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THE COMPARISON OF BISEGMENTAL REPRESENTATIONS OF *sC* CLUSTERS IN ENGLISH

Abstract

The distribution of *sC* clusters and their interactions with phonological rules point to a unique status of such consonant sequences, which opens the possibility of ascribing more than one representation to them. The primary goal of this article is to establish the most suitable representation of *sC* clusters, understood in the narrow sense as /s/ plus a stop cluster: /sk/, /st/ and /sp/ only, from among the theoretically possible variants generated by the autosegmental theory of the syllable. The differing representations display various compliance with phonotactic generalisations and phonological behaviour of the clusters in question in English.

The article is organised as follows. Section 1 introduces background information. Section 2 examines the logically possible two-segment structures as ensuing from the application of the Syllable Structure Algorithm. Section 3 presents the Branching Onset model and its variants. Section 4 considers the specific predictions made by the Appendix model. Section 5 offers conclusions and points to the most appropriate bisegmental representation.

1. Theoretical background

This section briefly presents the phonological framework in which the analysis is carried out. It introduces basic concepts, such as the autosegmental theory, the Syllable Structure Algorithm and the Sonority Sequencing Generalisation.

The basic assumption made in the article is that phonological structure can be represented on three largely independent tiers: the melodic tier, the skeletal tier and the syllablic tier. In the autosegmental theory, which dates back to the proposition Goldsmith (1976), who credits the idea to Clements's

unpublished paper, features and their combinations are marked on the melodic tier. The skeletal tier represents the relative duration of segments. The relation between segments and features can be on the one-to-one, one-to-many or many-to-one basis.

The syllabic tier is where the syllable structure is determined. The major processes that lead to its creation are commonly known as the Syllable Structure Algorithm (henceforth the SSA; cf. Rubach 1999). The SSA consists of five rules: N-Placement, CV Rule, Complex Onset, Coda Rule and Complex Coda. N-Placement assigns a syllable nucleus node (N) to a vowel; the CV Rule erects the syllable node (σ) and attaches the preceding consonant, if there is any, to that node. These two rules constitute the obligatory part of the SSA. The Complex Onset Rule adds another consonant to the syllable node, the Coda Rule creates the rhyme node (R) and joins a consonant to that node, and Complex Coda links another consonant to the rhyme. These three rules are optional: they can be active or inactive, depending on the language. Moreover, their ordering differs from language to language. Complex Coda and Complex Onset can apply in an iterative way. Another common property of the optional rules is that they can be blocked by constraints.

One of the constraints blocking the SSA relevant to the present study is the Sonority Sequencing Generalisation (henceforth the SSG; summary based on Rubach 1999), which plays a crucial role in determining the well-formedness of syllable margins. The idea dates back to Whitney (1865 [1971]), and was developed later by other linguists, mainly Sievers (1881) and Jespersen (1904). This constraint is based on the assumption that there exists a universal hierarchy of sounds with respect to their sonority. The version currently considered standard recognises four steps on the sonority scale: vowels (the most sonorous), followed by liquids, nasals, fricatives, and stops (the least sonorous). Taking this into account, the SSG may be formally stated as in (1):

(1) SONORITY SEQUENCING GENERALISATION
The sonority of segments must decrease towards the edges of a syllable, where the sonority of segments is defined by the following scale of decreasing sonority: vowels – liquids – nasals – fricatives – stops. (Booij – Rubach 1990)

The application of the SSG may be demonstrated on the following example (after Rubach 1999: 283). English is an onset maximising language as evidenced by words such as *suppress* and *supply*, which syllabify /sə.pres/ and /sə.plaɪ/. However, in cases where onset maximisation would imply violation of the SSG, clusters are heterosyllabic, as exemplified by *comprise*

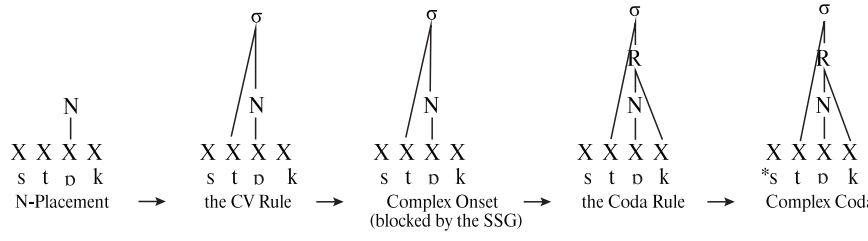
/kəm.praɪz/, *selfish* /sel.fɪʃ/, or *Afghan* /æf.gæn/.

2. Survey of possible two-segment representations

This section analyses problems related to the syllabification of *sC* clusters by the SSA. Two different models of the bisegmental representation of *sC* clusters are briefly introduced as separate solutions motivated by the need to prevent Stray Erasure.

I begin by examining the syllabification steps in a word containing an initial *sC* cluster, e.g. *stock*, by means of the universal SSA:

(2)



The relevant stage is the application of Complex Onset, which is blocked by the SSG, since the fricative (more sonorous) cannot precede a stop in the onset. As a result, the initial /s/ remains extrasyllabic. However, if this syllabification was final, /s/ would be deleted at the end of the derivation due to Stray Erasure, which is defined by Steriade (1982: 89) as in (3):

(3) STRAY ERASURE CONVENTION
Erase elements and skeleton slots unless attached to higher levels of structure.

In other words, on the surface, there would be no difference (at least phrase-initially) between words such as *tub* and *stub* or *strip* and *trip*, which is clearly incorrect.

As can be seen, allowing for the /s/ to remain extrasyllabic at the end of the derivation is not an option. Certain modifications in the derivation must be posited, which may include a language-specific sonority hierarchy, a more local constraint overriding the SSG or a rule independent of the SSA linking /s/ to a higher prosodic structure (such as prosodic word – PW). Those solutions may generate different outputs, presented in (4ab):

(4) a. 

b. 

Although adopted by a number of linguists, e.g.: Hooper (1976) for Spanish and Vennemann (1982) for Icelandic, the first solution is unsatisfactory. Adapting the SSG to English syllabification inevitably leads to paradoxes. The argument below comes from Rubach (1999: 283). Clusters like */tl-/ and */dl-/ are ill-formed in English[1], so it could be stipulated that /l/ is lower in the English-specific sonority hierarchy than stops, and therefore lower than fricatives. As a result, we would expect the word-internal consonants in *ulcer* and *selfish* to be tautosyllabic since English is an onset-maximising language. However, **u.lcer* and *se.lfish* are not the correct syllabifications. In other words, there would still be a need to posit additional constraints upon the SSG to exclude such syllabifications. The fact is that the syllable boundary is placed between the liquid and the fricative, resulting in *ul.cer* and *sel.fish*, as predicted by the universal SSG. As regards the other solutions, a constraint suspending the SSG would make the Complex Onset Rule apply, the output being the one in (4a), with /s/ and /t/ forming a complex onset. This structural model will be called the Branching Onset representation.

Another solution consists in positing a rule different from the Complex Onset Rule. The important question here concerns the ordering of the rule with respect to other syllabification rules and the node to which /s/ should be attached. In two of the combinatorial variants, the structure obtained at the end of the derivation is identical to that in (4a): a rule linking /s/ to the syllable node, be it either in the middle of the SSA derivation or after its completion, leads to creating the Branching Onset structure, which does not mean that those solutions are fully equivalent with respect to English processes (discussed in Section 3).

The third possibility is that there exists a rule, applying after the SSA derivation, which links /s/ to the PW node. The representation it yields is as shown in (4b), with a complex word-initial cluster, but not a complex onset, since the /s/ does not belong to the onset. The name assigned to this representation is the Appendix model (analysed in Section 4).

The fourth combinatorial variant, namely positing a rule that links /s/ to the PW node in the middle of the SSA derivation, would, in fact, destroy the

structure of the algorithm. Hence, it will not be taken into further consideration.

Concluding, within the autosegmental framework[2], there are two plausible bisegmental representations of *sC* clusters requiring further analysis. The ensuing sections provide an examination of those representations, beginning with the Branching Onset.

3. Branching Onset

The Branching Onset representation is the standard structural model which assumes that *sC* clusters consist of two separate segments linked to the syllable node, forming a complex onset (4a). Since there is more than one logical possibility of arriving at this representation, it is necessary to decide which processes or constraints are responsible for such syllabification.

3.1 *s*-Onset

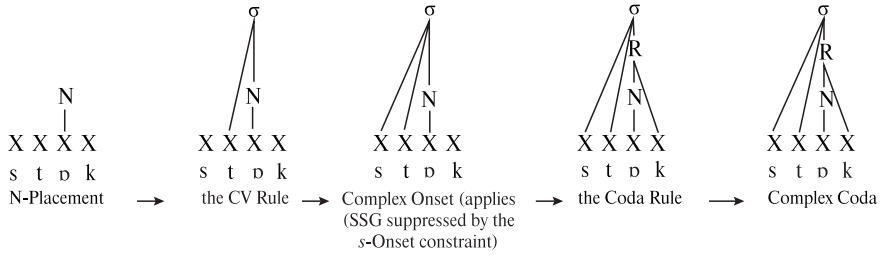
Let us first consider the situation, as assumed in Major (1996, 2001), Ohala (1999), and Carlisle (2006), in which the Branching Onset structure is created before completion of the SSA derivation. Arriving at this structure in a word like *stock* /stɒk/ could be then carried out in the following steps. N-placement assigns /ɒ/ to the syllable nucleus node. The CV Rule links the segment nearer the syllable nucleus, that is /t/, to the syllable node. The Complex Onset Rule tries to apply to the element further from the nucleus, that is to /s/. However, the sequence *sC* in the onset, where *C* is a stop, incurs a violation of the SSG, which blocks Complex Onset.

As shown in the previous section, one of the ways to syllabify /s/ into the onset is to suppress the operation of the SSG by a language-specific constraint; the alternative solution is to posit a rule that is ordered after the Complex Onset Rule and that links /s/ to the syllable node. The constraint typically suggested in the literature to legitimise *sC* clusters is the so-called *s*-Onset constraint, which can be expressed as in (5).

(5) *s*-ONSET
/s/ plus stop is a well-formed onset. (Rubach 1999: 284)[3]

The *s*-Onset constraint prevents the SSG from blocking the Complex Onset Rule, resulting in the syllabification of *stock* as in (6):

(6)



Rubach (1999: 284) observes that the same generalisation can be phrased in the form of a syllabification rule directly following the Complex Onset Rule.

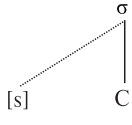
Even though positing an *s*-Onset constraint or *s*-Onset rule ensures that /s/ is parsed, the generated output still violates SSG, which was sought to be avoided. However, this is not to say that the idea of violable constraints (cf. constraints in Optimality Theory) is unacceptable. Let us now examine the other way of arriving at the Branching Onset structure.

3.2 *s*-Adjunction to σ

This section examines the possibility of positing a rule of adjunction that links /s/ to the syllable node, which is the approach represented, for example, by Kaye (1989), Kenstowicz (1994), and Barlow (2001). Adjunction to the syllable node is attested in other languages, a typical example being Italian (Rubach 1999: 293–294).

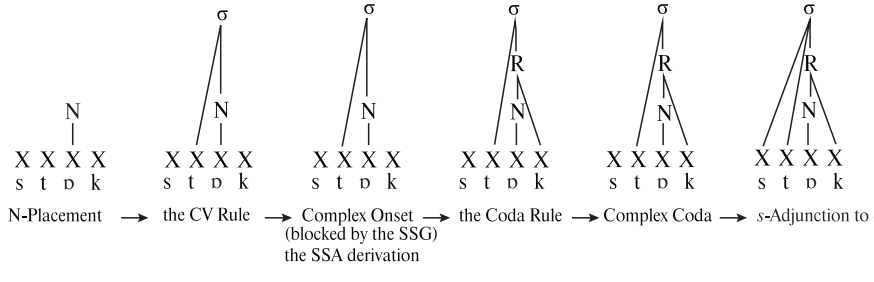
In English, the rule syllabifying /s/ is stated as in (7), following Kenstowicz (1994: 58):

(7) *s*-ADJUNCTION TO σ[4]



Including the rule in (7) among the English syllabification rules would result in assigning the syllable structure to *stock* in the steps represented under (8).

(8)



Here, the application of *s*-Adjunction to σ apparently generates the correct output. As a further piece of motivation for the rule in (7), certain facts from the phonotactics of clusters containing /s/ can be adduced, which could be easily accounted for if *s*-Adjunction to σ were to be accepted. Let us consider the possible two-consonant onset clusters in English, as presented in the table in (9), after Kenstowicz (1994: 256):

(9)

	w	**j**	**r**	**l**	**m**	**n**	**p**	**t**	**k**
p	–	+	+	+	–	–	–	–	–
t	+	+	+	–	–	–	–	–	–
k	+	+	+	+	–	–	–	–	–
b	–	+	+	+	–	–	–	–	–
d	+	+	+	–	–	–	–	–	–
g	+	+	+	+	–	–	–	–	–
f	–	+	+	+	–	–	–	–	–
θ	+	+	+	–	–	–	–	–	–
ʃ	–	–	+	–	–	–	–	–	–
s	+	+	–	+	+	+	+	+	+

Kenstowicz (1994: 256–257) notes that English, in a very systematic way, bans clusters of obstruents followed by a nasal (**θn*-, **kn*-, **dm*-) and of stops followed by fricatives (**tf*-, **kθ*-), even though such sequences comply with the SSG. A generalisation could be advanced that English allows only complex onsets consisting of consonant clusters separated by at least two points on the sonority scale. However, words such as *small* and *snack* seem to contradict this proposal because the /s/ and the following nasal are separated by only one point on the sonority scale. The *s*-Adjunction to σ Rule allows us to preserve the generalisation because, by definition, adjunction rules disregard such constraints, just as was the case with the SSG.

The *s*-Adjunction to σ Rule proves useful in explaining yet another curious property of /s/. Neither the SSG nor the minimal sonority distance requirements suffice to explain the absence of a few other clusters in English. The lack of **pw*-, **bw*- and **fw*- onsets (while /w/ combines with other stops and fricatives, e.g.: *tw*-, *θw*-, as in *twin* and *thwart*) and the lack of **tl*-, **dl*- and **θl*- onsets (vs. the presence of *pl*-, *fl*- onsets, as in *play* and *fly*) point to the fact that English avoids sequencing of tautosyllabic consonants having the same place of articulation. This principle is violated by /s/ (and also by /r/).

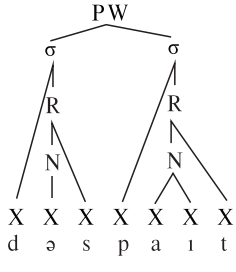
Words such as *sly* and *slack* are well-formed in English, even though both /s/ and /l/ are coronals, which is another situation where *s*-Adjunction to σ can serve as an explanation. In these words, /s/ can syllabify in the onset before /l/ since such general constraints as the SSG or the ban of homorganic clusters in the onset are binding only in the case of general syllabification rules, and not in the case of adjunction.

A final argument for *s*-Adjunction to σ resides in the fact that it correctly predicts the possible three-consonantal English onsets, all of them being a combination of /s/ and stop followed by a liquid or a glide, i.e. /s/ plus a possible two-consonant onset (Kenstowicz 1994: 258). In summary, all the above mentioned instances seem to lend support to *s*-Adjunction to σ.

However, there are arguments that militate against *s*-Adjunction to σ. In the previously adduced distributional motivation, there seems to be a kind of inconsistency. Allowing *s*-Adjunction to σ to apply to every instance of unsyllabified /s/ preceding any consonant (as opposed to /s/ followed by a strong stop) leads to the prediction that /s/ can appear before any consonant and before any possible two-segment cluster as well. In other words, not only /sk/, /sp/ and /st/ plus a glide or liquid, but also **sfl*- and **sθr*- should be well-formed onsets in English. The *s*-Onset constraint or the alternative *s*-Onset Rule avoids this type of difficulty since they do not refer to /s/ alone, but to /s/ plus stop clusters.

More importantly, assuming *s*-Adjunction to σ leads to false predictions with syllabification of word-internal *sC* cluster. If an adjunction rule were to be posited and not a local constraint limiting the application of the SSG or a syllabification rule preceding the Coda Rule, we predict that *sC* sequences can never be tautosyllabic word-internally. Keeping in mind that the SSG blocks Complex Onset, the only available possibility in words such as *despite* is joining /s/ to the coda of the preceding syllable, as shown in (10):

(10)



If this was the case, the syllabification of the English *sC* clusters would be parallel to that in Italian[5], with *s*-Adjunction to σ operating on **s* word-initially, but not word-internally.

Let us examine whether this kind of syllabification is borne out by the processes of English. Consider the data presented in (11)[6]:

(11) a. pit ['pʰɪt], tie ['tʰaɪ], come ['kʰʌm]; b. bit ['bɪt], die ['daɪ], gum ['gʌm];
c. spit ['spɪt], sty ['staɪ], scum ['skʌm]; d. attain [ə'tʰeɪn], account [ə'kʰaʊnt];
e. competitor [kəm'pʰetɪtə]; f. despite [dəspaɪt], distil [dɪstɪl][7].

The words in (11ab) show that voiceless, but not voiced, stops are aspirated in initial position in English. The data in (11cd) indicate that the syllable, and not the word, is the domain of the process. As a result, the rule of Aspiration can be stated as in (12):

(12) ASPIRATION OF VOICELESS STOPS

$$\begin{bmatrix} + & \text{consonantal} \\ - & \text{continuant} \\ - & \text{sonorant} \\ - & \text{voice} \end{bmatrix} \rightarrow [+\text{aspirated}]/_{\sigma}[\ \_\_\_$$

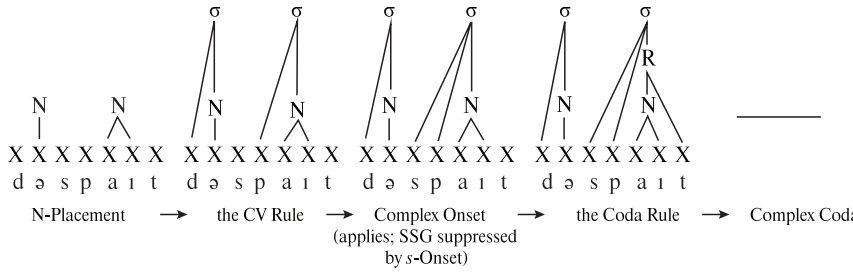
(Giegerich 1993: 239)[8]

The contrast crucial to the present analysis is shown in (11ef): the [pʰ] in *competitor* is syllable-initial (no words begin with **mp*-) and, in accordance with the prediction made by the rule in (12), it is aspirated; if the [pʰ] in *despite* was syllable-initial as well, which is what positing *s*-Adjunction to σ predicts, it would have to be aspirated just like the [pʰ] in *competitor*. However, /p/ in *despite* displays behaviour parallel to the behaviour of /p/ in *spit* and lacks aspiration. As a consequence, we have to admit that the stop is not in the syllable-initial position and syllabify /s/ into the onset.

A parallel argument might be developed as regards the devoicing of sonorants after voiceless stops that would otherwise receive aspiration. At the beginning of words (as in *pray* [p̥reɪ] and *clue* [kl̥u:]), and inside words (as in *apply* [əpl̥aɪ] and *acquire* [əkw̥aɪə]), the liquid and glides devoice, but only when the stop plus liquid or glide cluster is syllable initial. When the clusters are preceded by [s], devoicing is blocked (as in *spring* [sprɪŋ] or *split* [splɪt]). Only by assuming that [s] in words such as *discreet* [dɪskri:t] syllabifies into the onset, unlike the [m] in *comply* [kəmpl̥aɪ], can the difference between the devoiced liquid in *comply* and the voiced one in [dɪskri:t] be accounted for.

The conclusion is that, contrary to the predictions made by assuming *s*-Adjunction to σ, what we see in words like *despite* and *discreet* is [də.'spaɪt] and [dɪ.'skri:t] (not *[dəs.'pʰaɪt] or *[dɪs.'kr̥i:t]), and this is the syllabification correctly predicted by *s*-Onset. The syllabification of *despite*, assuming the *s*-Onset constraint, is presented in (13):

(13)



Crucially, at the stage when the Coda rule applies, /s/ is already syllabified by the Complex Onset rule.

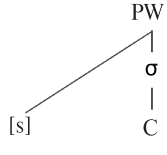
In conclusion, the implications of the Branching Onset representation crucially depend on the processes responsible for arriving at the structure. The *s*-Adjunction to σ Rule stated in (7) is unable to deal successfully with word-internal syllabification of *sC* clusters. Moreover, it is incorrect from the point of view of Aspiration and Sonorant Devoicing. In contrast, application of the *s*-Onset syllabification rule or the *s*-Onset constraint stated in (5) allows for the existence of legitimate *sC* clusters in the onset both word-initially and word-internally and does not complicate the analysis of Aspiration and Sonorant Devoicing. Let us now look at the other representation of *sC* clusters and examine whether it offers a better, simpler solution.

4. Appendix Model

The next model will be referred to as the Appendix model. This model, considered in Levin (1985), Giegerich (1993), Fikkert (1994), and Goad – Rose (2004), assumes that /s/ is not linked to the syllable node by the regular SSA rules or by *s*-Adjunction to σ stated in (7), but by an adjunction linking /s/ to the phonological word (PW) node.

Such a possibility is theoretically available and is used, for example, to account for the different behaviour of word-initial versus word-internal and word-final /r/ with respect to Voice Assimilation in Polish (see Rubach 1999). The Polish example affords us the possibility of stipulating that /s/ in words such as *stock* could be linked directly to the PW node as in (4b). The rule responsible for this syllabification would have to be stated as in (14).

(14) *s*-ADJUNCTION TO PW

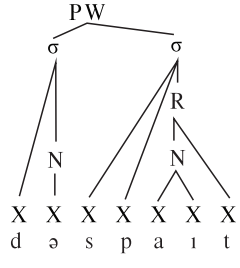


The primary advantage of the Appendix model over the Branching Onset (in either of its variants) is that it avoids SSG violations since only the stop belongs to the onset. Moreover, the Appendix model displays all the advantages of the Branching Onset model derived by *s*-Adjunction to σ in (7), successfully accounting for the appearance of /s/ in word-initial onset positions and for certain facts from the phonotactics of English.

However, the Appendix model repeats the incorrect predictions made by *s*-Adjunction to σ as regards word-medial syllabifications of *sC* clusters, the behaviour of /s/ with respect to aspiration of the following stops, as well as the devoicing of sonorants in three-segment onsets. Since the line of argumentation in the case of the Appendix model would be nearly identical to that of the Branching Onset model arrived at by *s*-Adjunction to σ, it will not be developed fully. Let usjust look at some problems ensuing from the word-internal syllabification of *sC* clusters in the Appendix representation.

The /s/ in word-internal *sC* clusters in words such as *despite* could be easily syllabified into the coda of the preceding syllable, thus blocking the possibility of *s*-Adjunction to PW (since the rule lacks power to re-syllabify strings). Consequently, the syllabification presented in (15) would be impossible to arrive at:

(15)



However, it is the syllabification in (15) that is supported by the processes of Aspiration and Sonorant Devoicing.

In addition, it is generally acknowledged that extrasyllabic segments are prone to be deleted and frequently trigger epenthesis (Minkova 2003: 211). However, in English, neither medial epenthesis nor deletion is attested as far as the clusters *sp*-, *sk*- and *st*- are concerned. These conclusions are drawn, among others, from the study of loanword adaptations and interlanguage, which show that *sC* clusters are exceptionally rarely broken by an epenthetic vowel in comparison to other clusters (Fleischhacker 2000). Minkova (2003: 305) also argues that the strong degree of coarticulation between /s/ and the following obstruents is another reason why extrasyllabicity should not be posited in this case.

Concluding, although the Appendix model avoids SSG violations, in which it appears superior to the Branching Onset model, it cannot be accepted since a rule of adjunction that joins /s/ to the PW node repeats the predictions of *s*-Adjunction to σ as far as word-internal syllabification of /s/ is concerned. Moreover, the Appendix model fails to reflect the cohesive nature *sC* clusters confirmed by the lack of deletion or medial epenthesis.

5. Conclusions

The results of the analysis presented in this article have provided arguments suggesting that the "unorthodox" representations of *sC* clusters, involving any form of adjunction, are inferior to the standard Branching Onset model generated by the application of the *s*-Onset rule or the *s*-Onset constraint.

Although the Appendix model avoids an SSG violation, which is not offered by the Branching Onset model, it fares far worse as regards word-internal syllabification of *sC* clusters. Aided by less categorical evidence, Aspiration and Sonorant Devoicing challenge any representation derived by syllabifying /s/ after the application of the Coda Rule. Linking /s/ to the syllable node directly before the Coda Rule, on the other hand, guarantees the correct division into syllables and is not contradicted by the phonological behaviour of *sC* clusters with respect to the afore mentioned rules.

NOTES

[1] An anonymous reviewer suggests that absence of those clusters can be attributed to an accidental gap, citing Jones (1958: 75), who quotes RP speakers systematically using /tl-/ for /kl-/ and /dl-/ for /gl-/, as in *clean* [tli:n] and *glue* [dlu:]. This view might be contested by the fact that in a word such as *Atlantic* the syllable boundary falls between *t* and *l* (Kenstowicz 1994: 251), proving that *tl-* is not a well formed onset in English.

[2] Other theoretical frameworks may offer different possibilities, including a coda-onset representation also for phrase-initial clusters with *s* attached to an empty nucleus, as proposed by Kaye (1992) within Government Phonology. Phrase-initially, such a structure is hardly possible in the framework used in this article (here, it would probably correspond to the model generated by one of the adjunction rules).

[3] As pointed out by the reviewer, the constraint in (5) might have to be further restricted to voiceless stops to exclude syllabifications such as *Cro.sby*, unless English phonology offers independent means of prohibiting obstruent clusters disagreeing in voice in syllable margins. As regards borrowings such as *sphere*, *sphinx*, or *sthenic*, the presence of a stop + *f* onset, which would normally be excluded by the constraint in (5), might be attributed to the fact that those words are subject to the rules of loanword phonology. As mentioned by Rubach (1999: 284), the generalization expressed here as a constraint can also be phrased as a rule, generating the same results.

[4] See ft. 3.

[5] For more details, see Rubach (1999: 288–294).

[6] Data adapted from Rubach (1999: 283), Giegerich (1993: 219, 226), Collins – Mees (2003: 81, 91), and Odden (2005: 45–47). The presence or absence of aspiration/devoicing in stressed syllables is uncontroversial.

[7] In (13f), the stress is not marked since the syllable boundary is the issue under investigation. In *despite* and *distil*, the stress falls on the second syllable.

[8] Aspiration is a more complicated issue than it is possible to present in detail within the article. The reviewer, referring to Selkirk (1980, 1982), suggests that the domain of aspiration is the stress foot, and that adjacency might be sufficient for *s* to deprive stops of aspiration.

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