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The Sonority Sequencing Principle and the Structure of Slovak Consonant Clusters

1. Introduction

Generally, the structure of the syllable in languages is governed by the so-called Sonority Sequencing Principle (also known as the Sonority Sequencing Generalization), which states that the centre of the syllable is created by the most sonorous sound and the sonority of the other segments in the syllable decreases towards its margins (see, for example: Blevins, 1995; Goldsmith, 2011; Zec, 2007). This idea is usually connected with the work of Jespersen (Jespersen, 1904). In Jespersen's theory, each speech sound is characterized by a certain degree of sonority. Sonority – the relative loudness of a sound – is given by the functioning of vocal cords and the opening of supra-glottal cavities during the articulation of the sound (see, for example, Ladefoged, 1992), that is, it depends on the articulatory-acoustic and perceptual characteristics of sounds.¹ All speech sounds are ranked on the sonority scale with vowels as the most sonorous sounds at the top of this hierarchy and obstruents at its bottom. The sonority hierarchy “vowels > liquids > glides > nasals > fricatives > stops” is considered language-universal and can also be found in the Universals Archive as Universal Number 626 (<https://typo.uni-konstanz.de/rara>).

¹ This is the phonetic dimension of sonority. For the phonemic delimitation of this notion, see, for example, Parker, 2018; Zec, 2007.

However, despite this declared universal nature of the sonority hierarchy, it is well known that the arrangement of consonantal segments determined by their sonority slightly varies across languages and combines language-universal aspects with those that are language-specific (see, for example, Parker, 2012).

Nevertheless, contrary to the Sonority Sequencing Principle (hereinafter SSP), in languages, there are syllables that do not follow this rule. For example, in Polish, there are many word-initial (i.e. syllable-initial, see below) consonant clusters violating the SSP (for further details, see Pawelec, 2012). Similarly, it seems that Russian syllables do not obey the SSP either, as reported by O'Brien (O'Brien, 2006). The SSP is violated in many other (not only Slavic) languages (see, for example, DeLisi, 2015; Engstrand & Ericsson, 1999; Parker, 2018, who provides a detailed overview of the relevant literature). Preliminary research in Slovak (Gregová, 2012) indicates that the organization of segments in the structure of the Slovak syllable is not fully in accordance with the principle of sonority sequencing.

Consequently, the aim of this paper is to provide a detailed analysis of initial and final consonant clusters in Slovak on the basis of the SSP. Following the functional theory of the syllable structure (see, for example, Gregová, 2016; Kuryłowicz, 1948; Sabol, 1989), the medial clusters will not be included in the analysis since they are easily decomposable into legal initial and final clusters (Hammond, 1999, p. 69) or, in other words, they are “the possible combinations of initials and finals” (Jones, 1976, p. 121). First, I will introduce the sonority hierarchy delimited for Slovak, then the models of the initial and the final clusters will be specified and analysed from the viewpoint of the SSP. The results will be summarized and commented on in the conclusion.

2. The sonority hierarchy in the Slovak language

The literature on sonority offers a number of sonority scales (for details, see Parker, 2002). They all agree on vowels as the most sonorous segments and obstruents as the sounds with the lowest degree of sonority. Parker, in his account of sonority, mentions that he found more than 100 sonority hierarchies, some of them promoting their universality and others being suitable only for particular languages (Parker, 2002, p. 62). One of the most quoted sonority scales is that proposed by Jespersen (Jespersen, 1904). Considering the aim of my research, a sonority-based analysis of initial and final consonant clusters, attention will be paid to the ranking of consonants. Following Jespersen's theory, consonant

sounds are arranged into the following sonority hierarchy: “r-sounds > laterals > nasals > voiced fricatives > voiced stops > voiceless fricatives > voiceless stops” (Jespersen, 1904, p. 192). When comparing this hierarchy to the sonority scale offered by Universal 626 (see above), it is clear that Jespersen’s scale provides a more detailed sonority specification of voiced and voiceless fricatives and stops. Languages with affricates offer even more refined sonority hierarchies, as for example the following one for Polish: glides > liquids > nasals > fricatives > affricates > stops (Pawelec, 2012, p. 184). In the Slovak language, there are nine degrees of the sonority of consonants depending on the place and manner of articulation of these segments, as specified in Table 1.²

Table 1. The sonority hierarchy of Slovak consonants (cf. Sabol & Ivančová, 2014)³

Degree of sonority	Type of consonant
8	liquids r, l
7	nasals m, n
6	sonorants j, ĺ, ň ⁴
5	voiced fricatives v, z, ž, h
4	voiceless fricatives f, s, š, χ
3	voiced affricates ʒ, ʒ ⁵
2	voiceless affricates, c, č
1	voiced plosives b, d, ď, g
0	voiceless plosives p, t, t̥, k

² For a detailed phonetic and phonemic discussion about the sonority differences among obstruents in languages and the different sonority of voiced and voiceless sounds in languages, see Parker, 2002.

³ The transcription symbols for some Slovak consonant phonemes are different from the symbols used by the IPA. In particular, the Slovak symbols /[š, ž, č, ʒ, ĺ, ň, ĺ]/ stand for the IPA /[ʃ, ʒ, ʧ, ʤ, ʈ, ɖ, ɲ, ʎ]/, respectively. See also note 5.

⁴ Usually, the label “sonorant” is used to indicate all consonantal segments /r, l, m, n, j, ĺ, ň/ to distinguish them from obstruents (i.e. fricatives, affricates and plosives) in Slovak. Nonetheless, there are differences in the degree of sonority among sonorants, and thus the name “sonorant” is used here only to indicate the sounds with an identical degree of sonority that is lower than the sonority of the other sonorants, liquids /r, l/ and nasals /m, n/. A similar simplification is applied to nasals. In Slovak, there are three nasal phonemes /m, n, ň/; however, the sonority of /ň/ is lower than the sonority of /m, n/, which is why /ň/ is covered by the term sonorant only.

⁵ The symbol /ʒ/ stands for the alveolar voiced affricate as pronounced, for example, in the word *priadza* ‘yarn’, and the symbol /ʒ/ indicates the post-alveolar voiced affricate occurring, for example, at the beginning of the word *džavot* ‘jabber’.

2.1. The Sonority Sequencing Principle and Slovak initial clusters

According to Kuryłowicz (Kuryłowicz, 1948), the beginning of the word is at the same time the beginning of the first syllable of the word and the end of the word is at the same time the end of the last syllable of the word. In Slovak, the maximum number of consonants occurring word/syllable-initially is four. No word in Slovak can begin with more than four consonants.⁶ Most of the initial consonant clusters are binary (CC). These clusters represent almost 93.9% of all consonant clusters occurring in the initial position of a word (syllable). Less frequent are three-consonant clusters (CCC), representing 5.8%, and the lowest frequency of occurrence can be observed in four-consonant clusters (CCCC), accounting for only 0.3% (Sabol & Ivančová, 2014).

2.1.1. The sonority-based analysis of initial two-consonant clusters

Slovak initial CC clusters fall into 34 different types⁷ (Table 2), and seven of them violate the SSP as specified for Slovak.⁸

⁶ Claims that some Slovak words start with a five-consonant cluster (e.g. *zmrzlina* ‘ice-cream’, *žblnkot* ‘murmur’ or *žbrnda* ‘pigswill’) do not respect the difference between the graphic and the sound level of a language and the important fact that the syllable is a sound unit. The word *zmrzlina* ‘ice-cream’ is three-syllabic: *zmr.zli.na* with ‘-r-’, ‘-i-’ and ‘-a-’ as syllabic nuclei. The words *žblnkot* ‘murmur’ and *žbrnda* ‘pigswill’ are both di-syllabic: *žbln.kot* and *žbrn.da* with the syllabic nuclei ‘-l-’, ‘-o-’ and ‘-r-’, ‘-a-’, respectively. In line with the idea that a consonant cluster is a sequence of consonants that appear together in the syllable without a vowel between them (see, for example, Jones, 1976) and that the centre of the syllable can be a vowel but also a consonant with a high degree of sonority, in all three words there are only two-consonant initial clusters (see also Gregová, 2016).

⁷ An exhaustive list of (almost) all tokens of initial, medial and final clusters obtained by the comparison of several sources, as well as by an in-depth analysis of the Slovak national corpus, can be found in Gregová, 2012, 2016.

⁸ In the Slovak language, the combinations of two obstruents or two nasals are allowed word-initially (Zec, 2007, p. 189); for example, *ktorý* ‘which’ or *mnoho* ‘many’. Sonority plateaus are acceptable in this language and the Minimal Sonority Distance for Slovak is 0.

Table 2. Types of initial two-consonant clusters in Slovak⁹

Type of cluster	Sample cluster(s)	Sample word(s)
voiceless stop + voiceless fricative	pš	<i>pšenica</i> ‘wheat’
voiceless stop + nasal	tm, km	<i>tma</i> ‘darkness’, <i>kmeň</i> ‘tribe’
voiceless stop + sonorant	pň	<i>pniak</i> / <i>pňiak</i> / ¹⁰ ‘stump’
voiceless stop + liquid	pr, kl	<i>proti</i> ‘against’, <i>plat</i> ‘income’
voiceless stop + voiceless stop	tk, kt	<i>tkáč</i> ‘weaver’, <i>kto</i> ‘who’
voiceless stop + voiced fricative	tv, kv	<i>tvár</i> ‘face’, <i>kvet</i> ‘flower’
voiced stop + voiced stop	bd’	<i>bdelo</i> / <i>bdělo</i> / ‘being awake’
voiced stop + voiced fricative	bz, dv	<i>bzukot</i> ‘humming’, <i>dva</i> ‘two’
voiced stop + sonorant	dň, bl’	<i>dnes</i> / <i>dňes</i> / ‘today’, <i>blabot</i> ‘gibberish’
voiced stop + liquid	br	<i>brána</i> ‘gate’
voiced stop + nasal	dn	<i>dno</i> ‘bottom’
voiceless fricative + voiceless stop	sp, st	<i>spolu</i> ‘together’, <i>sto</i> ‘hundred’
voiceless fricative + voiceless fricative	sχ, fš	<i>schuti</i> / <i>sχuťil</i> / ‘with taste’, <i>všetko</i> / <i>fšetko</i> / ‘all’
voiceless fricative + voiced fricative	sv, χv	<i>svet</i> ‘world’, <i>chvála</i> / <i>χvála</i> / ‘praise’
voiceless fricative + voiceless affricate	χc, fč	<i>chcieť</i> / <i>χcieť</i> / ‘want’, <i>včela</i> / <i>fčela</i> / ‘bee’
voiceless fricative + nasal	sn	<i>snaha</i> ‘endeavour’
voiceless fricative + sonorant	sň, fl’	<i>sneh</i> / <i>sňeh</i> / ‘snow’, <i>flak</i> ‘stain’
voiceless fricative + liquid	sl, šr	<i>slon</i> ‘elephant’, <i>šrot</i> ‘scrap’
voiced fricative + voiced stop	vd, vd’	<i>vdova</i> ‘widow’, <i>vdaka</i> ‘thanks’
voiced fricative + voiced fricative	zv, vz	<i>zvázok</i> ‘bundle’, <i>vziat</i> ‘to take’
voiced fricative + nasal	zn, hn	<i>znak</i> ‘sign’, <i>hnat</i> ‘to rush’
voiced fricative + sonorant	zň	<i>zniesť</i> / <i>zňiest</i> / ‘to bear’
voiced fricative + liquid	zl	<i>zlosť</i> ‘anger’
sonorant + nasal	ľn	<i>ľnúť</i> ‘to cling’
nasal + nasal	mn	<i>množina</i> ‘set’
nasal + sonorant	mň, ml’	<i>mňaukať</i> ‘mew’, <i>mlieť</i> / <i>mliet</i> / ‘to mill’
nasal + liquid	ml	<i>mladý</i> ‘young’
liquid + voiceless stop	lk	<i>lkať</i> ‘to lament’
liquid + voiced fricative	ľž	<i>ľživo</i> ‘falsely’
voiceless affricate + voiced fricative	cv	<i>cvik</i> ‘exercise’

⁹ Clusters violating the SSP are highlighted in grey.¹⁰ When the sound form of a word is different from its graphic form, the sound form is marked between slashes.

Type of cluster	Sample cluster(s)	Sample word(s)
voiceless affricate + voiceless stop	ct'	<i>ctiť</i> / <i>ctiťť</i> / 'to honour'
voiceless affricate + nasal	cn, čn	<i>cnosť</i> 'virtue'
voiceless affricate + sonorant	cň, čň	<i>cnieť sa</i> / <i>čňieť sa</i> / 'to miss', <i>čňieť</i> 'to soar'
voiceless affricate + liquid	cl	<i>clo</i> 'tariff'

The clusters that do not follow the SSP will now be analysed in more detail.

2.1.1.1. The analysis of the initial two-consonant clusters violating the SSP

As it follows from Table 2, initial two-consonant clusters that violate the Sonority Sequencing Principle, that is, their Minimal Sonority Distance is 0 (see note 8), fall into five categories, depending on their initial segment:

- (1) starting with a voiceless fricative, for example: sp, st, sv, xv
- (2) starting with a voiced fricative, for example: vd, vd'
- (3) starting with a nasal, for example: mň, mľ
- (4) starting with a liquid, for example: lk, lž
- (5) starting with a voiceless affricate, for example: ct'

The visual difference between the so-called well-formed and ill-formed syllables with well-formed and ill-formed initial clusters from the viewpoint of the SSP can be seen in Figures 1–3. The sonority degrees of consonants are captured in Table 1. Degree 10 belongs to vowels, and degree 9 indicates the sonority of the semi-vowels [i] and [û] that occur at the beginning of Slovak diphthongs (see Figure 6).

Figure 1. Sonority graph of the monosyllabic word *znak* 'sign' with the initial cluster 'zn'

Figure 2. Sonority graph of the monosyllabic word *tkáč* 'weaver' with the initial cluster 'tk'

Figure 3. Sonority graph of the word *spolu* 'together' with the initial cluster 'sp'

Figure 1 illustrates CC cluster 'zn' with rising sonority, and Figure 2 – cluster 'tk' with the plateau between 't' and 'k', representing the Minimal Sonority Distance of 0 that is acceptable in Slovak (see note 8). Figure 3 visualizes the cluster 'sp' that violates the principle of rising sonority in the syllable onset (see Pawelec, 2012, pp. 185–186 for similar findings in Polish).

The clusters in (2)–(5) are very rare in Slovak. The sample clusters in (2) can only be found in the words *vdova* 'widow', *vdaka* 'thanks' and their derivatives. The exceptional clusters in (3) occur in some onomatopoeic

words and their derivatives (*mňaukať* ‘mew’) or in the so-called higher pronunciation style of some words (Král, 2005) as a result of a neutralization process (for details, see Sabol, 1989). The clusters starting with a liquid (4) manifest themselves in some poetic and literary expressions, that is, in stylistically marked words borrowed from Czech (Sabol, 1975, p. 204), for example, *lkať* ‘to lament’ or *lživo* ‘falsely’. The cluster ‘ct’ occurs only in words derived from *ctený* ‘honoured’ or *ctiť* ‘to honour, to revere’, which are considered archaic and not stylistically neutral, either. However, CC combinations with a voiceless fricative at their beginning, especially those starting with ‘s’ (‘sp’, ‘st’, ‘sv’), are the most frequent initial CC clusters in Slovak (Sabol, 1975, p. 53).

2.1.2. The sonority-based analysis of initial three-consonant clusters

There are 28 types of initial CCC clusters in standard Slovak (see note 7), and 16 of them do not follow the SSP (Table 3).

Table 3. Types of initial three-consonant clusters in Slovak¹¹

Type of cluster	Sample cluster(s)	Sample word(s)
voiceless stop + voiceless stop + voiced fricative	tkv	<i>tkviet</i> ‘to lie’
nasal + voiced stop + liquid	mdl	<i>mdlý</i> ‘insipid’
nasal + voiceless fricative + voiceless stop	mstʃ	<i>mstivý</i> / <i>mstivý</i> / ¹² ‘vengeful’
voiced fricative + voiced fricative + voiced stop	vzd	<i>vzdať sa</i> ‘to give up’
voiced fricative + voiced fricative + sonorant	zhl	<i>zhluk</i> ‘clump’
voiced fricative + voiced fricative + liquid	vzr	<i>vzrast</i> ‘growth’
voiced fricative + voiced fricative + nasal	vzn	<i>vznášať sa</i> ‘to hover’
voiced fricative + voiced stop + liquid	zbl	<i>zblázniť sa</i> ‘get crazy’
voiced fricative + voiced stop + voiced fricative	zdv	<i>zdvihnúť</i> ‘to lift’
voiced fricative + voiced stop + sonorant	zgň	<i>zgniaviť</i> / <i>zgňiaviť</i> / ‘to get sb. down’
voiced fricative + voiced stop + nasal	zdn	<i>zdnu</i> ‘from the inside’
voiceless fricative + voiceless fricative + voiceless stop	fst	<i>vstať</i> / <i>fstať</i> / ‘to get up’

¹¹ See note 9.

¹² See note 10.

Type of cluster	Sample cluster(s)	Sample word(s)
voiceless fricative + voiceless fricative + voiced fricative	sχv	<i>schválne /sχválŋe/</i> ‘intentionally’
voiceless fricative + voiceless fricative + sonorant	sχŋ	<i>schňapnúť /sχňapnúť/</i> ‘to snatch’
voiceless fricative + voiceless fricative + nasal	sχm	<i>schmatnúť /sχmatnúť/</i> ‘to grip’
voiceless fricative + voiceless fricative + liquid	sχr	<i>schránka /sχránka/</i> ‘case’
voiceless fricative + voiceless fricative + voiceless fricative	fsχ	<i>vzchopiť sa /fsχopiť sa/</i> ‘to recover’
voiceless fricative + nasal + liquid	smr	<i>smrad</i> ‘stench’
voiceless fricative + voiceless affricate + voiced fricative	scv	<i>scvrknúť sa</i> ¹³ ‘to shrink’
voiceless fricative + voiced fricative + liquid	svr	<i>svrab</i> ‘scabies’
voiceless fricative + voiceless stop + liquid	str	<i>strana</i> ‘page’
voiceless fricative + voiceless stop + sonorant	fpl	<i>vpletať /fplɛtať/</i> ‘to wreath’
voiceless fricative + voiceless stop + voiced fricative	štv	<i>štvorec</i> ‘square’
voiceless fricative + voiceless stop + nasal	stm	<i>stmievať sa</i> ‘getting dark’
voiced fricative + nasal + liquid	hml	<i>hmla</i> ‘fog’
voiced fricative + nasal + nasal	zmn	<i>zmnožiť</i> ‘to multiply’
voiced fricative + nasal + sonorant	hml	<i>hmľisto /hmlisto/</i> ‘hazily’
sonorant + voiceless fricative + voiceless stop	lst	<i>lstivo /lstivo/</i> ‘tricky’

2.1.2.1. The analysis of the initial three-consonant clusters violating the SSP

Table 3 shows that the initial CCC clusters violating the SSP are the following types:

- (1) starting with a nasal, for example: mdl, mst
- (2) starting with a voiced fricative, for example: vzd, zbl, zdv, zgŋ, zdn, hml
- (3) starting with a voiceless fricative, for example: fst, scv, svr, str, fpl, štv, stm
- (4) starting with a sonorant, for example: lst

¹³ See note 6.

It is clear that the initial segments disturbing the principle of sonority in the initial three-consonant combinations are the sounds ‘m’, ‘v/f’,¹⁴ ‘z/s’,¹⁵ ‘h’ and ‘ŕ’. The sonority shapes of the sample CCC clusters violating the SSP are illustrated in Figure 4 and Figure 5.

Figure 4. Sonority graph of the word *mdlý* /*mdli*/ ‘insipid’ with the initial cluster ‘mdl’

Figure 5. Sonority graph of the word *vstat'* /*fstat'*/ ‘to get up’ with the initial cluster ‘fst’

¹⁴ The occurrence of either ‘v’ or ‘f’ depends on the character of the following segment due to the regressive assimilation of voicing (neutralization of the phonological opposition voiced – non-voiced) in the Slovak language. See also note 15.

¹⁵ The occurrence of either ‘z’ or ‘s’ depends on the character of the following segment due to the regressive assimilation of voicing (neutralization of the phonological opposition voiced – non-voiced) in Slovak. See also note 14.

Clusters starting with ‘h’ and ‘ŕ’ are very rare. The cluster ‘hml’ in *hmľisto* /*hmľisto*/ ‘hazily’ originated as an anagram from Old Church Slavic **mbgla* (see Králik, 2015). The clusters with an initial ‘ŕ’ can be found in borrowings from Czech (*ľstivo* /*ľšťivo*/ ‘tricky’). The clusters with a nasal sound at their beginning (‘mdl’, ‘mst’) can also be found only in words with a Czech origin (see Table 3 for examples). The other sequences of consonants of the types (2) and (3), that is, those starting with a voiced/voiceless fricative, are among the most common types of initial consonant clusters in Slovak (see Gregová, 2016; Sabol, 1975).

2.1.3. The sonority-based analysis of initial four-consonant clusters

When considering the initial consonant clusters, the combinations with four segments (CCCC) are the least numerous. There are five types of initial four-consonant clusters in Slovak (Table 4).

Table 4. Types of initial four-consonant clusters in Slovak¹⁶

Type of cluster	Sample cluster(s)	Sample word(s)
voiceless stop + voiceless fricative + voiceless stop + liquid	pstr	<i>pstruh</i> ‘trout’
voiced fricative + voiced fricative + voiced fricative + sonorant	vzhľ	<i>vzhľad</i> ‘appearance’
voiced fricative + voiced fricative + voiced stop + nasal	vzdm	<i>vzdmúť sa</i> ‘to hoist’
voiceless fricative + voiceless fricative + voiceless stop + liquid	fspr	<i>vzpriamený</i> / <i>ľspriamení</i> / ¹⁷ ‘upright’
voiceless fricative + voiceless fricative + voiceless stop + voiced fricative	fskv	<i>vzkvitať</i> / <i>ľskvitať</i> / ‘to flower’

Four types of initial CCCC clusters violate the SSP, as indicated in Table 4 and visualized in Figure 6.

¹⁶ See note 9.

¹⁷ See note 10.

2.1.3.1. The analysis of the initial four-consonant clusters violating the SSP

Taking into account the SSP, and as it follows from Table 4, the exceptional initial CCCC clusters are of two types:

- (1) starting with a plosive, for example: pstr
- (2) starting with a fricative, for example: vzd_m, fspr, fskv

Four-consonant clusters starting with a plosive, for example, the cluster in (1), are very limited. The clusters in (2) can be seen as initial three-consonant clusters starting with a fricative (Table 3) preceded by the initial fricative ‘v/f’.¹⁸ Thus, the sonority is violated by the initial sequence “fricative – fricative” as a whole, as can be seen in the sample analysis of the cluster ‘fspr’:

f – sonority degree 4, s – sonority degree 4, p – sonority degree 0,
r – sonority degree 8

the sequence of sonority in the cluster ‘fspr’ = 4 – 4 – 0 – 8

(see Table 1 and Figure 6 for sonority degrees)

Figure 6. Sonority graph of the word *vzpriamit'* /*fspriamit'* 'to raise sth.' with the initial cluster 'fspr'

¹⁸ See note 14.

2.2. The Sonority Sequencing Principle and the Slovak final clusters

The phonotactic possibilities at the end of Slovak words (syllables) are not as rich as in the initial position (see 2.1). There are only two- and three-consonant clusters in the word/syllable-final position in Slovak (see, for example, Gregová, 2016; Sabol, 1975). Final two-consonant clusters prevail over three-consonant clusters in the final position by 91.4% to 8.6%, respectively.

2.2.1. The sonority-based analysis of final two-consonant clusters

In the Slovak language, the final two-consonant clusters fall into 19 types (Table 5, see also note 7), and only two types of those clusters violate the SSP. A graphical presentation of a sample cluster that does not follow the SSP is given in Figure 7.

Table 5. Types of final two-consonant clusters in Slovak¹⁹

Type of cluster	Sample cluster(s)	Sample word(s)
voiceless stop + voiceless fricative	ps, ks	<i>člups</i> 'plop', <i>keks</i> 'biscuit'
voiceless stop + voiceless stop	kt	<i>akt</i> 'act'
voiceless fricative + voiceless plosive	st, ft	<i>test</i> 'test', <i>kšeft</i> 'racket'
voiced fricative + voiced stop	zd	<i>drozd</i> 'robin'
voiced fricative + voiceless stop	vk	<i>huriavk</i> 'clamour'
nasal + voiceless stop	mp	<i>lump</i> 'rogue'
nasal + voiced stop	ng	<i>ceng</i> 'ding'
nasal + voiceless fricative	mf	<i>tromf</i> 'trump'
nasal + voiceless affricate	nc	<i>kredenc</i> 'cupboard'
liquid + nasal	lm	<i>film</i> 'film'
liquid + voiceless stop	lp	<i>skalp</i> 'scalp'
liquid + voiced stop	ld	<i>fald</i> 'pleat'
liquid + voiceless affricate	lc	<i>filc</i> 'felt'
liquid + voiced fricative	lz	<i>pulz</i> 'pulse'
liquid + voiceless fricative	lš	<i>falš</i> 'spin'
liquid + sonorant	rň	<i>čerň</i> 'blackness'

¹⁹ See note 9.

Type of cluster	Sample cluster(s)	Sample word(s)
sonorant + voiceless stop	jt	<i>policajt</i> ‘policeman’
sonorant + voiced stop	jd	<i>pôjd</i> ‘loft’
sonorant + nasal	jn	<i>kombajn</i> ‘harvester’

2.2.1.1. The analysis of the final two-consonant clusters violating the SSP

Final CC clusters that are not in line with the SSP can be classified into two categories, according to the final segment:

- (1) ending with a fricative, for example: ps
- (2) ending with a nasal, for example: jn

The clusters ending in a nasal are very exceptional and can be found only in words of foreign origin, for example, ‘jn’ in the word *kombajn* ‘harvester’ (English origin) or in the word *dizajn* ‘design’ (French origin, cf. e.g. Králik, 2015). Final two-consonant clusters ending in a fricative are not frequent, either. They manifest themselves in some onomatopoetic expressions, for example, *člups* ‘plop’ and in foreign words, for example, *kolaps* ‘collapse’ (taken from Latin) or *čips* ‘chips’ (English origin).

Figure 7. Sonority graph of the word *člups* ‘to plop’ with the final cluster ‘ps’

2.2.2. The sonority-based analysis of final three-consonant clusters

There are three types of final three-consonant clusters in Slovak (Table 6) and they are all fully in agreement with the SSP, which states that the sonority lowers towards the edges of the syllable (see above).

Table 6. Types of final three-consonant clusters in Slovak

Type of cluster	Sample cluster(s)	Sample word(s)
nasal + voiceless plosive + voiceless plosive	nkt	<i>inštinkt</i> 'instinct'
sonorant + voiceless fricative + voiceless plosive	jst'	<i>nájst'</i> 'to find'
sonorant + voiced fricative + voiced plosive	jzd'	<i>nájst'</i> 'to find' ²⁰

3. Discussion and implications for further research

Considering the overall number of word/syllable-initial consonant clusters in Slovak (67 types), 40% of them are not in line with the principle of sonority. Although the occurrence of many of those clusters is limited to borrowings from other languages, initial two- and three-consonant clusters starting with fricatives, among them especially those starting with 's', are the most common types of consonant clusters in standard Slovak (see 2.1.1.1 and 2.1.2.1). The final clusters are less numerous and the number of those violating the SSP is lower, too (9%). The present analysis thus proves the claim about the distribution and character of tokens and types of consonant clusters per syllable position: in the Slovak language, the word/syllable-final combinations of consonants are not only less frequent (compared to the initial and medial positions) but also the least varied (cf. Gregová, 2016; Sabol, 1975).

The findings on the initial clusters raise two basic questions: (1) Is the Slovak language somehow exceptional pursuant to the principle of sonority? and (2) If the syllables whose structure violates the Sonority Sequencing Principle are considered ill-formed, why are they so prevalent in the language?

²⁰ The word *nájst'* 'to find' is pronounced as /nájzd'/ when followed by a voiced sound. The assimilation of voicing in Slovak is regressive and occurs at word boundaries, too (for details, see, for example, Sabol, 1989).

The answer to the first question is definitely negative. As already mentioned, the existence of consonant clusters whose sonority line does not increase towards the syllable's centre as predicted by the SSP is a well-known phenomenon in many languages. Nevertheless, the question about the popularity of the sonorously ill-formed clusters in Slovak remains unanswered.

In a slightly elided theory about the creation of consonant clusters on the basis of the distinctive features of phonemes and the phonological oppositions between the individual phonemes in the consonant cluster, Sabol says that the possible combinations of segments in words are given not only by the articulatory-acoustic properties of those segments but also by their phonological characteristics (Sabol, 1975, p. 204). Taking into account the Slovak language and the structure of its consonant clusters, in the sequence of two obstruents, the pattern “fricative + occlusive” is more natural than the reverse one. This means that the phonotactics of the consonantal sounds in Slovak predominantly uses the phonological opposition “occlusive – non-occlusive”, which offers communicatively suitable combinations of sounds (Sabol, 1975, p. 206).

Consequently, all exceptional CCC clusters (see 2.1.2) reflect the ordering of contrasting distinctive features typical of Slovak: occlusive – non-occlusive and vocalic – non-vocalic, that is, the sequence “fricative consonant – plosive consonant – sonorant”, which is clearly favoured in the structure of Slovak words (Sabol, 1975, p. 206). Those clusters are ill-formed from the viewpoint of their phonetic properties, their sonority (see note 1); nonetheless, all of those clusters can be evaluated as well-formed in line with the combinability of sounds depending on their phonological features.

The adjustment of consonant sequences to “suitable communicative needs” (Sabol, 1975, p. 204) is also implied in the theory of Engstrand and Ericsson, whose experiment indicates that “onsets such as [sp], [st] and [sk], and codas such as [ps], [ts] and [ks] have a perceptual advantage over those predicted by the sonority hierarchy” (Engstrand & Ericsson, 1999, p. 49).

To prove or disprove either the theory of the combinability of sounds on the basis of their distinctive features and phonological oppositions (Sabol, 1975) or the assumption about the perceptual convenience of sonorously ill-formed clusters (Engstrand & Ericsson, 1999) requires a more detailed analysis of the consonant clusters violating the SSP in the Slovak language and in other typologically identical and different languages. The results of such research may thus have broader typological implications.

4. Conclusion

In accordance with the Sonority Sequencing Principle (SSP), also known as the Sonority Sequencing Generalization, the structure of the syllable in languages depends on the sonority of the individual segments: the most sonorous sound creates the peak of the syllable (the syllabic nucleus, centre) and the sonority of segments in the syllable onsets and codas increases towards the syllable peak. A detailed analysis of initial and final consonant clusters in Slovak delimited on the basis of Kuryłowicz's functional approach (Kuryłowicz, 1948) has shown that almost 40% of initial clusters in Slovak violate the SSP. Although some of those sonorously ill-formed clusters occur only in words that are on the periphery of the Slovak vocabulary, many clusters, mainly those starting with a voiced/voiceless fricative, are very common in the central vocabulary. The frequent initial ill-formed clusters violating the SSP usually have the consonant /s/ as their initial segment. Similar findings on the violation of the SSP in the word-initial position can be observed in other (not only Slavic) languages (see section 1). The data about the violation of sonority in languages indicate both that the sonority of segments is not the only criterion a language uses for the creation of words, and that the process of the creation of consonant sequences can also be governed by the combinability of segments on the basis of their distinctive features (Sabol, 1975) and/or by the perceptual advantage of consonants' combinations in languages (Engstrand & Ericsson, 1999). However, the verification of these two theories is a task for future research.

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The Sonority Sequencing Principle and the Structure of Slovak Consonant Clusters

Summary

In line with the Sonority Sequencing Principle (SSP), the centre of the syllable is the most sonorous sound and the sonority of the other segments in the syllable drops towards the syllable edges. Nevertheless, in many languages, there are syllable onsets and codas that violate this principle of sonority. Following the functional approach proposed by Jerzy Kuryłowicz, types of word/syllable-initial and word/syllable-final clusters in standard Slovak were delimited. A sonority-based analysis of those clusters revealed that almost 40% of the common initial consonant sequences violate the SSP. The situation with the final clusters is similar. These findings indicate that the creation of consonant clusters in a language does not depend solely on the sonority of the individual segments but also follows other phonological and/or perceptual regularities connected with the process of communication.

Zasada sekwencji sonorności a struktura zbitek spółgłoskowych w języku słowackim

Streszczenie

Zgodnie z zasadą sekwencji sonorności (Sonority Sequencing Principle, SSP) jądro sylaby jest dźwiękiem o najwyższej sonorności, a sonorność pozostałych segmentów sylaby maleje wraz z odległością od jądra. Niemniej jednak w wielu językach występują nagłosy i wygłosy, które naruszają tę zasadę. Przyjmując podejście funkcjonalne zaproponowane przez Jerzego Kuryłowicza, wyróżniono typy zbitek w nagłosie i wygłosie w standardowym języku słowackim. Ich analiza pod względem sonorności wykazała, że prawie 40% sekwencji powszechnie występujących w nagłosie narusza zasadę sekwencji sonorności. W przypadku

wygłosu wynik był podobny. Ustalenia te wskazują, że tworzenie zbitek spółgłoskowych nie zależy wyłącznie od sonorności poszczególnych segmentów, ale również od innych prawidłowości fonologicznych i/lub percepcyjnych związanych z procesem komunikacji.

Keywords: sonority principle; consonant cluster; Slovak language; sonority violation

Słowa kluczowe: zasada sekwencji sonorności; zbitka spółgłoskowa; język słowacki; naruszenie zasady sekwencji sonorności

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