background

the present study

Fortis stops in Polish: Evidence from acoustic measures of voice quality

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1 Phonetics vs. phonology in 2-series laryngeal contrasts

Competing phonological accounts of two-series systems

- Binary [voice] feature from SPE tradition
- More recent unary accounts arising from VOT typology
  - Unary [voice] vs. Ø: pre-voicing vs. short-lag stops
  - Unary [spread] vs. Ø: short vs. long-lag stops
- Use of VOT and unary approach has gained widespread acceptance
  - Phonetically transparent – laryngeal 'realism'
  - Arguments from voicing typology: short-lag is common and unmarked
  - Arguments from assimilation: regressive voicing requires active [voice]
- BUT: there is more to laryngeal contrasts than VOT, and additional cues may undermine the assumptions of the unary approach
  - Kirby & Ladd (2016): In French and Italian, voiceless consonants raise f_o but voiced consonants do not lower it
    - f_o effect (C f_o) suggests active [-voice], or [fortis], in voicing languages

2 Voicing in Polish

- Polish is commonly described as a voicing language
- Short-lag VOT contrasts with pre-voicing
- BUT:
  - short-lag VOT in Polish is longer than short-lag /b d g/ in aspiration languages (Keating 1979)
  - f_o effect similar to that in French and Italian (Schwartz et al. 2019)
  - F1 onset effect also suggestive of active [-voice] (Schwartz et al. 2019)
  - Phonological evidence for active [-voice] in progressive devoicing process (Rubach 1996)
- Active [-voice] or [fortis] in Polish challenges assumptions of laryngeal 'realism'
- Additional cues to the Polish laryngeal contrast are still in need of documentation . . .

3 Phonation as cue to voicing

- Research on English has suggested that voice quality may constitute as additional cue to laryngeal contrasts
  - Glottal reinforcement or replacement of voiceless stops in English realized as creaky phonation (many references)
  - Fortis-induced creak acoustically distinct from phrase-final creak (Garellek 2015)
  - Breathiness contributes to percept of longer vowels before voiced as opposed to voiceless consonants (Sanker 2019, 2021)
    - i.e. phonation cues voice contrast in codas

4 Motivating the present study

- If [fortis] is active in Polish, and phonation may serve as an additional cue to fortisness, then the voice quality of vowels may be affected by the underlying voicing of Polish obstruents

- Since Polish has word-final laryngeal neutralization (complete or incomplete), we focus on the effects of onset voicing on the phonation of following vowels

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1 The present study – introduction

Do acoustic measures of voice quality constitute an additional correlate of the Polish voice contrast?

For example, will the vowel in *pas* 'belt' show stiffer phonation than the vowel in *bas* 'bass' ?

2 Methods

Speakers: 15 monolingual Polish speakers (Females, aged 17-38)

Materials: 48 item word list (plus fillers) with word-initial voiced and voiceless stops (24 each); counterbalanced for POA (16 labial, 16 coronal, 16 dorsal); stops followed by non-high vowel

Procedure: recorded directly onto laptop via Shure head-mounted mic and Tascam USB audio interface; speakers read items in isolation, elicited using PowerPoint slides (1 item per slide)

Analysis: manual annotation in Praat, stats in R

- 'Traditional' measures of voicing extracted with Praat scripts
  - VOT, f_o at vowel onset (Cf_o), F1 at vowel onset
- Acoustic measures of spectral tilt extracted using VoiceSauce:
  - H1*-H2*, H2*-H4*, H4*-H2khz*, H2khz*-H5khz
  - Spectral tilt measures quantify differences within modal-voice, which we hypothesize for Polish
  - Measures like HNR/CPP more useful for modal vs. non-modal phonation differences (Garellek 2019)
- Mann-Whitney U-test for spectral tilt values

3 Results

Traditional cues

Series	VOT (ms)	Std Dev
voiceless	41.70ms	16
voiced	-92.05ms	26

Parameter	Onset	Average
F1- f_o	voiceless	4.9 Bark
	voiced	4.4 Bark
f_o	voiceless	195 Hz
	voiced	186.6 Hz

Spectral tilt measures – larger values expected after voiceless stops

- Expected differences in two measures, opposite effect for other two

Measure	Voiceless	Voiced
H1*-H2*	6.22 (9.93)	5.98 (10.6)
H2*-H4*	**3.14 (15.1)**	**5.68 (16.8)**
H4*–H2kHz*	**9.60 (15.4)**	**10.8 (12.5)**
H2kHz*–H5kHz	19.8 (23.8)	15.8 (20.4)

4 Discussion

Our mixed results raise questions about which measures of voice quality are appropriate for describing which aspects of which languages

Our hypothesis is that Polish voiceless stops are "Fortis", and might induce stiffer voice quality that is perceptually more salient

- Possible connection with word stress, quantified as amplitude difference between spectral bands (Sluijter & van Heuven 1996; Plag et al 2011)
- Below: pass-band filtered *bas-pas* (0-1khz; 1-5khz bands), including intensity contours
  - Perceptually sensitive 1-5khz band stronger after voiceless consonants; cf. our result for H4*-H2kHz*