New developments in the Polish sibilant system?!

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1. Introduction

Sibilant system of contemporary Standard Polish

dental/alveolar	retroflex	palato-alveolar
s z	ʂ ʐ	ɕ ʑ
t͡s d͡z	t͡ʂ d͡ʐ	t͡ɕ d͡ʑ

GOAL of the paper:
to report on a new development in sibilants observed in the pronunciation of young Polish women who instead of the alveolo-palatal /ɕ/ and /t͡ɕ/ produce their more fronted version, probably palatalized [sʲ] and [t͡sʲ].

2. Acoustic experiment

2.0 Hypothesis:

The Standard Polish alveolo-palatal /ɕ t͡ɕ / and their new variants [sʲ t͡sʲ] are pronounced differently by young women from central Poland.

2.1 Experimental design

2.2. Material: /ɕ t͡ɕ/ appearing in bisyllabic words stressed on the first syllable

Position: word-initial: __/a/ word-medial: /a/__ /a/

Examples: /ɕaka/ 'another' /kaɕa/ 'Kasia'

the words were put into:

frame sentence: *Powiedziała ... do ciebie* 'She said ... to you' — 5 repetitions of each sentence

a text passage in a non-focus position *13 sentences* — 3 repetitions of the text

Informants:

- 9 native speakers of Standard Polish from central Poland (Mazovia), women aged 19-23.
- incl. 6 speakers with the new development and 3 speakers with standard pronunciation (control group).

2.3 Acoustic analysis

- sampling rate = 44.1 kHz, spectra from 10Hz to 11kHz
- further analysis with PRAAT and Matlab
- at the midpoint of the phoneme we computed Multitaper spectra, allowing for higher spectral precision during short durations (see Blacklock 2004 , Lousdada, Jesus & Pape 2012 for more details).

2.3.1 Parameters

Using Multitaper spectra, the following acoustic parameters have been investigated at the midpoint of the frication:

- the highest spectral peak of the complete spectrum (p_{all}),
- the highest peak in the frequency range from 3-6kHz (p3-6kHz),
- the spectral moments according to the Praat formula (v. 5.2): Centre of gravity (COG), Standard Deviation of the spectrum (STD), Skewness, and Kurtosis ,
- the spectral moments M1, M2, M3, M4 according to Forrest et al. (1988),
- the spectral slopes m1 and m2 (Jesus & Shadle 2002).

2.3.2 Statistical analyses

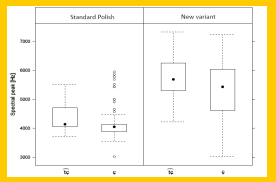
- conducted in R environment (R Development Core Team 2010).
- Linear mixed effects models for the dependent variables:

the highest spectral peak, the highest spectral peak in 3-6kHz, COG, STD, Skewness, Kurtosis, M1, M2, M3, M4, spectral slopes m1 and m2

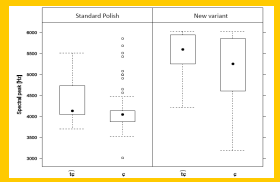
studied as an effect of SOUND (Standard Polish, new variant), SPEECH STYLE (Word, Text), POSITION (word-initial, word-medial). SUBJECT and ITEM were taken as random effects.

The lme models were run for /ɕ/ and /t͡ɕ/ separately. Only significant effects are presented below.

2.3.3 Results

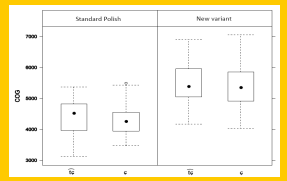


New variant vs. SP /ɕ/: t=3.498, pMCMC = 0.002
New variant vs. SP /t͡ɕ/: t=5.320, pMCMC = 0.0001



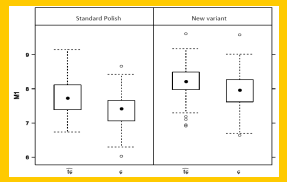
New variant vs. SP /ɕ/: t=3.637, pMCMC = 0.0003
New variant vs. SP /t͡ɕ/: t= 4.827, pMCMC = 0.0002

Fig.1: The highest spectral peak (left) and the highest spectral peak from 3-6 kHz (right).

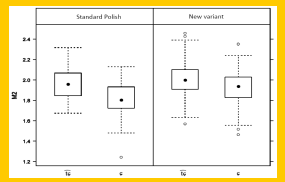


New variant vs. SP /ɕ/: t= 3.319, pMCMC = 0.0002
New variant vs. SP /t͡ɕ/: t= 2.222, pMCMC = 0.0154
STD, Skewness, Kurtosis = insignificant

Fig.2: Centre of gravity (COG)

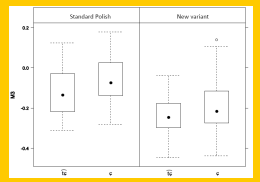


New variant vs. SP /ɕ/: t= 3.26, pMCMC = 0.003
Position /ɕ/: word-medial vs. -initial: t= 3.29, pMCMC=0.02
New variant vs. SP /t͡ɕ/: t=2.31 , pMCMC = 0.0238

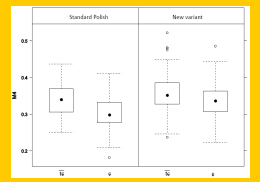


New variant vs. SP /ɕ/: t= 3.58, pMCMC = 0.0026

Fig. 3: M1 (left) and M2 (right) according to Forrest et al. (1988).



New variant vs. SP /ɕ/: t= -2.506, pMCMC = 0.0006;
Position /ɕ /: word-medial vs. word-initial: t= -3.000, pMCMC= 0.0366;
New variant vs. SP /t͡ɕ/: t= -2.222, pMCMC = 0.0066



New variant vs. SP /ɕ/: t=3.507, pMCMC = 0.0036

Fig. 4. Spectral moments M3 (left) and M4 (right) according to Forrest et al. (1988)

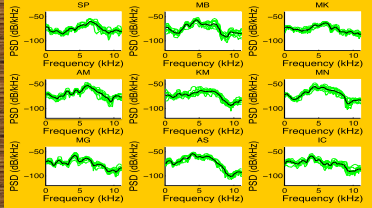
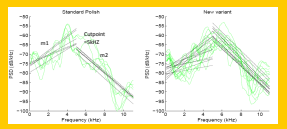


Fig. 5: All Multitaper spectra for /ɕ/ (green) and overlaid mean spectra (black) for each speaker.
The last row represents the control group.



m2: New variant vs. SP /ɕ/: t=-3.499, pMCMC = 0.0016
m2: New variant vs. SP /t͡ɕ/: t= -4.022, pMCMC = 0.0018

Fig. 6: Mean Multitaper spectra for /ɕ/ for each speaker (green) and spectral slopes m1 and m2 (black).

3. How can we explain the change?

→ Padgett &Żygis (2003), Żygis & Padgett (2010):

non-optimal contrast s ɕ ʃ Input (Old Polish)
optimal contrast s ɕ ʂ Output (Standard Polish)
new sound s ʂʲ ʂ Output

Żygis & Padgett (2010)

4. Summary

- The Standard Polish alveolo-palatal /ɕ t͡ɕ/ undergo a change: they are pronounced differently (with higher tonality) by young female students from central Poland.
- Several acoustic parameters, i.e., the highest peak in the spectrum, the highest peak in the range 3-6kHz, COG, M1, M2, M3, M4, are significantly different for /ɕ t͡ɕ/ when produced by the female students and the control group.
- Additional perceptual study is needed in order to see if the change can be explained in perceptual terms.

Acknowledgments

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References:

Forrest, K., Weismer, G., Milenkovic, P. & R. N. Dougall (1988) Statistical analysis of word-initial voiceless obstruents: Preliminary data. *Journal of the Acoustical Society of America* 84(1), 115-123.

Jesus, L. M. T. & C. H. Shadle (2002). A parametric study of the spectral characteristics of European Portuguese fricatives. Labov, W. (2001). *Principles of Linguistic Change: Social factors* (Vol. 2). Oxford: Blackwell

Thomson, D. (2000). Multitaper analysis of nonstationary and nonlinear time series data. In: Fitzgerald, W., Smith, R., Walden A. & P. Young (eds). *Nonlinear and Nonstationary Signal Processing*. Cambridge: Cambridge University Press. 317-394.

Żygis , M. & J. Padgett (2010). A perceptual study of Polish sibilants, and its implications for historical sound change. *Journal of Phonetics* 38.2, 207-226.