

Remarks on the Duration of Lithuanian Consonants in a Continuous Speech

Sigita DEREŠKEVIČIŪTĖ, Asta KAZLAUSKIENĖ

Vytautas Magnus University, Kaunas

The aim of the research

- to investigate the quantity of consonants in a corpus of continuous speech of Standard Lithuanian,
- to qualify spontaneous duration of the analyzed sounds considering qualitative (articulatory) features and ignoring other factors like:
 - the length of the segment
 - the sound's position in a word or
 - adjacent sounds.

The data

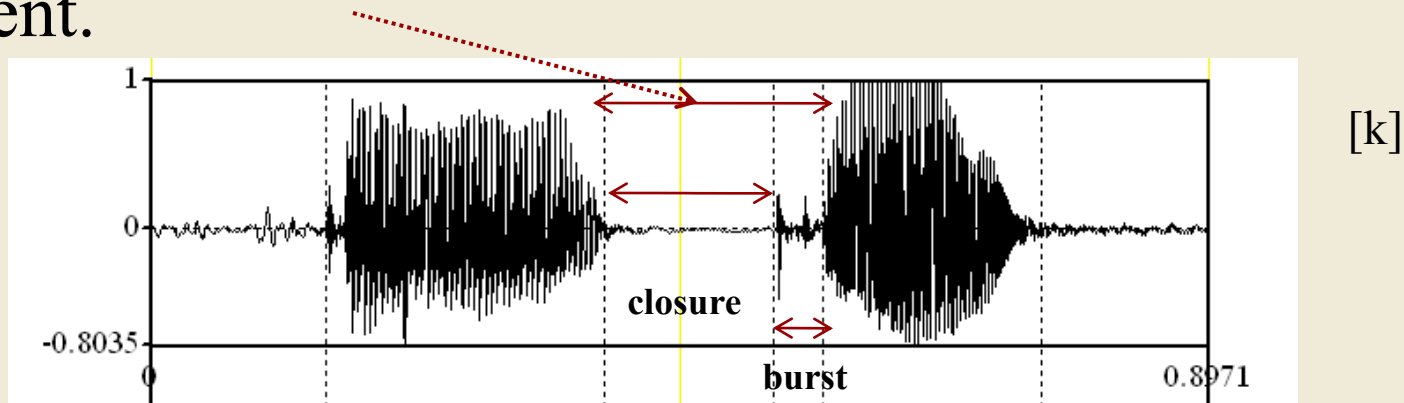
- A fragment from V. Mykolaitis-Putinas' novel "Altorių šešėly" read by an actor V. Širka (almost 1 h and 40 min. of records with approx. 60.000 sounds);
- Analyzed:
 - More than 14.000 of **sonorant** consonants;
 - Approximately 11.000 of **plosive** consonants;
 - Approximately 6.000 of **fricative** consonants.

The method

- Automatic annotation of sound records with the HTK speech recognition toolkit;
- Subsequently phone boundaries were manually corrected with the acoustic analysis program Praat;
- Results were processed statistically (duration was measured in seconds (s), mean, standard deviation, confidence interval (95 %)).

The method (2)

- Sonorant and fricative consonants were analyzed in all word positions;
- Plosive consonants, appearing in an initial word positions, were ignored. Closure and burst considered as a single segment.



- Affricates are not covered by this paper.

Results

Articulatory features:

- place of articulation;
- manner of articulation;
- voicing;
- palatalization.

The place of articulation and VOT patterns

PLOSIVES: VOT duration varies with place of articulation (Cho & Ladefoged)

VOT depends on a number of factors:

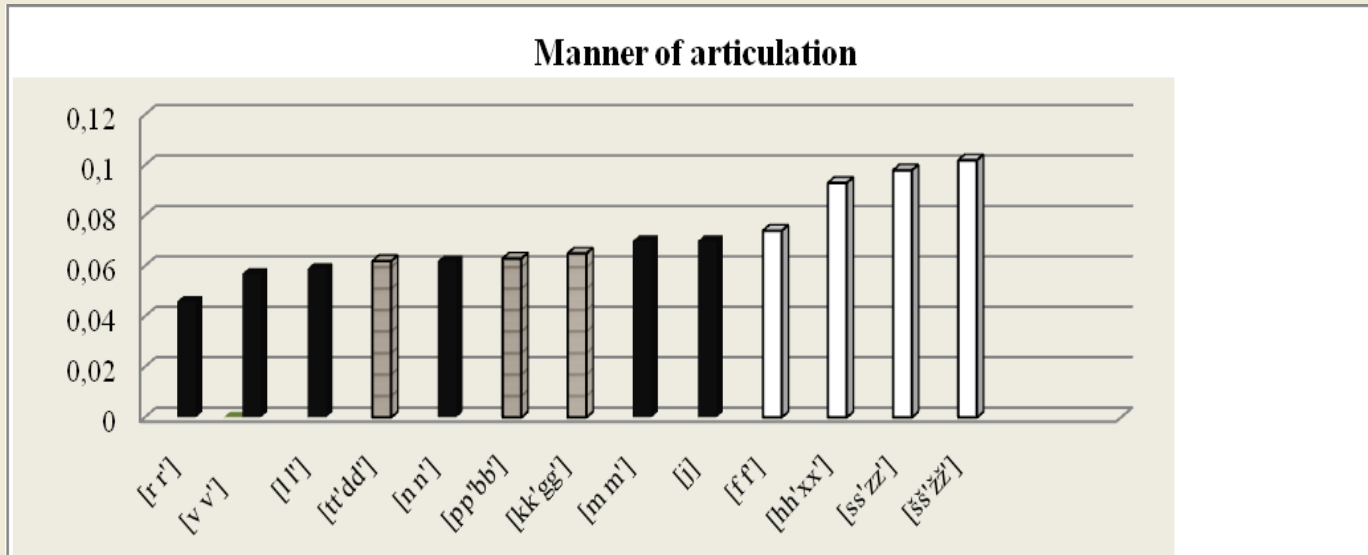
- laws of aerodynamics (Hardcastle, 1973; Maddieson, 1997; van den Berg, 1958);
- articulatory movement velocity (Kuehn & Moll, 1976; Hardcastle 1973; Maddieson 1997);
- differences in the mass of the articulators (Ladefoged & Maddieson, 1996; Stevens 1999);

RESULTS: *The place of articulation*

- Duration results of Lithuanian plosives correspond to the tendency to pronounce longer the sounds that are uttered in the back part of the cavity to pronounce longer.
- This also applies to fricatives ($[ff'] \rightarrow [ss'] \rightarrow [šš']$) and sonorants ($[rr'] \rightarrow [vv'] \rightarrow [ll'nn']$)
- Bilabial and dental / alveolar consonants (front part of the mouth) ? (*the velocity of the tongue and the mass and movements of the articulators ??*)

	Consonants	Sample size	Mean (s)	Stand. deviation	Confidence interval (95 %)
Plosives	$[pp'bb']$	2649	0,063	0,023	0,062 ÷ 0,064
	$[tt'dd']$	4876	0,062	0,025	0,062 ÷ 0,063
	$[kk'gg']$	3860	0,065	0,025	0,064 ÷ 0,066
Fricatives	$[ff']$	52	0,074	0,03	0,065 ÷ 0,082
	$[hh'xx']$	14	0,093	0,23	0,081 ÷ 0,105
	$[ss'zz']$	4498	0,098	0,03	0,097 ÷ 0,099
	$[šš'žž']$	1353	0,102	0,03	0,100 ÷ 0,103
Sonorants	$[r r']$	2036	0,046	0,019	0,045 ÷ 0,047
	$[v v']$	2036	0,057	0,027	0,056 ÷ 0,058
	$[l l']$	1627	0,059	0,028	0,057 ÷ 0,060
	$[n n']$	2116	0,062	0,028	0,061 ÷ 0,063
	$[m m']$	1726	0,070	0,023	0,069 ÷ 0,071
	$[j]$	1796	0,070	0,038	0,068 ÷ 0,071

RESULTS: *The manner of articulation*



- Sonorants are almost 1,5 times shorter but are more similar to plosives (~ 0,62 s).
- The duration differs in distribution of the consonants according the voicing: voiceless plosives and fricatives are the longest, the voiceless ones shorter and sonorants are the shortest in duration.

RESULTS: *The manner of articulation*

The fricative [s]

Consonant	<i>s</i>	<i>s + sp</i>	<i>s</i>	<i>s + sil</i>
Sample size	2062	570	2062	228
Mean (s)	0,102	0,182	0,102	0,182
St. deviation	0,04	0,05	0,04	0,03
Confidence interval (95 %)	0,100 ÷ 0,104	0,178 ÷ 0,186	0,100 ÷ 0,104	0,178 ÷ 0,186
The duration rates	1 : 1,8		1 : 1,8	

The symbol [s] marks here the duration of the fricative in the middle of the word;

s+sp – the [s] in the final position of the word before the pause in the middle of the phrase (*vaikas verkia*);

s+sil – the [s] in the final position of the word before the pause at the end of the phrase (*verkia vaikas*).

In the final word position fricative [s] is usually uttered longer (almost twice).

RESULTS: *The manner of articulation* *Process of degemination*

Consonant	<i>s</i>	<i>ss</i>	<i>s'</i>	<i>ss'</i>
Sample size	499	145	499	79
Mean (s)	0,100	0,108	0,098	0,104
St. deviation	0,04	0,03	0,03	0,03
Confidence interval (95 %)	0,097 ÷ 0,104	0,103 ÷ 0,112	0,095 ÷ 0,101	0,098 ÷ 0,110
The duration rates	1 : 1,1		1 : 1,1	

- The sequence of two identical adjacent consonants (occurring only at the morpheme boundary) undergoes degemination (*pusseserė*);
- The possible geminates are only 1,1 times longer than unambiguously non-geminates;
- Synthesizing a combination of words like *vaikas serga* at normal speech rate would require longer pause between them in order to obtain two separate sounds.

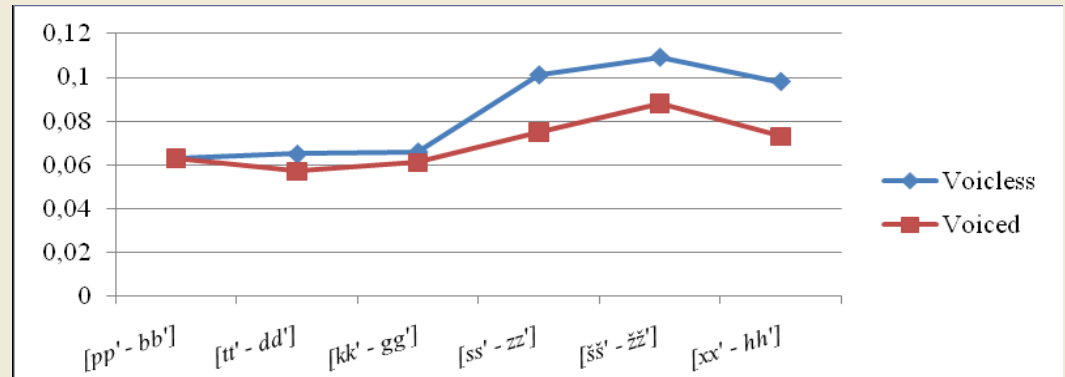
RESULTS: *The manner of articulation*

Sonorants in monophthongs and diphthongs. Stressed / unstressed

Consonant	V/C-V/C [m m']	V-C [m m']	V/C-V/C [r r']	V-C [r r']	V/C-V/C [n n']	V-C [n n']	V/C-V/C [l l']	V-C [l l']
Sample size	1726	269	2036	1164	2116	344	1627	228
Mean (s)	0,070	0,088	0,046	0,057	0,062	0,075	0,059	0,083
St. dev.	0,023	0,027	0,019	0,025	0,028	0,023	0,028	0,032
Confidence interval (95 %)	0,069÷0,071	0,085÷0,091	0,045÷0,047	0,055÷0,058	0,061÷0,063	0,073÷0,078	0,057÷0,060	0,079÷0,087
Duration rates	1:1,3		1:1,2		1:1,2		1:1,4	

- In diphthongs uttered sonorant consonants are 1,3 times longer in comparison to monophthongs.
- A diphthongal circumflexed (rising) allotone is produced by emphasizing and lengthening the second element of a biphonemic diphthong and by reducing its first element (for example, *kaltas*, *kaltas*).
- If the sonorant is a part of the diphthong and is stressed – it is approx. 1,25 times longer.

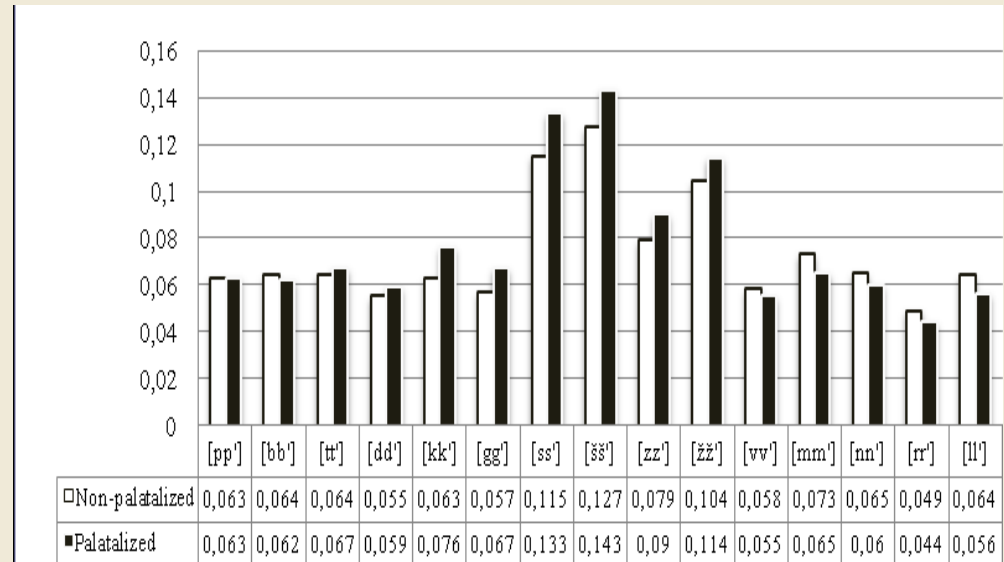
RESULTS: *Voicing*



- The quantity of plosive consonants which are articulated with a closed mouth (bilabials) is similar regardless if they are voiced or voiceless;
- Voiceless dental and velar consonants are slightly longer (1,1 time as long) than corresponding voiced ones. Small differences, but statistically significant;
- Vibration of vocal folds while uttering voiced consonants causes the shorter duration: when the articulation process requires the activity of more articulators, the production of sounds gets more complex and shorter;
- Why then the duration of the voiceless and voiced bilabial consonants is the same?
- Voiceless fricative consonants are 1,2 times longer than the voiced ones.

RESULTS: *Palatalization*

PLOSIVES



- Correlation between the consonant duration and its palatalization can partly prove that the duration can be influenced by the articulation's complexity (additional raise of the tongue).
 - Plosive dental palatalized consonants and palatalized consonants articulated in the depth of the mouth articulated (velars) are 1,1 times longer on the average than their non-palatalized counterparts;
 - The durations of both palatalized [p' b'] and non-palatalized [p b] plosive bilabials do not differ;

RESULTS: *Palatalization*

FRICATIVES and SONORANTS

- **Fricative** palatalized consonants are slightly longer (1,1 times) than the non-palatalized ones;
- This phenomenon does not follow the effect of Bernoulli (the airflow passing through narrower gap (in the case of palatalized fricatives) should pass faster);
- Only the palatalized **sonorant** consonants are shorter (1,1 times) in all classes than their respective non-palatalized counterparts.

FINAL REMARKS

- Fricatives (except [f f']) are almost one and a half times longer than plosives. Sonorant consonants are more similar to plosives considering their duration.
- Not the place of articulation but the way how the air penetrates determines some duration regularities.
- Palatalization appears to have no significant impact on the quantity of the consonants: only few palatalized plosive and fricative consonants are longer than the non-palatalized ones. On the contrary, only non-palatalized sonorant consonants are longer than the palatalized ones.
- The most significant feature to impact the duration of consonants is their voicing and the manner of articulation.

FINAL REMARKS

Additional factors should be considered:

- how the duration of the consonants depends on the position in a word,
- the adjacent sounds,
- or the phrase length.

The speech rate, intonation changes, different speakers also should be considered in further researches.

Human Language Technologies - THE BALTIC PERSPECTIVE

Riga, Latvia, October 7–8, 2010

Remarks on the Duration of Lithuanian Consonants in a Continuous Speech

Sigita DEREŠKEVIČIŪTĖ, Asta KAZLAUSKIENĖ

Vytautas Magnus University, Kaunas