Sonority-Based Analysis vs. Complex-Sound Analysis of the Word-Initial Consonant Clusters in English and in Slovak

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Abstract

Traditionally, the universal phonological principle known as the Sonority Sequencing Generalization (SSG) governs the phonotactics of syllable onsets and codas. Nonetheless, one of the latest approaches to syllable structure – the CVX theory – relativizes the reliability of this principle and analyses the syllable on the basis of a complex sound. This paper presents a comparative analysis of the word-initial consonant clusters in English and in Slovak in terms of both the sonority-based analysis and the complex-sound analysis. The research has shown that while the complex-sound analysis seems to be more suitable for English, the sonority-based analysis is more suitable for Slovak.

Keywords: sonority-based analysis, complex-sound analysis, consonant cluster, English, Slovak

1 Introduction

A core term for the traditional acoustic and/or perceptional delimitation of a syllable is sonority – the relative loudness of a sound given by the functioning of vocal cords and the opening of cavities (see, e.g., Ladefoged 221; Giegerich 132). Most phonetically oriented textbooks mention that "a syllable is a sequence of sounds containing one peak of prominence" (O'Connor and Trim 240). The prominence of a sound is given by its inherent sonority, length, stress, special intonation, or by combinations of these (for details, see Jones 55). O. Jespersen (1904) was the first linguist to arrange all speech sounds on the so-called sonority scale. The most sonorous sounds (the top of the scale) are usually those with an intrinsically voiced character, i.e. vowels and approximants, while sounds with a lower degree of sonority (the bottom of the scale) are those that can be voiced or voiceless, i.e. stops and fricatives (see, e.g., McMahon). Since that time, the notion of sonority and the sonority hierarchy has been discussed in a number of publications on the syllable and related issues (see, e.g., Clements for more information). The structure of the sonority hierarchy in a particular language then depends on the type and number of speech sounds in the given language (cf. Tab. 1, 2).

In general, it can be said that the syllable, as the smallest unit of continuous speech, comprises three phases: initial (onset), central (peak) and final (coda). The nucleus or the peak formed by a vowel or by syllabic consonants is the main phase. Sounds with the ability to form the peak of the syllable are called sonants. The other two phases of the syllable may be filled with non-sonants (consonants). The possible number and structure (i.e. combination) of consonant elements in onsets and codas is given by language-specific phonotactic rules and by the universal phonological principle which is known as the Sonority Sequencing Generalization (for details see, e.g., Rubach; McMahon).

The Sonority Sequencing Generalization (SSG), which governs the shape of both syllable onsets and codas, states that "the sonority of segments must decrease towards the edges of the syllable in accordance with the following scale: nucleus – liquids – nasals – fricatives – stops" (Rubach 213).

In other words, the peak or the centre of the syllable is the most sonorous sound and the sonority of other syllable segments decreases towards the margins. For example, in the monosyllabic word *pet* [pet], the vowel [e][1] is the sound with the highest degree of sonority, whereas the elements [p] and [t] occupy the lowest level in the sonority scale and can form only the margins of the syllable.

A significant exception to this rule is represented by the consonant /s/, whose occurrence at the beginning of onsets violates the SSG in many languages (for details see McMahon 108), as I will also mention later in my analysis.

Syllable is a key term in the phonetic and phonemic description of a language and its structure. Although linguists agree on the fact that native language users can intuitively count the number of syllables in a word, linguistic definitions of the substance, origin, structure and function of this unit are not uniformly subscribed to (see, e.g., Abercrombie; Romportl; Roach; Gregová, 2008).

One of the recent theories of syllable structure is the CVX theory by S. Duanmu (2009), which claims that CVX is the upper limit of syllable size in all languages. All three syllable parts (C, V and X[2]) can be a complex sound and any extra consonants at word edges are easily accounted for by morphology – the Affix Rule[3], the Potential Vowel[4], and the Anti-Allomorphy[5]. The crucial concept for syllable analysis in terms of this morphological approach to its structure is – as Duanmu mentions – the notion of a complex sound based on the minimalist feature theory and the articulator-based feature geometry (Duanmu 35, see also Tab. 3).

A complex sound is characterized by a gestural overlap of at least two sounds (Duanmu 25). This 'overlapping' or merging of sounds is governed by the No Contour Principle, according to which "an articulator cannot make the same feature twice within one sound" (ibid. 174). This means that the only sounds that can form a complex sound are those whose articulatory features overlap (ibid. 5), because overlapping gestures are made simultaneously. And thus a complex sound – consisting of originally two sounds with overlapping gestures or features – takes just one timing slot. For example, the gesture of [b] is Labial and that of [r] is Coronal; they are independent and can overlap. Therefore [br] forms a complex sound and fits into a single slot. On the other hand, conflicting gestures must be made in a sequence and require more than one timing slot; they cannot overlap. For example, a complex sound cannot be characterized simultaneously by both [+nasal] and [-nasal], and that is why a consonant cluster [bm] cannot represent a complex sound (for details see Duanmu).

Duanmu evaluates his theory of the syllable on five languages – Standard Chinese, Shanghai Chinese, Jiarong, English and German. In order to exemplify the advantage of the analysis of consonant clusters in onsets and codas in terms of the notion of a complex sound, he compares the sonority-based analysis to the complex-sound analysis of consonant clusters in English onsets (Duanmu 168–179). The author comes to the conclusion that when the word-initial consonant /s/ is excluded from the syllable structure[6], the occurring clusters do not satisfy the Sonority Sequencing Generalization, but "all English onset clusters can be represented as a complex sound" (ibid. 179), which requires only one timing slot, or they can be accounted for by morphology (see notes 2–4). Simply stated, most of the word-initial onset clusters in English violate the traditional analysis based on the sonority of sounds, but it seems that all of them satisfy the complex-sound analysis.

However, the application of the CVX theory of the syllable to Slovak (see Gregová, 2011) has shown that in the Slovak language, which allows maximum four-consonant clusters in the onset, not all word-initial consonant sequences can be treated as complex sounds or can be supported by morphological rules, and at least a two-slot onset template is required in this language[7] (for details see ibid.). Thus the question arises here: if the Slovak word-initial consonant clusters do not satisfy the complex-sound analysis, do they satisfy the sonority-based analysis?

In order to answer this question I have decided to analyse all possible onsets, i.e. word-initial[8] consonant clusters, in English and in Slovak. First, the sonority-based and the complex-sound analysis of the English word-initial consonant clusters – as carried out by Duanmu – will be briefly introduced in order to illustrate the methodology and crucial terminology of the traditional and the new approach to the structure of the syllable. Then the same types of analyses will be carried out in Slovak, a language that is typologically different from English and that seems not to satisfy the complex-sound analysis. The results of these analyses and their comparison will be summarized in the Conclusion.

2 The sonority-based analysis of the word-initial consonant clusters in English

As mentioned above, "the sonority of a sound is its relative loudness compared to other sounds, everything else […] being equal" (Giegerich 132). In English, as well as in other languages, there are several less or more detailed versions of the sonority scale. They all agree on vowels as the most sonorous sounds, i.e. always at the top of the hierarchy, and obstruents, i.e. fricatives and stops, as the less sonorous sounds, at its bottom end. For example, A. McMahon's hierarchy: low vowels – high vowels – glides – liquids – nasals – voiced fricatives – voiceless fricatives – voiced plosives – voiceless plosives (107) or Zec's slightly different scale with its different ordering of fricatives and stops: low vowels – mid vowels – high vowels – rhotics – laterals – nasals – voiced fricatives – voiced stops – voiceless fricatives – voiceless stops (178).

Duanmu's analysis of consonant clusters is based on four degrees of consonants' sonority as introduced by Kenstowicz (1994): glides (degree of sonority 4) – liquids (degree of sonority 3) – nasals (degree of sonority 2) – obstruents (degree of sonority 1). The Minimal Sonority Distance (MSD) for the word-initial onset clusters in English is 2 (Duanmu). This means that the sonority of the second consonant in the CC cluster should be "at least two degrees higher than that of the first" (ibid. 168). For example, CC cluster [pr]: the sonority degree of [p] is 1, the sonority degree of [r] is 3, the MSD is 2, i.e. [pr] is a good onset cluster. But for example, CC cluster [sn] does not satisfy the MSD: the sonority degree of [s] is 1, the sonority degree of [n] is 2, so the MSD of this cluster is only 1 (for details, see Duanmu 168–169). The sonority analysis of all possible and (even) impossible English word-initial clusters has revealed that in English, there are many clusters that do not satisfy the MSD. On the other hand, many CC clusters that meet the condition of the MSD do not occur in the language (ibid.). In order to give a complete picture of a sonority-based analysis of the English consonant clusters, I will now specify all word-initial consonant clusters in terms of the Kenstowisz sonority scale and the principle of the Minimal Sonority Distance.

The maximum number of consonants at the beginning of English words is three (cf. e.g. Giegerich; Roach). There are 55 word-initial two-consonant clusters in the English language (see Gregová, 2010). The first element is usually /s/ and the second segment is one of the approximants /l, r, w, j/ (see also Roach 73; Duanmu 160).

Initial CC clusters in English

starting with oral plosive: pr, pl, pj, pw, pf, ps, pʃ, br, bl, bj, tr, tw, tj, dr, dj, dw, kr, kl, kw, kj, km, kn, kv, gr, gl, gw (26)

starting with nasal plosive: nj, mj, mw (3)

starting with fricative: fl, fr, fj, vj, vw, θr, θw, θj, st, sp, sk, sl, sw, sn, sm, sf, sj, sr, sv, zl, ʃr, ʃm, ʃn, ʃp, ʃw, hj (26)

starting with approximant: –

starting with affricate: –

(Gregová, 2010)

Six CC clusters [pf, ps, pʃ, km, kn, kv] out of 26 CC clusters starting with an oral plosive do not satisfy the MSD (see Tab. 4). All CC clusters starting with a nasal plosive fulfil the MSD condition. In the group of the word-initial CC clusters starting with a fricative, 10 CC clusters [st, sp, sk, sn, sm, sf, sv, ʃm, ʃn, ʃp] do not satisfy the MSD (Tab. 4). All in all, 16 word-initial CC clusters in English out of 55 do not satisfy the MSD, which makes 29%. This means that almost one third of the existing initial CC clusters in English violate the principle of the MSD. Even if we accept the special status of /[s]/ (see above), which excludes seven consonant clusters that are not well-formed in terms of their sonority, there are still nine clusters, i.e. 16%, left that do not meet the principle of the MSD. And, as Duanmu argues, if we go even further and we agree on the special status of /[ʃ]/, the sonority theory is not followed without exceptions (Duanmu 168–170); there are six frequently occurring CC clusters that do not have a proper sonority rise and cannot be accounted for.

As to the initial three-consonant clusters in English, their number is quite limited. There are nine of them, all starting with [s]: [spl, spr, spj, str, stj, skl, skr, skw, skj] (see Gregová, 2010). If the initial [s] is excluded from the analysis, they all satisfy the MSD. As already mentioned, the exceptional behaviour of the voiceless fricative [s] is well-known not only in English, but also in other languages (McMahon 168).

3 The complex-sound analysis of the word-initial consonant clusters in English

The complex-sound analysis predicts that "if we treat the initial C separately […] then all CC onsets can form a complex sound" (Duanmu 174). As explained in the Introduction, a complex sound has a root node with at least two articulators with overlapping gestures made simultaneously (see, e.g., de Lacy 342).

Duanmu's analysis of the initial CC clusters has shown that most of the two-consonant onset clusters can represent a complex sound (ibid. 174–179). I will now re-analyse all 55 CC clusters in terms of the theory of complex sound. The results of the analysis are summarized in Table 4.

As is clear from the Articulator-Based Feature Geometry (Tab. 3) and the notion of a complex sound, 32 word-initial CC clusters [pr, pl, pj, ps, pʃ, br, bl, bj, tw, dw, kr, kl, kw, kv, gr, gl, gw, mj, fl, fr, fj, vj, θw, sp, sk, sw, sf, sv, ʃm, ʃp, ʃw, hj] can represent a complex sound since they involve different articulators (cf. Duanmu 174–175). For example: [p] – Labial [+stop], [l] – Coronal [+lateral], [pl] – complex sound. [g] – Dorsal, [r] – Coronal, [gr] – complex sound. 12 CC clusters [pw, pf, tr, tj, dr, dj, kj, nj, mw, vw, θj, sj] have the same articulator, but without conflicting features, and thus they can form a complex sound. 11 clusters [km, kn, θr, st, sl, sm, sn, sr, zl, ʃr, ʃn] are not complex sounds. However, Duanmu argues that these clusters are found in word-initial positions only, "where the first C can be treated as lying outside the onset" (177). These unsyllabified consonants are simply accounted for by morphology – the Potential Vowel Rule (see note 3).

All word-initial three-consonant clusters in English start with [s] – [spl, spr, spj, str, stj, skl, skr, skw, skj] – which can be excluded (e.g. McMahon; Duanmu) – and the remaining CC clusters can form a complex sound (Duanmu 177; Tab. 4).

To conclude, the sonority-based theory does not apply to all English word-initial consonant clusters. Even if one accepts the special status of the consonants /s/ and /ʃ/ there are still six clusters that do not follow the MSD or the SSG. However, the complex-sound analysis, supported by the morphological rules of the CVX syllable theory, seems to cover all onset clusters without exceptions.

4 The sonority-based analysis of the word-initial consonant clusters in Slovak

The inventory of consonant phonemes in Slovak, as well as their phonetic specification and the subsequent specification of distinctive features, is slightly different from that in English (cf., e.g., Sabol; Hall). The sonority hierarchy of Slovak consonant phonemes is presented in Tab. 2. Slovak, similarly to Bulgarian, allows combinations OO, ON, NN, NL, and OL[9] in onset clusters, and it can be characterized as a language whose minimal sonority distance (MSD) is 0 (Zec 189).

In Slovak, there are 116 two-consonant clusters, 23 three-consonant clusters and two four-consonant clusters[10].

Initial CC clusters in Slovak[11]

starting with oral plosive: ps, pš, px, pn, pň, pl, bď, bz, bl, bľ, br, tk, tx, tv, tm, tl, tľ, tr, dv, dm, dn, dň, dl, dr, kt, kv, km, kn, kň, kr, kl, kľ, gn, gň, gl, gľ, gr (37)

starting with nasal plosive: mn, mň, ml, mľ, mr (5)

starting with fricative: sp, st, sť, sk, sx, sv, sm, sn, sň, sl, sľ, zb, zv, zn, zň, zl, zr, šp, št, šť, šk, šm, šn, šl, šľ, šr, žv, žm, žň, žľ, žr, hn, hň, hl, hľ, hr, hm, hv, xc, xv, xm, xl, xľ, xr, ft, fť, fč, fs, fš, fl, fľ, fr, vd, vz, vn, vň, vl, vr, lk, lž (60)

starting with affricate: cv, cť, cm, cn, cň, cl, cľ, čp, čv, čm, čn, čl, čľ, čr (14)

Initial CCC clusters in Slovak

starting with oral plosive: tkv (1)

starting with nasal plosive: mdl (1)

starting with fricative: vzd, vzl, str, skl, skľ, skv, smr, stl, zdr, zvl, zbr, zhl, škr, štv, škv, štr, špľ, špr, hml, hmľ, ľst (21)

starting with affricate: –

Initial CCCC clusters in Slovak

starting with oral plosive: pstr, pštr (2)

starting with nasal plosive: –

starting with fricative: –

starting with affricate: –

(Gregová, 2011)

4.1 The sonority-based analysis of the initial CC clusters in Slovak

The results of the sonority-based analysis of the Slovak word-initial two consonant clusters are illustrated in Table 5. The examination of the clusters starting with an oral plosive shows that all 37 initial CC clusters report excellent values in the SSG; the MSD is not below 0.

In the group of five initial CC clusters starting with a nasal plosive, two clusters [mň, mľ] do not follow the SSG. Their sonority rise is lower than the MSD of 0. However, the frequency of occurrence of these clusters is relatively low in the language.

As to the CC clusters starting with a fricative, 16 of them – [sp, st, sť, sk, zb, šp, št, šť, šk, cx, ft, fť, fč, vd, lk, lž] – do not follow the MSD specified for Slovak. Eight CC clusters that violate the MSD can be excluded from this analysis since they start with [s] or [š] – [ʃ] in the IPA transcription – (see above; for transcription symbols see note 11). Clusters [lk] and [lž] represent a special case, too – the occurrence of the cluster [lk] is limited to one word and its derivatives, and the occurrence of [lž] is similar (cf. http://korpus.juls.savba.sk). Consequently, if the exceptional and rare clusters are excluded[12], only six CC clusters starting with a fricative violate the SSG.

And finally CC clusters starting with an affricate: two clusters, [cť] and [čp] – both with limited occurrence – do not satisfy the sonority requirements. Their MSD is below 0.

In total, there are 116 word-initial CC clusters in Slovak. The sonority-based analysis of these clusters reveals that 20 of them do not have a proper sonority rise. But if the exceptional consonant sequences (starting with [s] and [š]) are left aside and only those with a higher frequency of occurrence are taken into account, one may conclude that six word-initial CC clusters (5%) in Slovak do not follow the MSD 0 required for this language.

4.2 The sonority-based analysis of the initial CCC clusters in Slovak

There are two requirements for three-consonant clusters: (1) the MSD between two adjacent segments should be at least 0, and (2) the closer to the nucleus the segment is, the higher its sonority will be. Simply stated, sonority should increase towards the syllabic nucleus, or at least flat sonority (MSD 0) is necessary. But, of course, the sonority of onset elements has to be lower than the sonority of the nucleus. This paper deals with onsets only. The minimal requirement of the SSG for Slovak is rising or at least flat sonority between neighbouring elements (Zec).

There is one CCC cluster starting with an oral plosive [tkv] that fulfils the minimal requirement of the SSG – flat sonority between the first two consonants and increasing sonority between the second and the third consonant. One CCC cluster starts with a nasal plosive [mdl]. This cluster violates the MSD principle since nasal /m/ has a higher sonority degree than the voiced plosive /d/. Slovak word-initial CCC clusters usually start with fricatives. 12 onset CCC clusters start with the voiceless fricative /s/ or /š/ and violate the MSD, but the remaining CC clusters (after removing this initial fricative) show a good sonority distance. This finding proves the special status of /s/ and /ʃ/ in the sound systems of languages (see, e.g., McMahon; Duanmu). The clusters [vzl, zvl, zhl, hml, hmľ] satisfy the sonority-based analysis. They have flat sonority at the beginning and rising toward the nucleus. The cluster [vzd] has flat sonority at the beginning, but the sonority degree of both /v/ and /z/ is higher than that of /d/. The clusters [zdr, zbr] do not meet the sonority requirements. The segments that are the closest to the syllable peak have the highest degree of sonority (see Tab. 2) instead of the lowest one. This completely violates the SSG. And the cluster [ľst] has falling sonority instead of flat and/or rising sonority. However, the frequency of occurrence of this cluster is very low.

To sum up, there are 23 onset CCC clusters in Slovak. 12 of them start with consonants /s/ or /ʃ/ and can be excluded from further evaluation. One cluster can be excluded due to its low frequency of occurrence. Six clusters have good sonority rise. Finally, there are four CCC clusters that violate the MSD principle.

4.3 The sonority-based analysis of the initial CCCC clusters in Slovak

There are only two word-initial four-consonant clusters in Slovak – [pstr, pštr]. They both show rising sonority when they are analysed as a combination of two CC clusters (see Table 2). Otherwise these sequences of consonants violate the SSG principle. But the cluster [pstr] occurs only in a word *pstruh* (> *trout*) and its derivatives. The cluster [pštr] can also be found in one word only, *pštros* (> *ostrich*) and its derivatives. Due to this limited occurrence both four-consonant clusters can be excluded from the sonority-based analysis.

To conclude, in the Slovak language, there are 141 possible combinations of consonants in the word-initial position. 10 of them (7%) do not follow the MSD of 0 required for Slovak.

5 The complex-sound analysis of the word-initial consonant clusters in Slovak

All possible monomorphemic consonant clusters occurring at the beginning of Slovak words were also analysed in terms of the notion of a complex sound (see Gregová, 2011). Speech sounds can merge into a complex sound when their articulatory features, i.e. gestures, overlap. This means that these sounds either use different articulators, or they are made by the same articulator with no conflicting gestures (see above or Duanmu).

5.1 The complex-sound analysis of the initial CC clusters in Slovak

Segments in 51 two-consonant onset clusters [ps, pš, px, pl, bď, bz, bl, bľ, br, tk, tx, tv, dv, kt, kv, kr, kl, kľ, gl, gľ, gr, mn, mň, sp, sk, sx, sv, zb, zv, šp, šk, žv, hľ, hv, xľ, ft, fť, fč, fs, fš, fl, fľ, fr, vd, vz, vl, vr, lk, cv, čp, čv] are good complex sounds; they involve different articulators. For example, [p] – Labial, [s] – Coronal, [ps] is a complex sound, or [m] – Labial, [ň] – Coronal, [mň] is a complex sound.

Sounds in the cluster [zr] are made by the same articulator – Coronal, but without conflicting gestures; both are Coronal [+anterior]. This cluster is a good complex sound, too.

On the other hand, the remaining 64 CC clusters (see Tab. 5) cannot be represented as complex sounds. Consonants in these clusters involve the same articulator, which makes the opposite value of the same feature. For example, [pn] and [pň] are not good complex sounds because of the opposite value carried by the articulator Velum: [p] – [-nasal], [n, ň] – [+nasal]. Or [dr], although it is a complex sound in English (Duanmu), it is not in Slovak: [d] – Coronal [+anterior, -fricative], [r] – Coronal [+anterior, -fricative] (Gregová, 2011).

The notion of a complex sound was introduced in order to simplify two- and/or more-consonant clusters into a single timing slot (Duanmu). If this simplification is not possible, onset or coda clusters can be covered by morphology (see above). In Slovak, the Affix-Rule accounts for the monomorphemic initial CC clusters starting with [s, z, š, v, d]. These initial segments can be treated as prefix-like sounds. For example, [s] in *sneh* [sňex] (>*snow*) is not a prefix, but a prefix-like sound. The syllable structure of this word is s[ňex], i.e. CVC, with extrasyllabic [s].

Another solution for CC clusters that are not complex sounds is offered by the Potential Vowel Rule (note 3). Unsyllabified word-initial consonants can serve as the coda of a vowel that may come with a V-final suffix in a previous word.

Although both morphological principles (the Affix-Rule and the Potential Vowel Rule) reduce two-initial consonant clusters that are not complex sounds into one timing slot, this reduction supports the CVX theory of syllable structure, but it has no influence on the fact that the complex-sound analysis of the Slovak onset CC clusters cannot account for 64 clusters, i.e. 55%, while the sonority-based analysis has revealed that only 5% of these clusters violate the principles of the SSG (cf. 4.1).

5.2 The complex-sound analysis of the initial CCC clusters in Slovak

Having accepted the special status of /s/ and /ʃ/ in the phonotactics of many languages (see McMahon or 4.2), clusters [str, kl, skľ, skv, smr, stl, škr, štv, škv, štr, špľ, špr] can be simplified to the clusters CC, which can all – except [tr, mr] (Tab. 5) – form a complex sound. Although the Affix-Rule and the Potential Vowel Rule cover the first consonant in the clusters [tkv, vzd, vzl, zdr, zvl, zbr, zhl] as extrasyllabic, and the remaining CC clusters are good complex sounds, none of these initial three-consonant clusters in Slovak can be accounted for as a single complex sound. Moreover, the clusters [hml, hmľ, mdl, ľst] cannot be simplified even by the morphological principles of the CVX theory, and they cause difficulty for a single-slot analysis (Gregová, 2011).

The sonority-based analysis evaluates as 'inconvenient' only four Slovak word-initial CCC clusters (see 4.2).

5.3 The complex-sound analysis of the initial CCCC clusters in Slovak

The consonants [ps] in the cluster [pstr] can be solved by morphology as an affix-like segment, and [t] may serve as a coda of a potential vowel. However, the cluster as a whole cannot be reduced into one complex sound. [pš] in the cluster [pštr] is a good complex sound (C^s), but [tr] is not and requires two timing slots. The cluster as a whole needs at least three slots – C^sCC.

Due to their limited occurrence, these two clusters can be excluded not only from the sonority-based analysis (4.3), but also from the complex-sound analysis.

6 Conclusion

Traditional analysis of consonant clusters in syllable onsets and/or codas is based on "the notion of sonority, which is roughly the loudness of a sound" (Duanmu 168). In particular languages, speech sounds are ranked in the so-called sonority hierarchy, which serves as the basis for the description of syllable structure. The ordering of segments in a syllable is governed by the Sonority Sequencing Generalization (SSG). The SSG states that the sonority of segments rises towards the peak of a syllable. A significant exception to this rule is represented by the consonant /s/ (McMahon). Some linguists accept also the special status of /ʃ/ (Duanmu).

However, Duanmu (2009), in his morphological approach to syllable structure (the CVX theory), claims that the sonority-based analysis does not solve two main problems: 1) many clusters that do not follow the SSG occur in a language, and 2) clusters predicted to be good are missing (173–174). On the other hand, a complex-sound approach – based on the idea that sounds can merge into a complex sound when their articulatory features (gestures) overlap (Duanmu; Marlo) – seems to be more reliable for the analysis of consonant clusters. It solves all cases and – as Duanmu adds – it is more suitable for the CVX theory itself (43). There are no onset clusters in the CVX theory. "What appears to be an onset cluster is a complex sound" (43). He supports his view by the data from English, German, Standard Chinese, Shanghai Chinese and Jiarong (for details see Duanmu, 2009).

Nevertheless, my previous research in this field has raised doubts about the universal applicability of the CVX theory of syllables and the notion of a complex sound. It turns out that in Slovak (a language typologically different from any of the languages mentioned above), not all word-initial onset clusters can form a complex sound, and at least one more timing slot is necessary for onsets in this language (for details see Gregová, 2011). By implication, if the complex-sound analysis is not very suitable for the Slovak language, is the sonority-based analysis more suitable? Do all Slovak word-initial consonant clusters follow the principles of the SSG?

In order to answer these questions, the aim of this paper has been to compare the onset clusters in English and in Slovak in terms of both the sonority-based analysis and the complex-sound analysis.

It follows from my research that most of the word-initial onset clusters in English are better accounted for by the complex-sound analysis than by the sonority-based analysis. This finding supports Dunamu's assumptions.

By contrast, in the Slovak language, the complex-sound analysis of the word-initial two, three- and four-consonant clusters brings many exceptions and ambiguities (see 5–5.3), but the sonority-based analysis has shown that most of these clusters follow the principles of the SSG and the MSD required for Slovak (see 4–4.2).

Of course, in the follow-up research, the word-final and word-medial clusters should be included in the comparative analysis of this type in order to gain more reliable information about the character of consonant clusters in the Slovak language. Then it will be necessary to extend the sample of languages analysed in order to find out which of these two principles – a sonority-based structure or a complex-sound structure – tends to prevail in the phonotactics of individual languages.

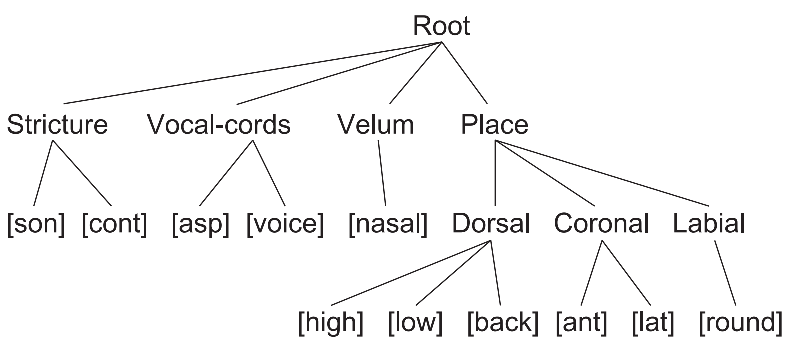
sonority degree	**type of consonant**
4	glides [j, w]
3	liquids [r, l]
2	nasals [m, n, ŋ]
1	obstruents [p, b, t, d, k, g, f, v, ɵ, ð, s, z, ʃ, ʒ, ʧ, ʤ, h]

(Duanmu 186)

Table 1 *The sonority hierarchy of English consonants*

sonority degree	**type of consonant**
8	sonorous [r, l]
7	sonorous [m, n]
6	sonorous [j, ľ, ň]
5	voiced fricatives [v, z, ž, h]
4	voiceless fricatives [f, s, š, x]
3	voiced affricates [ʒ, ǯ]
2	voiceless affricates [c, č]
1	voiced plosives [b, d, ď, g]
0	voiceless plosives [p, t, ť, k]

Table 2 *The sonority hierarchy of Slovak consonants*



(Marlo 80)

Table 3 *Articulator-based Feature Geometry*

consonant cluster	**sonority-based analysis/ MSD**	**complex-sound**		**consonant cluster**	**sonority-based analysis/ MSD**	**complex-sound**
pr	good[13]/2	yes		**mw**	good/2	yes
pl	good/2	yes		**fl**	good/2	yes
pj	good/3	yes		**fr**	good/2	yes
pw	good/3	yes		**fj**	good/3	yes
pf	bad/0	yes		**vj**	good/3	yes
ps	bad/0	yes		**vw**	good/3	yes
pʃ	bad/0	yes		**θr**	good/2	no
br	good/2	yes		**θw**	good/3	yes
bl	good/2	yes		**θj**	good/3	yes
bj	good/3	yes		**st**	bad/0	no
tr	good/2	yes		**sp**	bad/0	yes
tw	good/3	yes		**sk**	bad/0	yes
tj	good/3	yes		**sl**	good/2	no
dr	good/2	yes		**sw**	good/3	yes
dj	good/3	yes		**sn**	bad/1	no
dw	good/3	yes		**sm**	bad/1	no
kr	good/2	yes		**sf**	bad/0	yes
kl	good/2	yes		**sj**	good/3	yes
kw	good/3	yes		**sr**	good/2	no
kj	good/3	yes		**sv**	bad/0	yes
km	bad/1	no		**zl**	good/2	no
kn	bad/1	no		**ʃr**	good/2	no
kv	bad/0	yes		**ʃm**	bad/1	yes
gr	good/2	yes		ʃn	bad/1	no
gl	good/2	yes		**ʃp**	bad/0	yes
gw	good/3	yes		**ʃw**	good/3	yes
nj	good/2	yes		**hj**	good/3	yes
mj	good/2	yes				

Table 4 *Sonority-based analysis and complex-sound analysis of the English word-initial CC clusters*

consonant cluster	sonority-based analysis/ MSD	complex-sound		consonant cluster	sonority-based analysis/ MSD	complex-sound
ps	good/4	yes		**zr**	good/3	yes
pš	good/4	yes		**šp**	bad/-4	yes
px	good/4	yes		**št**	bad/-4	no
pn	good/7	no		**šť**	bad/-4	no
pň	good/6	no		**šk**	bad/-4	yes
pl	good/8	yes		**šm**	good/3	no
bď	good/0	yes		**šn**	good/3	no
bz	good/4	yes		**šl**	good/4	no
bl	good/7	yes		**šľ**	good/2	no
bľ	good/5	yes		**šr**	good/4	no
br	good/7	yes		**žv**	good/0	yes
tk	good/0	yes		**žm**	good/3	no
tx	good/4	yes		**žň**	good/1	no
tv	good/5	yes		**žľ**	good/1	no
tm	good/7	no		**žr**	good/3	no
tl	good/8	no		**hn**	good/2	no
tľ	good/6	no		**hň**	good/1	no
tr	good/8	no		**hl**	good/3	no
dv	good/4	yes		**hľ**	good/1	yes
dm	good/6	no		**hr**	good/3	no
dn	good/6	no		**hm**	good/2	no
dň	good/5	no		**hv**	good/0	yes
dl	good/7	no		**xc**	bad/-2	no
dr	good/7	no		**xv**	good/1	no
kt	good/0	yes		**xm**	good/3	no
kv	good/5	yes		**xl**	good/4	no
km	good/7	no		**xľ**	good/2	yes
kn	good/7	no		**xr**	good/4	no
kň	good/6	no		**ft**	bad/-4	yes
kr	good/8	yes		**fť**	bad/-4	yes
kl	good/8	yes		**fč**	bad/-2	yes
kľ	good/6	yes		**fs**	good/0	yes

gn	good/6	no
gň	good/5	no
gl	good/7	yes
gľ	good/5	yes
gr	good/7	yes
mn	good/0	yes
mň	bad/-1	yes
ml	good/1	no
mľ	bad/-1	no
mr	good/1	no
sp	bad/-4	yes
st	bad/-4	no
sť	bad/-4	no
sk	bad/-4	yes
sx	good/0	yes
sv	good/1	yes
sm	good/3	no
sn	good/3	no
sň	good/2	no
sl	good/4	no
sľ	good/2	no
zb	bad/-4	yes
zv	good/0	yes
zn	good/2	no
zň	good/1	no
zl	good/3	no

fš	good/0	yes
fl	good/4	yes
fľ	good/2	yes
fr	good/4	yes
vd	bad/-4	yes
vz	good/0	yes
vn	good/2	no
vň	good/1	no
vl	good/3	yes
vr	good/3	yes
lk	bad/-8	yes
lž	bad/-3	no
cv	good/3	yes
cť	bad/-2	no
cm	good/5	no
cn	good/5	no
cň	good/4	no
cl	good/6	no
cľ	good/4	no
čp	bad/-2	yes
čv	good/3	yes
čm	good/5	no
čn	good/5	no
čl	good/6	no
čľ	good/4	no
čr	good/6	no

Table 5 *Sonority-based analysis and complex-sound analysis of the Slovak word-initial CC clusters*

Notes

[1] When a sound is treated as a particular speech sound, square brackets [ ] – phonetic notation – are used. When referring to a sound as to the element of an abstract system, slanted brackets / / – phonemic notation – are used.

[2] C stands for a consonant, V for a vowel and X represents either a vowel or a consonant. Thus the maximal syllable size is CVC or CVV (Duanmu 70).

[3] The Affix Rule states that "affix or affix-like sounds can be pronounced, whether they can fit into a syllable or not" (Duanmu 50). For example, the syllabic structure of the monosyllabic word *ax* [æks] is only CV. The final consonant [s] does not belong to the syllable. It is covered by morphology, by the Affix Rule, as an affix-like sound or a "perceived suffix" (ibid.).

[4] The Potential Vowel Rule solves the issue of extra consonants at word edges. It is based on the prediction that in languages having suffixes starting with a vowel, an extra consonant is allowed in a word-final position. This consonant can function as the onset of the suffix vowel. Analogically, in languages that have prefixes ending in a vowel, an extra consonant can exist in word-initial position in order to form a coda of the prefix with a vowel at its end (Duanmu 70, 150). For example, the final [p] in the word *help* is an extra C when the word is in isolation (supported also by Anti-Allomorphy; see note 4), but this [p] functions as the onset of the following V in the word *helping* – [hel]p, [hel][pɪŋ] (ibid.).

[5] Anti-Allomorphy: "Keep a morpheme in the same shape regardless of the environment" (Duanmu 47). This rule supports the syllabification of *help* as CVC + extrasyllabic consonant [hel] p (ibid.).

[6] The special position of the consonant [s] in the sound systems of languages – as already mentioned – seems to be a language-universal phenomenon (cf. McMahon). The CVX syllable theory treats this word-initial consonant in English as an extra-syllabic, because it can be explained by the Potential Vowel and the Anti-Allomorphy (for details see Duanmu or notes 3, 4).

[7] A similar objection to the universal syllable size CVX was raised by Marlo, who had analysed languages that allow long consonant clusters in onset positions (cf. Marlo).

[8] This simplification is based on the well-known idea that the beginning of the word is the beginning of the first syllable and the end of the word is at the same time the end of the last syllable (Kuryłowicz).

[9] O stands for obstruent, N is nasal and L stands for liquid.

[10] In order to follow Duanmu's analysis, only monomorphemic word-initial consonant clusters were taken into account (cf. Duanmu; Gregová, 2010).

[11] The transcription symbols of post-alveolar and alveopalatal consonants in Slovak are different from those used by the IPA. The Slovak /[š, ž, č, ť, ď, ň, ľ]/ stand for the IPA /[ʃ, ʒ, ʧ, tʲ, dʲ, nʲ, lʲ]/, respectively.

[12] The main condition for relevant comparative research is to make the analysis as similar to Duanmu's as possible. He has taken into account only the most productive clusters in all analysed languages and has excluded the less frequent or otherwise exceptional sequences of consonants (for details see Duanmu).

[13] When the consonant cluster follows the SSG and the MSD of the given language, it is labelled as 'good'. When the consonant cluster violates the sonority theory, it is indicated as 'bad'. The labels 'good', 'bad' are used in accordance with Duanmu's analysis (see, e.g., Duanmu 168–169).

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