and /ʃ/ appeared in CoG in all recording sessions, while it also changed across age and the measurement points. The contrast in SD and kurtosis appeared only in the latter recordings. The contrast in skewness did not appear in the four recording sessions.
- In the boy's pronunciation the contrast of /s/ and /ʃ/ appeared in CoG, SD and in skewness, however, not in the kurtosis. The values of SD, skewness and kurtosis changed across the age.

## Conclusions

- The contrast of /s/ and /ʃ/ was apparent in both children's pronunciation already in their first recordings, however, not in all measures. Skewness and kurtosis seem to follow the adult's sample later.
- The contrast in the children's speech tended to get more similar to the adult's during the interval of the two years. The boy's contrast became more like the adult's, which is due to his older age, that meant more stable motor control. (as both children are typical developing children.)
- Some contrast did appear in the first recording, but did not in latter ones. The growth curve of the speech organs are different [15], therefore their ratios, angles to each other may change between two consecutive recording sessions. Therefore the children might need to adapt their articulation from time to time to these circumstances. Also the growth curves do not follow the same tendencies in the two genders [16]. Therefore in some measures the boy may have less clear contrast though his older age.
- The variability of the measures was typically larger in the children's speech, which is due to the continuous change of the speech organs and the not yet adult like motor control.
- The skewness and the kurtosis is less similar to the adult samples in the children's /s/ and /ʃ/ realizations.

	LOC <sub>2-1</sub>	factor	ANOVA
Woman	C	F(1, 92) = 4.956, p = 0.028	
Girl	C	F(1, 364) = 51.051, p < 0.001	
Boy	C*age	F(3, 354) = 3.416, p = 0.018	

	Total duration		
	factor	ANOVA	
CoG	woman	C	F(1, 30) = 61.320, p < 0.001
	girl	C*age	F(3, 120) = 7.710, p < 0.001
	boy	C	F(1, 121) = 92.256, p < 0.001
SD	woman	C	F(1, 30) = 5.309, p = 0.002
	girl	C*age	F(3, 120) = 130.900, p < 0.001
	boy	C	F(1, 121) = 146.635, p < 0.001
skewness	woman	C	F(3, 121) = 13.014, p < 0.001
	girl	C*age	F(3, 120) = 5.727, p = 0.001
	boy	C	F(1, 121) = 46.392, p < 0.001
kurtosis	woman	C	F(3, 121) = 28.010, p < 0.001
	girl	C*age	F(3, 120) = 6.750, p < 0.001
	boy	C*age	F(3, 121) = 3.824, p = 0.012

	0%, 50%, 100% duration points		
	factor	ANOVA	
CoG	woman	C*point	F(2, 90) = 9.880, p < 0.001
	girl	C	F(1, 367) = 25.652, p < 0.001
	age	F(3, 367) = 8.312, p < 0.001	
SD	point	F(2, 367) = 4.187, p = 0.041	
	boy	C	F(1, 370) = 22.703, p < 0.001
	woman	C	F(1, 90) = 31.073, p < 0.001
skewness	girl	C*age	F(3, 367) = 4.370, p = 0.005
	boy	C	F(1, 370) = 44.780, p < 0.001
	woman	C	F(1, 370) = 8.076, p < 0.001
kurtosis	point	F(2, 90) = 13.293, p < 0.001	
	girl	age	F(3, 367) = 13.628, p < 0.001
	boy	C	F(1, 370) = 4.219, p = 0.041
kurtosis	age	F(3, 370) = 9.967, p < 0.001	
	point	F(2, 370) = 12.938, p < 0.001	
	woman	C	F(1, 90) = 4.051, p = 0.047
kurtosis	point	F(2, 90) = 4.500, p = 0.014	
	girl	C*age	F(3, 367) = 4.828, p = 0.003
	boy	age	F(3, 370) = 7.091, p < 0.001
point	F(2, 370) = 8.175, p = 0.004		