SPECTRAL CHARACTERISTICS OF THE LITHUANIAN OBSTRUENTS ACCORDING TO GENDER: PRELIMINARY RESULTS OF EXPERIMENTAL RESEARCH

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A different physiological structure has an impact on the apparatus of male and female voices and the articulation apparatus. The aim of the paper is to compare acoustic features of the consonants pronounced by males and females and to determine which differences depend on the gender of an announcer, and which are related to the individual articulation of the announcers. Three acoustic features are investigated: 1) duration of the release phase;2) frequency of the spectral peak; 3) relative intensity. The investigation shows that the only parameter – frequency of the spectral peak – can be related to the announcers' gender.
Key words: *Standard Lithuanian, obstruent, acoustic feature, gender, duration of the release phase; frequency of the spectral peak; relative intensity.*

Gender relevant voice parameters. A different physiological structure has an impact on the apparatus of male and female voices (on the length and thickness of the vocal cords, in particular) and the articulation apparatus (chiefly mouth and nasal resonators). Males and females have different vocal fold sizes (Stevens, 1998, 25; Johnson, 2003, 83–84; Kent&Read, 2002, 19; Кодзасов & Кривнова, 2001, 110). The male vocal tract is about 16,9 cm, female vocal tract is about 14,1 cm. Adult male voices are usually lower pitched due to longer and thicker folds. The male vocal folds are between 17 mm and 25mm in length, while female vocal folds are between 12 mm and 17 mm in length. The difference in vocal fold length and thickness between males and females causes a difference in vocal pitch. Fundamental frequency of male voices is about 120 Hz, female voices – 220 Hz. The male speaking pitch range is between 80 Hz and 170 Hz, while female speaking pitch range is between 150 Hz and 270 Hz. Smaller vocal tract means higher resonances (for female voices) and larger vocal tract means lower resonances (for male voices).

Researchers of the school of Lithuanian phonology have been carrying out instrumental investigations exceptionally with male voices for a long time. Cf. Aleksas Girdenis arguments: "It is best to take male speakers as announcers (if, of course, there is a choice), since the ear perceives and distinguishes sounds pronounced with a high voice less well. Male voices are especially desirable when the same data is intended for spectral analysis: high female voices are poorly suited for such studies, since they have few harmonics" (Girdenis, 2014, 50). Female voices started to be systematically studied in Lithuanian phonetic works only at the beginning of the 21st century.

The main aims of this article are: 1) compare distinctive acoustic features of the consonants of Standard Lithuanian pronounced by males and females; 2) discuss which differences depend on the announcers" gender and which are related to the announcers' individual articulation.

Recorded material. Lithuanian obstruents were analysed in prevocalic positions in CVC type syllables pronounced in isolation. The research material was produced by the Lithuanian native speaker announcers in standard pronunciation. The material was read by 12 Lithuanian announcers (6 male and 6 female, aged 20–50 years).

The analysis of consonants is based on the objective experimental methods. The obtained data was processed using *MS Excel*, as well as the *SPSS*; the analysis of the sounds was performed using a sound processing and analysis software program *Praat*.

This experimental research was carried out only with obstruents: plosives, fricatives and affricates. Lithuanian prevocalic obstruents in CVC sequences were characterized on the following acoustic features: 1) duration of the release phase; 2) frequency of the spectral peak; 3) relative intensity.

Duration of the release phase. In the case of plosives in prevocalic CVC position it is the interval between the release of the closure and the beginning of voicing of the next vowel. The duration of the release phase depends on the size of the resonator (mouth cavities) before and after the release of the closure: the larger the size of resonating cavities, the longer the release phase.

Both male and female data show that the duration of the release phase in voiced obstruents is shorter than in the corresponding voiceless obstruents. In the group of voiced obstruents, consonants produced by males (Figure 1) tend to have higher statistical means of the duration of the release phase to compare to the same obstruents produced by females (Figure 2). The exception is voiced affricates [ʤ] and [ʤʲ], [b], [dʲ], [gʲ] which have longer duration of the release phase in female data than in the male. In the subsystem of voiceless consonants those produced by females have longer duration of the release phase.

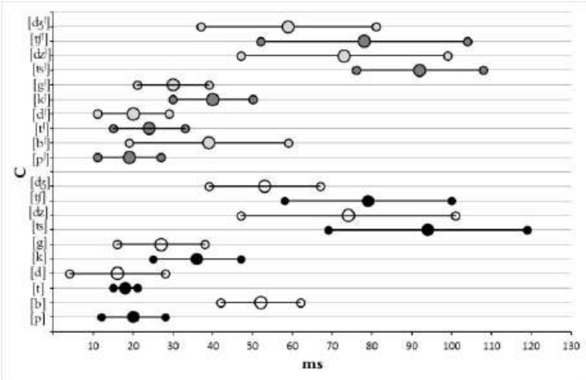

Figure 1. Duration of the release phase: male data (obstruent: ● non-palatalized voiceless, ○ non-palatalized voiced, ● palatalized voiceless, ● palatalized voiced).

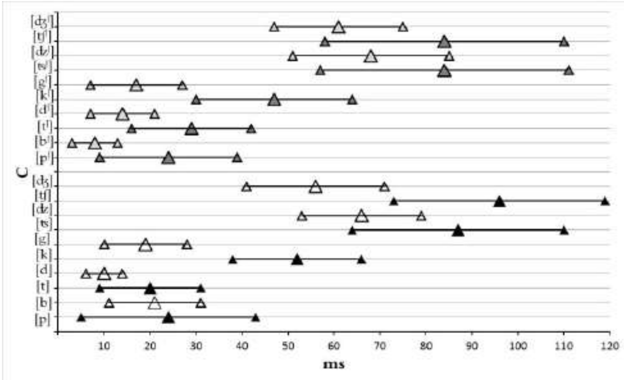

Figure 2. Duration of the release phase: female data (obstruent: ▲ non-palatalized voiceless, △ non-palatalized voiced, ▲ palatalized voiceless, ▲ palatalized voiced).

Comparing intervals for the duration of the release phase for male and female data show, that this data separates voiced and voiceless obstruents: voiced consonants have shorter duration of the plosive phase than their voiceless equivalents.

The duration of the release phase is also affected by the differences in production by different genders: women produce voiced consonants in a ‘more voiced’ way, while men add voicing to the voiceless consonants.

This data might mean that the duration of the release phase, after all, is more affected by the individual peculiarities of announcers, not the differences in production by different genders.

Frequency of the spectral peak. The regions of concentrated spectral energy with higher amplitudes of spectral components are called *peaks*. Since the distribution of peaks in the FFT spectrum depends on the vocal tract resonator, it is believed that the analysis of FFT spectrum provides information on the place of articulation of consonants. Thus in the obtained FFT spectrum the energy distribution was analysed in the range of 0–8000 Hz. The frequencies were measured in the spectrum of the dominating, i.e. the highest peak. This interval is considered to be optimal, because it is enough broad not to loose any crucial acoustic information.

The distribution of peaks in the FFT spectrum depends on the vocal tract resonator is more or less dependent of the resonator of the mouth: the larger its size, the lower the F2 frequency.

Obstruents produced by males (Figure 3) have lower statistical means of the frequency of the spectral peak to compare to the same consonants in female data

(Figure 4). In the group of voiceless consonants, the exceptions are the non-palatalized fricative [s] and the palatalized fricative [s^j], which produced by females are shorter than for the same sounds produced by males. In the group of voiced consonants, the mean frequency of the spectral peak for affricates [ʣ], [ʣ^j] produced by females is shorter than for the same sounds produced by males.

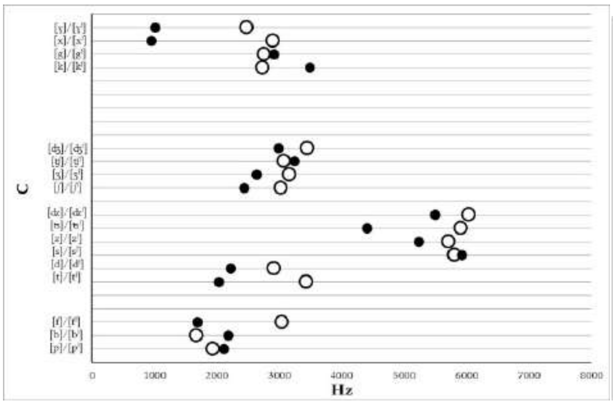

Figure 3. Frequency of the spectral peak: male data (● non-palatalized obstruent, ○ palatalized obstruent).

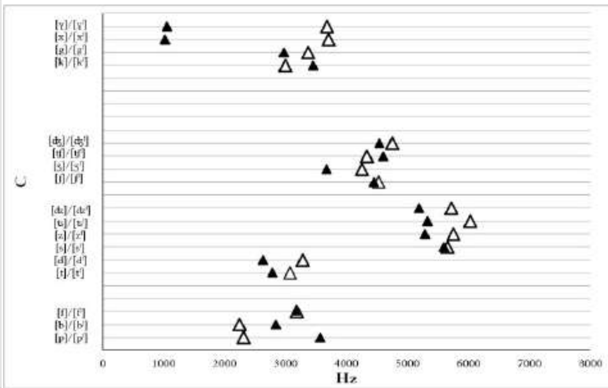

Figure 4. Frequency of the spectral peak: female data (▲ non-palatalized obstruent, △ palatalized obstruent).

The order of increasing the frequency of the spectral peak is starting from the lowest (velar [x], [ɣ] in male (M) pronounciation) to highest ([ʣ^j], [z^j], [ʦ^j], [s^j] in female (F) pronounciation):

M. [x], [ɣ] < F. [x], [ɣ] < M. [b^j], [p^j] < M. [f] < M. [d], [t] < M. [p], [b] < F. [b^j], [p^j] < M. [ʃ], [ʒ] < F. [d], [t] < M. [k^j], [g^j], [ɣ^j], [x^j] < F. [p], [b] < M. [g], [k] < M. [ʤ], [ʧ] < F. [g], [k] < M. [f^j] < F. [k^j], [g^j] < F. [f], [f^j] < M. [ʃ^j], [ʧ^j], [ʒ^j], [ʤ^j] < M. [d^j] [t^j] < F. [ɣ^j], [x^j] < F. [ʃ], [ʃ^j], [ʧ], [ʧ^j], [ʒ], [ʒ^j], [ʤ], [ʤ^j] < M. [ʦ], [z], [ʣ], [s] < F. [ʣ], [z], [ʦ], [s] < M. [z^j], [s^j], [ʦ^j], [ʣ^j] < F. [ʣ^j], [z^j], [ʦ^j], [s^j].

Obstruents produced by males tend to have lower statistical means of the frequency of the spectral peak to compare to the same consonants in the female data. Frequency of the spectral peak can be related to the announcer's gender.

Relative intensity shows the relation between the mean intensity of the fricative or affricate and the mean intensity of the vowel in their phonetic environment. The *mean intensity* shows the mean sound intensity in a given interval. The mean values of intensity were obtained from the intervals with duration of 10 ms, while the intensity of vowels was obtained from the intervals with duration of 50 ms, located approximately in the middle of the vowel.

Results of our experiment show that obstruents produced by males (Figure 5) tend to have lower mean relative intensity than the same consonants produced by females (Figure 6). This trend is more consistent in the group of voiced consonants (except velar consonants: the relative intensity of [ɣ], [ɣ^{j}] in male data is higher than in female data). In the group of voiceless consonants there are more exceptions, cf.: in male data, the mean relative intensity of labiodental [f], [f^{j}], dental [s], [s^{j}], alveolar [ʧ^{j}] and velar [z], [x^{j}] is higher than in female data.

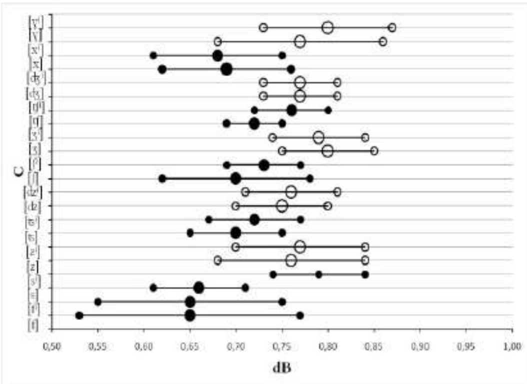

Figure 5. Relative intensity: male data (● non-palatalized obstruent, ○ palatalized obstruent).

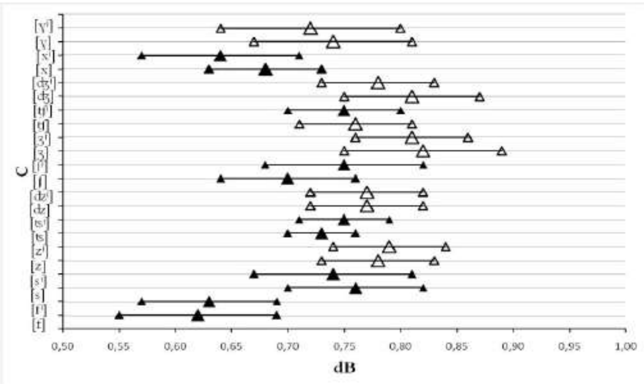

Figure 6. Relative intensity: female data (▲ non-palatalized obstruent, △ palatalized obstruent).

In the group of voiceless consonants, the relative intensity of non-palatalized and palatalized consonants increases in the following sequence: *labiodental* < *velar/palatovelar* < *dental/alveolar*. Thus in the group of voiceless consonants the relative intensity differentiates three articulatory groups of consonants. Dental and alveolar consonants do not differ, but it is possible to say that they have one of the highest means of relative intensity.

Relative intensity in voiced consonants increases in different patterns. In male data, dental consonants have lowest relative intensity, while alveolar and velar consonants show a mixed pattern. In female data, velar consonants have the lowest mean relative intensity, while alveolar consonants have the highest. Thus the relative intensity increases in different sequences in male and female data; cf.:

male: *dental* < *alveolar/velar (palatovelar);*

female: *velar (palatovelar)* < *dental* < *alveolar.*

The influence of gender on the relative intensity is uncertain, since the observed differences do not show a clear pattern.

Conclusions. Comparing distinctive acoustic features of the consonants of Standard Lithuanian pronounced by males and females:

1) The results of the duration of the release phase obtained do not confirm the impact of the announcer's gender on the length of the release phase, the differences fixed are not regular.

2) The results of the relative intensity obtained do not confirm the impact of the announcer's gender on the data of relative intensity, the differences fixed are not regular.

3) The investigation shows that the only one parameter – frequency of the spectral peak – can be related to the announcer's gender: lower frequencies of the spectral peak are usually characteristic of the obstruents articulated by male speakers than of the same obstruents articulated by females.

The results of the investigations of the consonants of the Lithuanian language could be compared with the analogous investigations of the consonants of the Latvian language (Urbanavičienė, Indričāne, Jaroslavienė and Grigorjevs, 2019).

In Lithuanian and Latvian, the duration of the release phase in male and female productions varies and there are no consistent differences related to gender.

In Lithuanian, the frequencies of the spectral peaks in plosives, fricatives and affricates produced by males are lower than in the same consonants produced by females. In Latvian, obstruents produced by males have lower mean frequency of the spectral peak than the same obstruents produced by females.

In Lithuanian and Latvian, the influence of gender on relative intensity is uncertain, since the observed differences do not show a clear pattern.

In order to obtain more accurate results we need to gather more data. But current results already show universal tendencies in both Baltic languages comparing male and female pronounciation.

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