A Study of Chosen Temporal Relations within Syllable Structure in Polish*

Analiza wybranych związków iloczasowych zachodzących w obrębie sylaby w języku polskim

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ABSTRACT

This paper presents data on the most common syllable patterns in Polish based on corpora of approximately 40 minutes of read speech as well as on a word list of nearly 700 000 items. First, the results of statistical analysis concerning the frequency of occurrence for the possible syllable patterns in Polish are described. Then, chosen problems connected with segmental duration within the syllable structure are addressed by presenting results of duration measurements for particular elements of the syllable as related to stress and contextual conditions.

STRESZCZENIE

Artykuł prezentuje wyniki badań dotyczące najczęstszych struktur sylab języka polskiego. Badania są oparte na nagraniu około 40 minut mowy oraz na korpusie tekstowym zawierającym około 700 000 wyrazów. W pierwszej kolejności zaprezentowano wyniki analiz dotyczących częstotliwości występowania poszczególnych struktur sylab w języku polskim. Następnie opisano wybrane zagadnienia związane z iloczasem segmentalnym w obrębie poszczególnych struktur sylab. W badaniach uwzględniono czynniki akcentu oraz czynniki kontekstowe.

1. Background

The status of the syllable and its interpretation has been widely discussed in the literature. Within the syllable structure, three constituent parts of the syllable are typically distinguished i.e. onset, nucleus, coda (nucleus and coda being often called rhyme (rime)). In the Polish language normally vowels appear as syllable nuclei, however it might be discussed whether liquids or nasals could also be considered as syllable centers for specific realizations of words like *drwić*, *mleć*.

Some researchers claim that it is impossible to provide an unequivocal definition for the syllable as a unit (eg. [1]). Krull and Traunmuller [2], on the basis of an experiment conducted for Estonian, report that listeners do not perceive syllables as temporal

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entities, nor do they refer to relations between duration of neighboring syllables. A different tendency was observed by Zellner-Keller [3] for French. In her study, the author grouped syllable patterns into "syllabic duration classes", then compared the duration of the syllables' elements occurring in the syllable onset, nucleus or coda, and concluded that duration of each of the elements was to a certain extent correlated with the corresponding syllabic duration class. Hawkins, S. and Nguyen, N. in a number of papers e.g. [4] report that there are relationships between the formant structure and duration of consonants in the syllable onset and coda enabling prediction of coda voicing on the basis of acoustic properties of the syllable onset. According to the authors, the observation might be an important clue in speech recognition.

In practice, the syllable is often treated as a unit for speech technology purposes, e.g. the syllable-based duration model for English [5] or syllable duration characteristics for the Thai language [6]. It should be noted thought there have been claims that preference should be given to models that predict segmental durations as precisely as possible rather than to the syllable intervals as a base e.g. [7] or [8].

2. Study material

The results presented in the present study were collected from two datasets. The first one was a list of 694 937 Polish words. The list served as the material for frequency statistics of syllable patterns for the Polish language whose results are showed in point 3.1. of this paper. The results of the statistics were compared to the results obtained from the recorded database including about forty minutes of read speech obtained from a professional male speaker. The texts were fragments of prose or newspaper articles read in a neutral style, the process of database annotation was semi-automatic – all files were manually verified.[1] On the basis of the recordings, some of segmental duration relations within the most frequent syllable patterns were investigated.

3. Results

3.1. Statistics

In all the present material, syllable boundaries were inserted automatically according to rules defined in conformity with the maximal onset principle (assigning intervocalic consonants into the syllable onset unless it contradicts the sonority principle) unless it contradicts the sonority hierarchy (sonority rise within the onset and its fall within the coda, the nucleus being the most sonorous element) (cf. e.g. [9] for Polish).

Table 1. shows four most popular syllable patterns for Polish. The first column shows the percentage of particular syllable patterns in the recorded material. The second column contains the respective values obtained for the word list of almost 700 000 items. The last column shows results reported by Steffen-Batogowa [10] for one- and two-

[1] A more detailed description of the recorded database is available from Katarzyna Klessa. It was included in her PhD thesis *Modelowanie iloczasu głoskowego na potrzeby syntezy mowy polskiej. (Modeling segmental duration in Polish for Speech Synthesis Purposes.)*

Table 1. The most frequent syllable structures in Polish

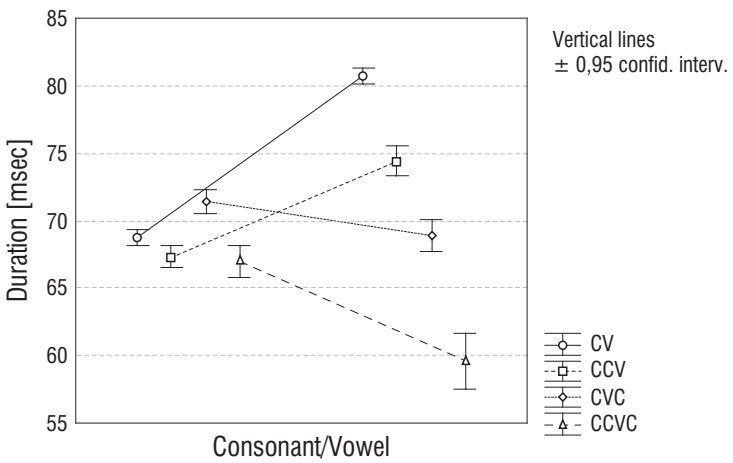
Syllable Structure	Frequency of occurrence (recorded speech) [%] Professional speaker	Words containing that syllable structure (Word list) [%]	Frequency of occurrence in the data of Steffen-Batogowa [10] [%]
CV	30	64,77	26,7
CVC	23	30,16	12,3
CCV	17	28,41	3,2
CCVC	13	11,19	3

syllable words in written texts (applying normative syllabification). As it can be easily observed, the order of the syllable patterns in terms of their "popularity" is the same in all of the three datasets (data on the order of the less common patterns in the present material are included as the Appendix 1. of this paper).

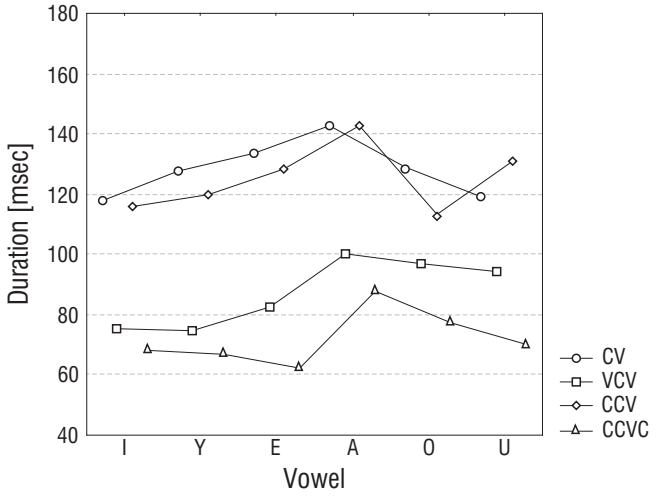
3.2. Segmental duration within syllable structure

The duration of speech sounds may be modified depending on the syllable structure containing them. The differences noted for vowels are much more significant than for consonants (see Picture 1) which confirms previous results [1].

It is anticipated that the differentiation in vowel duration results also from other sources of variability both on the level of segmental contextual conditions as on the higher levels of utterance organization. For example when the syllable position relative to pauses was taken into consideration a clear distinction between open and close syllables was observed, the nuclei of the former ones being the longest, which is shown in Picture 2.



Picture 1. The duration of consonants and vowels within the syllable structure (four most popular syllable patterns). Only syllables in non-prepausal position.



Picture 2. The duration of vowels appearing as nuclei within syllables preceding pauses.

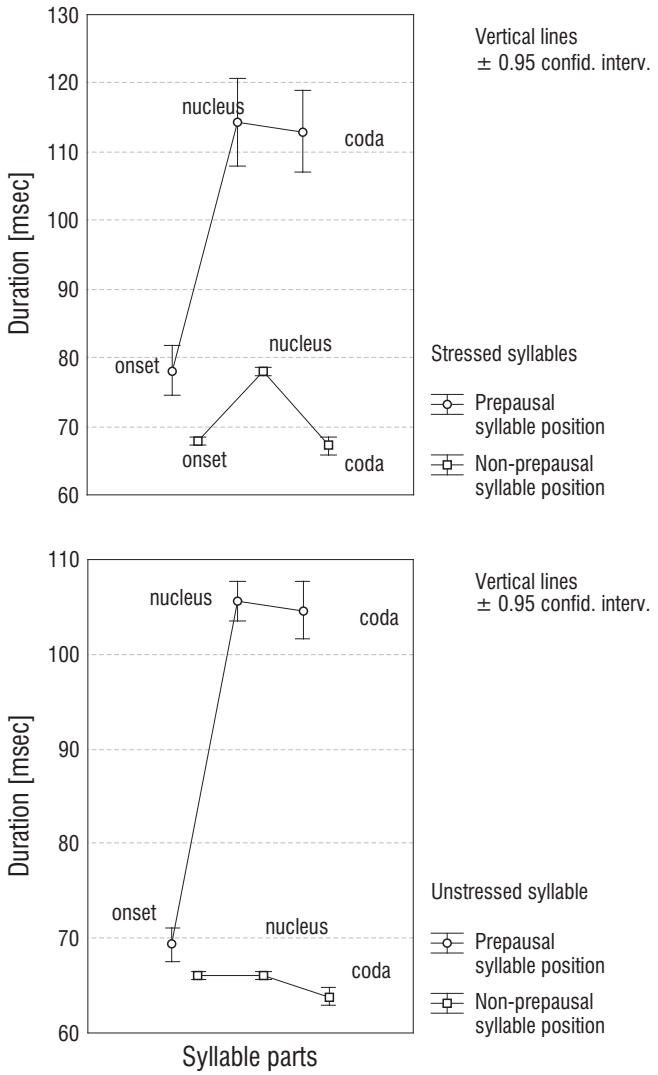
3.3. Vowel duration depending on the presence of word stress and position relative to pauses

The duration of particular syllable parts depends significantly on the presence of word stress and on the syllable's position with respect to pause. The top figure of Picture 3. depicts average duration values for stressed syllables' onset, nucleus, and coda either preceding a pause or occurring in any other position. The bottom figure of the same picture shows analogous relations for unstressed syllables. The greatest lengthening due to the influence of the pause in the right context was noted for nuclei and codas both for the stressed and unstressed syllables. For the set of stressed syllables preceding a pause the deviation is larger than for the unstressed ones which might be caused by the fact that the set is less numerous than the other one as for the majority for Polish words the stress falls on the penultimate syllable. (In the present material the stress was marked mostly on the penultimate syllable; some exceptions were taken into consideration to put it on the third or fourth from the end, and to mark it on the last syllable: foreign origin words, one-syllable content words). Syllables occurring in non-prepausal position distinguish between their constituents' duration to a smaller extent. The most important tendency here appears to be the relative lengthening of the nuclei brought about by the presence of stress.

Additionally an analysis of variance was conducted to check if the word-initial syllable position influences segmental duration. The influence appeared to be statistically insignificant.

3.4. Vowel duration depending on syllable type and consonant articulation class

We also preliminarily attempted to verify the influence of the articulation manner of the consonants in the syllable onset or coda on the duration of vowel (the syllable nucleus). However, any systematic tendency was observed that could be related specific-



Picture 3. The duration of particular syllable parts depending on the presence of stress and syllable position relative to pause. Top: stressed syllables, bottom: unstressed syllables.

ally to the impact of syllable structure. The dependencies observed (e.g. vowel lengthening in CV syllables beginning with a nasal consonant as compared to syllables having consonants of other articulation classes) were noted to occur to a similar extent also without taking the presence of the syllable boundary into account which would (at least) confirm the primary function of the contextual effects. This claim however should be subject to more detailed analysis.

4. Final Remarks

The role of the syllable in the temporal organization of Polish speech requires to be investigated in more detail. Certain phenomena reported in the paper confirm the importance of the syllable structure for its components' durational characteristics, however other seem to be rather vague. The status and the usefulness of the syllable as a unit was not addressed here directly and need further examination.

References

[1] Sawicka, I. 1995. *Fonetyka i Fonologia*. red. H. Wróbel [In:] *Gramatyka współczesnego języka polskiego*. Wydawnictwo IJ PAN Wrocław. p. 164–166.

[2] Krull, D., Traunmüller, H. 2000. *Perception of quantity in Estonian*. [w:] *Proceedings of Fonetik 2000*, Universtity of Skövde.

[3] Zellner-Keller, B., 2002. Revisiting the status of speech rhythm. Speech Prosody 2002, pp. 727–730. Aix-en-Provence.

[4] Hawkins, S. and Nguyen, N. 2000. Predicting syllable-coda voicing from the acoustic proprieties of syllable onsets. Proceedings of the ESCA Workshop on Spoken Word Access Processes, 29–31 May 2000. Nijmegen. pp. 167–170.

[5] Campbell, N. 1992 *Multi-level timing in speech*. PhD Thesis. University of Sussex (Exp. Psychol).

[6] Hansakunbuntheung, Ch., Tesprasit, V., Siricharoenchai, R., Muto, M. and Sagisaka, Y. Analysis on syllable duration characteristics for Thai speech Synthesis, 2003 Autumn Meeting of ASJ: Acoustical Society of Japan, Nagoya University, Japan, September 2003.

[7] Möbius, B. Duration models in speech technology. http://www.ims.uni-stuttgart.de/~moebius/Trondheim/duration4.pdf#search=%22ntnu%20%22duration%20models%22%20mobius%22.

[8] McCrary, K. (2002) Syllable Structure vs. Segmental Phonotactics: The phonetics and phonology of segment duration in Italian. Paper presented at the 9th International Phonology Meeting, Vienna, Austria, November 1–3 2002.

[9] Szpyra-Kozłowska, J. 2002. *Wprowadzenie do współczesnej fonologii*. Wydawnictwo UMCS Lublin.

[10] Steffen-Batogowa, M. 1962. *Polskie testy do badań nad wyrazistością i zrozumiałością mowy*. [In:] *Przegląd telekomunikacyjny*. pp. 82–89.