

## THE CONSONANTAL-VOCALIC STRUCTURE OF THE CZECH WORD AND STRESS GROUP

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### ABSTRACT

Information about phonotactic structure is important when investigating the temporal features of spoken language. So far only the consonantal-vocalic structure of the syllable has thoroughly been described for Czech, while less attention has been paid to the C-V patterns in words and stress groups. In the current study, an analysis of the C-V patterns in Czech stress groups and words was performed on the production of twelve radio newsreaders, with special respect to the word-class membership of the words. The glottal stop and syllabic consonants were treated as separate units. It was discovered that the most frequent word patterns are represented by CV, CVCV and CVCCV, while those of stress groups by CVCV, CVCCV and CVCVCV; the material did not yield any stress group consisting of one phone only.

**Key words:** phonotactics, consonant, vowel, stress group

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### 1. Introduction

The basic physiological principle underlying the organization of human speech over time is the aperture-structure alternation. This contrast is projected into the structure of the elementary unit of connected speech, the syllable – its most common type consists of an onset consonant and the vocalic nucleus (CV). The *Frame and Content Theory* (MacNeilage, 1998) presumes that oral communication developed originally from the movements typical of the mechanism of food intake – sequences of jaw openings and closings thus created a *frame* for speech, while the motor execution of the other articulators was later adjusted to a global coordination for generating the *content* of speech (Rochet and Schwartz, 2005: 1013). However, in many languages including Czech various additional syllable types have gradually evolved; e.g. Czech employs sonorous consonants that may function as syllable nuclei. Rousset (2004: 111) investigated the distribution of different syllable types in 16 languages and concluded that the most common syllable structures were the CV and CVC types, while the types V, CCV, VC, CCVC and CVCC occurred less frequently. Other structures comprised less than one per cent of the sample.

Using a sample of Czech speech of approximately 10,000 syllables in length, Ludvíková (1987) attested the presence of 13 syllable types in Czech: CV, CVC, CCV (these comprised 87% of all syllables in the sample), followed by the less common types V, CCVC, VC, CVCC, CCCV, CCCC, CCCVC, CCVCC, CVCCC and CCCVCC. The onset position of the Czech syllable can thus be filled with up to four, exceptionally five consonants, the coda with three. This fact may lead us to the conclusion that consonant clusters will appear in Czech words and stress groups; nevertheless, groups of more than three members are relatively rare in speech (Volín and Churaňová, 2010: 54). It must be noted that there are no clear-cut rules for assigning syllable boundaries in Czech, and the findings about the frequency of occurrence of individual syllables and syllable types can be distorted – e.g. the disyllabic word “sestra” can be interpreted as the sequence of the syllables ses-tra (CVC-CCV), sest-ra (CVCC-CV) or se-stra (CV-CCCV). Kučera (1961) listed a set of rules for dividing words into syllables quite systematically (allegedly first proposed by Kuryłowicz, 1948): 1) onsets and codas should not be selected in such a way that they would enlarge the number of already existing onsets and codas; 2) if the first rule does not permit an appropriate segmentation or permits more options, we should base our decision on the frequency of the alternatives and select the most frequent one (Kučera and Monroe, 1968: 48).

The diversity of consonantal-vocalic syllable types unavoidably led to a great number of C-V patterns of words and higher prosodic units, such as stress groups. The *stress group* is usually defined by the grammars as a group of syllables dominated by a single stressed syllable; it must be noted, though, that the stress group unit is not necessarily conditioned by the patent sound qualities of the stressed syllable in the word. The fact that a stress groups in perceived as a coherent unit is a consequence of the modulation of acoustic properties in a sequence of syllables due to which a percept of independence is created (Palková et al., 2004: 66). The fundamental criterion for segmenting a stress group in Czech is the intonational cohesion of the unit (Palková, 2004a: 406; for details on the analysis of Czech stress see also Ondráčková, 1962 and Janota and Palková, 1974).

Although text properties do not offer clear cues for segmenting stress groups, certain tendencies can be considered regular. However, complete agreement among listeners is usually not achieved, since the ranking of the auditory realization is affected by the listeners’ individual sense of rhythmical structure (Ondráčková, 1968: 186). These tendencies nevertheless allow for stipulating rules for the segmentation of continuous speech into stress groups in TTS synthesis (see Palková, 2004b). The main aspects of the stress group – word relationship are the following (Palková, in print; in the examples below / means stress group boundary and ‘ indicates the “stressed” syllable):

- 1) Polysyllabic words usually form stress groups of their own (e.g. ‘Odpoledne / ‘chodím / ‘nakoupit.).
- 2) A monosyllabic word(s) can be assigned into a stress group with the preceding word (e.g. ‘Zít-ra tam / ‘pojed-me.).
- 3) A monosyllabic word can be linked to the following stress group as an unstressed anacrusis (e.g. A ‘řikal / ‘jsi mu / ‘o tom?) – but Ondráčková (1954: 156) considers it, unlike Daneš (1957: 23), a special type of a stress group; in the present study it is considered a part of the following stress group.

- 4) A sequence of monosyllabic words can form a single stress group with the first word potentially stressed (e.g. 'Už jsem / 'ho tam / 'nepotkal.).
- 5) A monosyllabic word (usually a preposition) is linked with the following word and becomes the stressed syllable of the unit (e.g. 'Student / 'o zákazu / 'nevěděl?).
- 6) A monosyllabic word can remain as an independent stress group (e.g. 'Přijdu / 'raději / 'hned.).

Generally, monosyllabic words occur as initial, medial or final syllables of a polysyllabic stress group, or the only syllable of a monosyllabic stress group – the differences lie in the likelihood of the situation. The perception and realization of monosyllabic words in relation to the stress group is also affected by the position within the intonation unit: initially the monosyllabic words are often anacruses or they form first and stressed syllables in a stress group, finally they could form independent stress groups, and medially they are usually linked with the preceding stress group; a sequence of several monosyllabic words bound within a single stress group occurs most frequently in the initial or medial position.

It is unclear to what degree the semantics of the word influences the selection of the options mentioned above. Although the semantic criterion does not function unconditionally, it is possible to observe a tendency towards a greater independence of autosemantic words from the perspective of both the speaker and the listener. Despite the assumption that synsemantic words do not bear stress and do not occupy independent stress groups, in real material such cases can occur (Palková, in print). These cases appeared in our material as well (e.g. 'v dalších / 'částech / 'země / 'se / 'částečně / 'zbortily / 'střechy / 'několika / 'dalších / 'výrobních / 'hal).

The stress group is a prosodic unit within the intonation phrase, a unit on which the rhythm of speech can be realized. Speech rhythm is based on specific configurations of contrast that define the language – we assume that a given language determines the information about the stress group and the C-V structure, and that this knowledge allows for effective perception.

The current study deals with the variability of consonantal-vocalic patterns of words and stress groups in read texts of Standard Czech. The research is not focused on the segmental content of individual C-V patterns or syllables, nor on the combinatorics of Czech segments and their frequency – these aspects of Czech phonotactics were investigated relatively thoroughly by Mazlová (1946), who dealt especially with the frequency of occurrence of individual phones; statistical research was further conducted by Ludvíková and Kraus (1966), who looked not only at individual segments, but also at bigrams in Czech texts of different stylistic variants. A comparable statistical analysis was performed by Kučera and Monroe (1968). Detailed data from written corpus were provided in *Statistiky češtiny* (Bartoň et al., 2009), these findings were, however, left without any interpretation in the book. With respect to specific elementary sound units, the glottal stop was taken into account in this study, although it does not have a phonemic status in Czech – it usually occurs only in words beginning with a vowel (the issue of the occurrence of the glottal stop in Czech speech was attended to in Novotná-Hůrková, 1974), and syllabic consonants were also paid attention to.

The motivation for the present study was the need to survey the C-V structure of contemporary spoken Czech. In the process, C-V patterns with high frequency of occurrence

were collected, for words and stress groups separately. The word-class membership was taken into account.

## 2. Method

### 2.1 Material

Ten texts of radio news broadcasts were selected for analysis. They were read by 12 professional native speakers of standard Czech (5 male and 7 female), without any dialect or slang features and with explicit pronunciation. The recordings were taken from the Prague Phonetic Corpus and were subsequently processed in the programme Praat (Boersma and Weenink, 2010).

The individual texts ranged between 413 and 764 words; the total sample consisted of 37,360 phones at the word-level (37,356 phones at the stress group-level), 6639 words and 5368 stress groups. The difference between segment counts at the respective levels is due to one word that was excluded from the analysis, as it contained a dysfluency. This word was a part of a multi-word stress group which had to be excluded as a whole, including the remaining words. The duration of the material (excluding pauses) was 45.57 minutes in total.

### 2.2 Procedure

The recordings were divided into breath groups, and TextGrid objects were accordingly created for annotation. The material was then divided into phones and words using the Prague Labeller algorithm (HMM-based forced aligner; see e.g. Pollák et al., 2007). The *word* is used in its most general sense, i.e. an orthographic unit (so e.g. abbreviations were treated as one word). While word boundaries were marked automatically, stress groups were segmented manually. The division of speech into real stress groups was based on the opinion of two trained phoneticians, including the author herself. Our decisions about division into stress groups were based on several factors: e.g. temporal changes, final nuclear tone, changes in the course of f0 and dynamics, pauses and hesitations. The division into stress groups was nevertheless not always clear-cut, as it is impossible to establish an unequivocal relation between a word and the way it behaves with regard to stress group segmentation. These cases concerned exclusively monosyllabic words – our decisions about them were based on perceptual evaluation of prominences (e.g. on the basis of f0 changes and perception of the prominence the preposition in the utterance *jen na / denní / hodiny* was linked with the previous word into a stress group; in the utterance *vše se / zatím / obešlo / bez / zranění* both the preposition *bez* and the following word *zranění* had perceptual and acoustic prominence; the conjunction *a* in some cases carried prominence and formed a single stress group as well – *mezi / Valašským / Meziříčím / a / Velkou / Lhotou*).

After the segmentation a script was used to convert the phones into code markings for consonants, vowels, syllabic consonants ([r l] in Czech, exceptionally also [m n]) and the glottal stop (when it was really produced). In this way we obtained consonantal-vocalic

patterns of all words and stress groups in the sample; these patterns consisted of the symbols C, V, R and ?. The output was processed further in spread sheet tables.

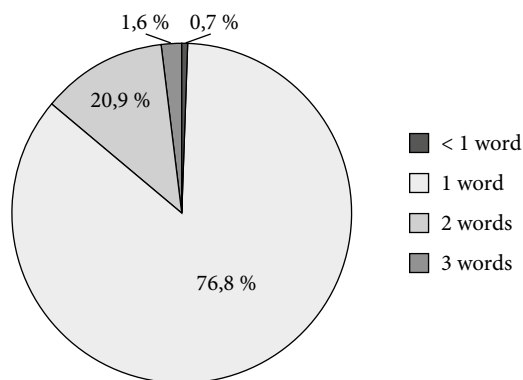
Transcripts of all recordings were input into a programme for recognizing word classes, which was provided by the Institute of Theoretical and Computational Linguistics at the FF UK. The assignment to word classes was manually checked and any automatically unrecognized units (especially foreign words and proper names) were assigned to the respective categories. The C-V patterns in the data were also checked and words and stress groups with dysfluencies that deformed the phonotactic structure of the unit were omitted from the analysis. The analysis itself required the use of filters and contingency tables from the resulting data.

### 3. Results

The analysed texts comprised 6639 words and 5368 stress groups in total; we recognized 413 different C-V patterns at the word level and 559 at the stress group level. The higher number of words is a consequence of the fact that several words may appear within one stress group, which also corresponded to a greater number of such patterns.

#### *Words and stress groups*

In the analysed material the most frequent stress groups consisted of one word (76.84%), but a high proportion comprised two words (20.86%). The corpus nevertheless included a few cases where the stress group contained three words (1.58%). The cases in which one word was divided into several stress groups were very rare (0.73%). This occurred mainly in the pronunciation of abbreviations (e.g. *KCNA*, *ODS*, etc.), when the last syllable was markedly accented. In several cases we noted a word divided into two stress groups (e.g. *pětapadesát*, “fifty-five”). The number of words in a stress group is shown in Figure 1.



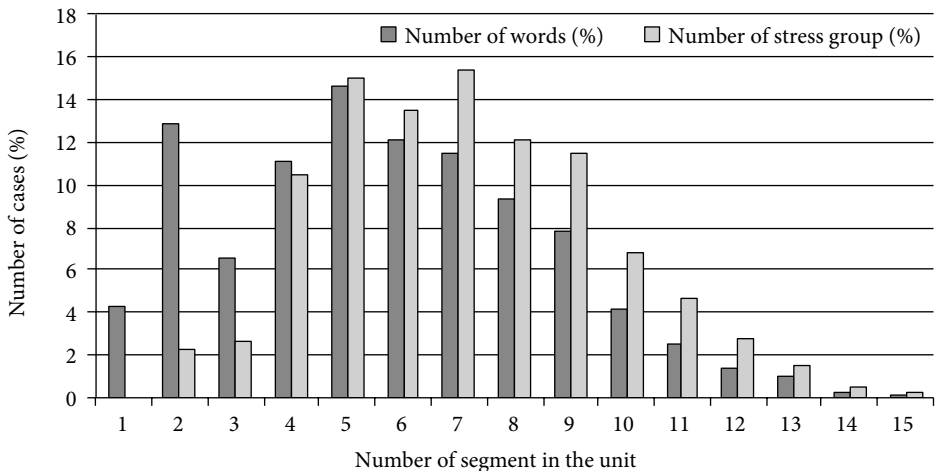
**Figure 1.** The percentage of the number of words in a stress group in Czech texts. < 1 word = division of a word into two stress groups.

## Phones

Words and stress groups yielded a considerable difference in the number of phones in the unit. Since the glottal stop was counted among the phones, there were few one-phone words in the corpus (278 words consisting of a consonant and 7 of a vowel); most of these were non-syllabic prepositions. One-phone stress groups (SGs consisting of a vowel without a glottal stop) did not occur in the corpus at all; the absence of the glottal stop can thus be considered as an indicator of the non-autonomy of such a one-segment unit. In the SG data, there appeared 63 cases in which the stress group was formed by the glottal stop and a vowel (ʔV; e.g. [ʔa]). As expected, the number of two-phone stress groups was low; the majority of cases included conjunctions with a glottal stop (e.g. [ʔa], [ʔɪ]) or prepositions ([do, na] etc.), although these were usually linked to the following stress group. The most frequent sizes of both words and SGs were represented by 5-phone units (most frequent in words: 971 instances), 6-phone units, and 7-phone units (most frequent in SGs: 829 instances). The longest unit (word and SG) contained 25 phones (the adjective “sixty-eight-million” [ʔosmafedesa:cimiltjonove:fo]).

Stress groups were more often longer than words, which corresponds with the fact that almost a quarter of stress groups included several words. Figure 2 visualises the differences in segment counts in words and stress groups up to the length of 15 phones (longer units occurred less than ten times in the material).

There were 883 glottal stops in the corpus; both words and stress groups allowed several glottal stops (e.g. at the beginning and at the morphological parse), but at most three. We also paid attention to syllabic consonants: although they function, like vowels, as syllabic nuclei in Czech, due to their specificity they are featured as distinct units in the analysis.



**Figure 2.** Number of words and stress groups with the given segment-count in Czech speech, converted into per cents. 100% = total number of words (6639) and stress groups (5368).

## **C-V patterns**

Although the material revealed various word and SG phonotactic patterns, it was possible to discover a tendency for certain patterns to appear more often than others. The most frequent word pattern was the combination of a consonant and a vowel (CV; 603 instances, e.g. [ʒe]), followed by the patterns CVCV (e.g. [sɪʃe]) and CVCCV (e.g. [dalʃi:]). In contrast, the most frequent stress group pattern was CVCV (380 instances, e.g. [si:la]); CVCCV (e.g. [filmu]) and CVCVCV (e.g. [nefɔda]) also appeared frequently. Table 1 shows the ten most frequent patterns according to words and stress groups (for extended table see <http://fu.ff.cuni.cz/obsah.php?x=materialy.html>).

**Table 1.** The most frequent phonotactic patterns in words and stress groups, 100% = total number of words (6639) and stress groups (5368).

Words			Stress groups		
pattern	instances	%	pattern	instances	%
CV	603	9.08	CVCV	380	7.08
CVCV	481	7.25	CVCCV	296	5.51
CVCCV	354	5.33	CVCVCV	229	4.27
C	278	4.19	CCVCV	223	4.15
CVCVCV	271	4.08	CVCVC	209	3.89
CCVCV	267	4.02	CVCCVCV	169	3.15
CVCVC	265	3.99	CCVCVCV	150	2.79
?V	237	3.57	CVCVCVC	132	2.46
CVC	211	3.18	CCVCCV	125	2.33
CVCCVCV	178	2.68	CVCVCVCV	124	2.31

It is clear from Table 1 that the most frequent SG C-V patterns tended to be longer in terms of the number of segments. Monosyllabic stress groups did not appear even once in the list of the ten most frequent patterns – unlike words with three monosyllabic and one non-syllabic units. One of the most frequent word patterns is also ?V. If we did not count the glottal stop as a special unit, but as a consonant, the occurrences of this pattern could be added to the number of words with the structure CV – the CV pattern would then include 840 instances in total (12.65% of all words).

Words and stress groups with syllabic consonants (most often liquids) also appeared in the material. These counted 158 (2.4% of all words and 2.9% of all SGs); two syllabic consonants at once did not appear in any unit. There were 49 patterns with a liquid in words (11.9% of all word patterns) and 66 patterns in stress groups (11.8% of all SG patterns). The most frequent patterns in words and SGs were CVCR (e.g. [vi:tr]), CRCCV (e.g. [prɔvni:]) and CRCV (e.g. [plɔne]).

### **Syllabicity of stress groups**

The most frequent units in the corpus were structures of two (33.9%), three (31.7%) and four syllables (20.3%). One-syllable stress groups were also represented significantly: we found 363 stress groups (6.8%), of which 104 consisted of genuine prepositions (*bez, na, o, od, po, pro, před, přes, u, ve, za, ze*), conjunctions (*a, či, i, než, však, zda, že*), the verb form *by* (e.g. in the utterance *'kolem / 'poledne / 'by / 'silnice / 'měly být / 'opět / 'průjezdě*) or the pronoun *se*. The classification of these words as single stress groups was based on clear perceptual prominence they carried. The most frequent pattern of monosyllabic SGs was CCVC (74 instances, e.g. [dnes]); the patterns ?V, CVC, CV and CCV were also represented numerously (approximately 50–60 instances, e.g. [ʔa, da:l, ze, jde]).

**Table 2.** Number of syllables in stress groups and its percentage.  
100% = number of all stress groups (5368).

Number of syllables	Frequency of occurrence	% of all stress groups
2	1816	33.83
3	1699	31.65
4	1089	20.29
1	363	6.76
5	308	5.74
6	72	1.34
7	12	0.22
10	4	0.07
9	2	0.04
8	1	0.02
11	1	0.02
12	1	0.02

**Table 3.** Frequency of occurrence of individual patterns in monosyllabic stress groups.

Pattern	Frequency of occurrence	Pattern	Frequency of occurrence
CCVC	74	CVCC	18
?V	63	CCCVC	12
CVC	59	VC	2
CV	55	CCVCC	2
CCV	52	CCCV	1
?VC	24	CVCCC	1



## Word classes

The most frequent word class in our material, based on news-reading, was the noun (39.3% in the corpus). A considerable part consisted of adjectives (13.8%), prepositions (13%) and verbs (12.5%). The smallest portion of the texts was represented by particles (less than 1%). Interjections did not appear in the texts at all, which is not surprising given the character of the material. The most frequent C-V patterns for each word class are reported in Table 4.

**Table 4.** The most frequent patterns for the given word classes.

Word class	The most frequent patterns – including the glottal stop
nouns	CVCV
adjectives	CVCCV
pronouns	CV
numerals	CCV
verbs	CVCV
adverbs	CVCV
prepositions	CV
conjunctions	?V
particles	?VC, CVC
interjections	–

The results of the word-class analysis in most cases agreed with the corpus-based research performed on written Czech (SYN2005 corpus) that was presented in *Statistiky češtiny* (Bartoň et al., 2009). An important difference lay in the interpretation of the glottal stop (in *Statistiky češtiny* the glottal stop was coded as a consonant: C). However, the analysis presented in the publication mentioned above was not based on actual occurrence of the glottal stop, but on estimates by rule.

## 4. Discussion

At the level of segmentation of connected speech, the codification of Czech pays attention only to the joining of a preposition with the following word: a genuine monosyllabic preposition usually forms the first syllable of the stress group that comprises the preposition plus the following word. There are a few exceptions to this rule, such as when the preposition is followed by an excessively long word, a word not governed by the preposition, or a word that is emphasised markedly (“contrastive focus” in Romportl, 1985: 130). Apart from one-syllable stress groups composed of lexical words, the material also yielded 104 cases where the stress group was formed by a genuine preposition or by a monosyllabic conjunction or enclitic.

Unlike Ludvíková (1987), who excluded the glottal stop from her analysis, and Bartoň et al. (2009), who apparently regarded the glottal stop a consonant in the word patterns, the present study treated the glottal stop independently, with a dedicated symbol. There were 883 glottal stops in the corpus – the stress group usually included only one glottal stop, less frequently two and exceptionally three of them (especially in acronyms such as *OSN* [ʔo:ʔesʔen]). The special marking of the glottal stop allowed for a finer-grained differentiation of the C-V patterns, which was important also for the analysis of the patterns according to word classes.

Although a stress group consisting of only one phone (i.e. vowel) is theoretically possible, there was no instance of this in the material, although such units appeared in the category of words. We may therefore presume that the presence of the glottal stop contributes to the perception of an independent monosyllabic stress group, which, however, requires further evidence, e.g. by perceptual testing.

Many languages of the world do not allow a consonant in the function of the syllable nucleus. Therefore, we opted for a special marking of these consonants, even though they play the same role in the syllable as vocalic nuclei. There were 158 words and stress groups with a syllabic consonant, comprising only 3% of the corpus; nevertheless, they represented almost 12% of all word and SG patterns (the most frequent pattern being CVCR).

The analysed material yielded a similar order of stress groups according to the syllable count as the material of Ondráčková (1954): the greatest portion was formed by two-syllable (34%), three-syllable (32%) and four-syllable stress groups (20%), followed by one-syllable (7%) and five-syllable (6%) stress groups; other sizes were rare. However, there is a difference in the three most frequent types: in contrast to Ondráčková we found only a small difference between the numbers of two- and three-syllable stress groups, and also a greater number of four-syllable stress groups. This might be a consequence of the different styles of the analysed texts.

The current study opens a wide area for further research – as the journalistic style and the read aspect of the texts render the material certain specificity, it would be useful to encompass other styles of speech, other dialects and also spontaneous productions. This would allow for a comparison of the individual results with each other and with the standard language, and for drawing conclusions relevant for a more detailed description of the Czech prosody.

## 5. Conclusion

The most frequent consonantal-vocalic patterns in words were the patterns CV, CVCV and CVCCV, while in stress groups the patterns CVCV, CVCCV and CVCVCV. Patterns with syllabic consonants were also taken into account – they comprised approximately 12% of both word and stress group patterns, the most frequent being CVCR. Unlike words, the stress group always included more than one phonotactic unit (a phone or the glottal stop). Stress groups tended towards longer structures, which corresponds with the fact that the stress group may include several words. Although one-word SGs were the most frequent (77%), two-word SGs also reached a considerable proportion (21%). Stress

groups that comprised three words were rare (less than 2%), as were the cases of words divided into two SGs (less than 1%).

The most frequent word class in the material was the category of nouns (39% in the corpus), with CVCV as their commonest pattern.

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## KONSONANTICKO-VOKALICKÁ STRUKTURA ČESKÉHO SLOVA A MLUVNÍHO TAKTU

### Resumé

Informace o fonotaktické struktuře je důležitá pro zkoumání temporálních vlastností mluveného jazyka. Doposud byla v češtině zevrubně popsána zejména konsonanticko-vokalická stavba slabiky, avšak méně pozornosti bylo věnováno C-V vzorcům slov a mluvních taktů. Český ráz jako fonotaktická jednotka byla v literatuře zpracovávána nejednotně. V rámci této studie tedy byla na základě dvanácti mluvených projevů rozhlasových hlasatelů provedena analýza C-V struktur českých mluvních taktů a slov s přihlédnutím ke slovnědruhovému příslušnosti slov. Ráz a slabikotvorné souhlásky byly zpracovány jako samostatné jednotky. Bylo zjištěno, že nejfrekventovanější vzorce slov představují CV, CVCV a CVCCV a taktů CVCV, CVCCV a CVCVCV; ve zkoumaném materiálu se nevyskytl žádný takt sestávající z jediné hlásky.