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The representation of sC clusters

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Introduction*

Clusters of the shape *s*+consonant (sC), exemplified by *stack*, have posed a challenge for theories of syllabification as they defy many of the constraints holding of true branching onsets, as in, for example, *track*. Accordingly, some researchers have proposed that *s* is organized outside the onset constituent that contains the following consonant. Others have proposed that this sort of analysis holds only for a subset of sC clusters; those that rise in sonority, for example *slack*, are represented in the same fashion as branching onsets. Yet others have argued that some sC clusters, those of the shape *s*+stop, form complex segments.

This chapter will critique each of these proposals. An element shared by all of them is that phonological units are highly articulated: the burden of explanation is placed precisely on the structural relationships that adjacent segments enter into. Although this approach captures many peculiarities of sC clusters, there is little attempt to explain why the consonant that displays unorthodox behaviour is typically *s*. Under the view that segments are ordered to maximize their perceptibility, the behaviour of *s* becomes less puzzling: strident fricatives have robust internal cues, ensuring their perceptibility even in non-optimal contexts.

If the acoustic properties of *s* are of central importance, it behooves us to ask whether the differences between sC clusters and branching onsets can be explained solely by perceptual considerations. This, of course, would challenge the view that a structural approach to cluster well-formedness is necessary. In the final section of the paper, I will argue that this position is too strong. I will conclude that an adequate understanding of sC clusters requires consideration of both perceptual and structural factors.

Much of the paper compares sC clusters with branching onsets. We will observe that they differ in several respects: phonotactic constraints, word-internal syllabification, allomorph selection, patterns of reduplication, options for cluster repair, etc. Although the general observations we will detail are likely to be accepted by most phonologists, there is little agreement on how these differences should be formally represented. In this context, there are three topics that will be addressed.

The first involves critical assessment of various proposals in the literature concerning the representation of sC clusters –as a single class– in contrast to obstruent+sonorant clusters. Henceforth, I will use the term 'obstruent' to refer to obstruents other than *s*. '*s*' is itself a cover term for the sibilant(s) appearing in sC clusters; although this sibilant is usually /s/, in some languages, other sibilants pattern as *s* (e.g., German *s* is usually /ʃ/; in Russian, /s z ʃ ʒ/ all pattern as *s*).

Concerning obstruent+sonorant clusters, there will be nothing particularly special to say about their representation; they form branching onsets and there is little controversy on this matter among those who accept a hierarchically-organized syllable. For sC clusters, in contrast, several options will be considered. Most of these share the idea that *s* is an appendix, a segment which is not organized by any sub-syllabic constituent; one views *s* as a coda. We will see, in addition, that some researchers propose a single representation for sC in all languages; others argue for different representations across languages.

The second topic that must be addressed is whether, in a given language, all sC clusters are represented in the same fashion. *s*+sonorant clusters are phonotactically ambiguous: like

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obstruent+sonorant clusters, they rise in sonority; yet, like *s*+obstruent clusters, they do not respect the place constraints holding of obstruent+sonorant clusters. Depending on the weight assigned to each of these, different conclusions will be arrived at concerning the analysis of *s*+sonorant. For those researchers who place most weight on sonority profile, *s*+sonorant clusters form branching onsets. This research itself falls into two categories. One body of work aims to show that *s*+sonorant patterns with branching onsets while *s*+obstruent patterns differently and is organized with some type of appendix. Another body of work considers *s*+sonorant clusters to be branching onsets, but focuses on arguing that *s*+stop clusters form complex segments.

The proposals sketched above assume that the syllable is hierarchically organized. However, there is a growing literature which de-emphasizes the role of constituency and aims to provide phonetically-grounded explanations for phonological behaviour. The third topic therefore considers whether differences in the behaviour of obstruent+sonorant, *s*+sonorant and *s*+obstruent can be explained by perceptual considerations alone. This topic will be the focus of the final section of the paper. Until then, a structural approach will be assumed.

Cluster phonotactics

We begin by detailing the phonotactic constraints most commonly held of obstruent+ sonorant clusters on the place and sonority dimensions, in turn, examining sC clusters on these same dimensions (see also Chapter 30: Syllable-internal Structure; Chapter 56: Onsets). Our focus will be on the left word edge; other types of phonological behaviour will be discussed in later sections when we examine alternative representations for sC clusters.

Consider the inventories of two-member clusters found in word-initial position in English and Dutch in (1) and (2) respectively.[1] The data are organized by the place and manner values of C_1 for obstruent+sonorant clusters and of C_2 for sC clusters. (On cluster phonotactics for English, see Fudge 1969, Selkirk 1982, Clements & Keyser 1983, Goldsmith 1990, Harris 1994; for Dutch, see Trommelen 1984, van der Hulst 1984, Fikkert 1994, Booij 1995, van der Torre 2003.)

(1) English:

a. Obstruent+sonorant:

pl	*tl		kl
pr	tr		kr
fl	*θl	*ʃl	
fr	θr	ʃr	

b. sC clusters:

sp	st	sk
sm	sn	
	sl	
	*sr	

[1] We restrict discussion of obstruents in clusters to those that are voiceless; some languages display fewer options for voiced obstruents (e.g., */vl vr/ in English). We avoid consonant+glide clusters altogether as there are more representational options available for glides than we have space to consider.

(2) Dutch:

a. Obstruent+sonorant:

	*tn	kn
pl	*tl	kl
pr	tr	kr
fl		χl
fr		χr

b. sC clusters:

sp	st	
		sχ
sm	sn	
	sl	
	*sr	

We first consider place identity which forbids the consonants in obstruent+sonorant clusters from having the same place (Chapter 20: Consonantal Place of Articulation). This captures the ill-formedness of */tl θl ʃl/ in English, (1a), and */tn tl/ in Dutch, (2a).[2] Turning to (1b, 2b), the well-formedness of /st sn sl/ indicates that sC clusters do not respect place identity, suggesting that sC clusters do not have the same representation as obstruent+sonorant clusters. However, before we can conclude this with certainty, we must consider place-sharing */sr/, which is ill-formed in English and Dutch.[3] Importantly, */sr/ is illicit even in Dutch dialects with dorsal /r/ suggesting that the ill-formedness of this cluster has nothing to do with place identity. We return to */sr/ later in the paper.

A second less commonly discussed constraint on place concerns asymmetries that hold between C_1 and C_2 in obstruent+sonorant clusters (when C_2≠glide). English is not very revealing because C_2 is restricted to liquids which are coronal. Dutch is (potentially[4]) more illuminating because it contains stop+nasal clusters and nasals contrast for place. As (2a) shows, when a nasal is in C_2 in an obstruent+sonorant cluster, it must be coronal: /kn/ is well-formed; */km/ is out. The broader generalization is thus that when C_2 is a contoid, it must be coronal (unless /r/; see note 2).

C_2 in sC clusters has a different profile: it can have any place of articulation. Indeed, in *s*+obstruent and *s*+nasal clusters, C_2 displays the same range of place contrasts attested for singleton onsets (e.g., /sp st sk/ alongside /p t k/ in English). Directly comparing nasal-final

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[2] Place identity is not respected with /r/. In English and Dutch dialects with coronal /r/, coronal+/r/ clusters are well-formed, as are dorsal+/r/ clusters in Dutch dialects with dorsal /r/. Even in languages where /t/ and /r/ are articulated near identically, the constraint is not respected (see Arvaniti 2007 on Greek). This may suggest that /r/ permanently lacks place (Rice 1992, Goad & Rose 2004; see also Chapter 28: The Representation of Rhotics).

[3] Concerning Dutch */sr/, some speakers realize /sχr/ as [sr] (Waals 1999). If this represents a reanalysis of /sχr/ (van der Torre 2003), then /sr/ is well-formed for these speakers. Concerning English /ʃr/, we have placed this cluster in the obstruent+sonorant category (Goad & Rose 2004), rather than treating it as an assimilated form of /sr/ (Clements & Keyser 1983, Goldsmith 1990).

[4] I say potentially because, as is undoubtedly evident, obstruent+sonorant clusters will be analysed as branching onsets below. There is, however, dispute about the status of /kn/ in Dutch, as branching onset (Fikkert 1994, Booij 1995) or appendix-initial (Trommelen 1984, van der Hulst 1984, Kager & Zonneveld 1985/86). Notably, intervocalic /kn/ is syllabified as coda+onset, contra the branching onset analysis.

clusters in Dutch, we arrive at the following: */km/, ✓/kn/; ✓/sm/, ✓/sn/. The absence of */km/ alongside the presence of /sm/ is unexpected if these clusters are represented identically.

Because of the disputed status of Dutch /kn/ (note 4), we turn to Modern Greek to better examine differences in place profile between C_2 in obstruent+sonorant versus sC clusters. (On Modern Greek cluster phonotactics, see Joseph & Philippaki-Warburton 1987, Drachman 1990, Klepousniotou 1998, Morelli 1999, Tzakosta & Vis 2009; on Attic Greek, see Steriade 1982.) The data in (3) reveal that, although C_2 in an obstruent+sonorant cluster can have any manner leading to a wider range of cluster profiles than in Dutch or English, C_2 must still be coronal (Klepousniotou 1998).[5,6] (3b) shows that sC clusters are more restricted on the manner dimension than they are in Dutch, but among clusters with obstruents in C_2, it can nevertheless be seen that C_2 can have any place.

(3) Modern Greek:

a. Obstruent+sonorant:

pt		kt
(pn)	*tn	(kn)
pl	*tl	kl
pr	tr	kr
ft	*θt	xt
fθ		(xθ)
*fn	(θn)	xn
fl	(θl)	xl
fr	θr	xr
(mn)		

b. sC clusters:

sp	st	sk
sf	(sθ)	sx
(sm)	(sn)	
	*sl	
	*sr	

In sum, we have observed that C_2 in an obstruent+sonorant cluster does not parallel C_2 in an sC cluster on the place dimension. On the contrary, a closer parallel is observed between C_1 in an obstruent+sonorant cluster and C_2 in an sC cluster, which we return to below.

We consider finally the sonority constraints that hold between C_1 and C_2 in initial clusters.[7] Greek is not very revealing here, as both obstruent+sonorant and sC clusters can have a falling, flat or rising sonority profile (although (3b) indicates that the productivity of the latter for sC clusters is questionable; we return to this below). We therefore focus on English and Dutch. (1) and (2) show that sC clusters need not rise in sonority, in contrast to obstruent+sonorant clusters.

[5] Thanks to Jenny Dalalakis and Katerina Klepousniotou for help with the Greek data.

[6] Stop+stop and fricative+stop are often considered to be archaic in spoken Modern Greek (Joseph & Philippaki-Warburton 1987, Morelli 1999). They do occur in higher registers which is why they are included here. /ps ts ks/ are absent from (3a); I assume they are complex segments (following Tzakosta & Vis 2009). Cluster in parentheses (as well as /tm/) are not productive, although the number of /sm/-initial roots is somewhat larger than for the others.

[7] I assume the following sonority scale which is roughly based on relative intensity: stop < fricative < nasal < liquid < vocoid. See also Chapter 50: Sonority.

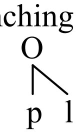
Although C_1 in an sC cluster is an obstruent and so the potential exists for these clusters to be limited to those that rise in sonority, this is not what is observed. Both languages contain falling sonority *s*+stop, and Dutch, flat sonority /sχ/.

sC clusters ≠ branching onsets

Our examination of phonotactic constraints has revealed that obstruent+sonorant and sC clusters pattern differently on three dimensions: place identity, C_2 place profile and C_1C_2 sonority profile. Hereafter, we turn to other types of phonological behaviour. Our first goal is to motivate the position that sC clusters are represented differently from obstruent+sonorant clusters. We then delve into the various options for sC clusters. For both of these topics, we will focus on phenomena where sC clusters pattern as a single class. The following section will then examine evidence that *s*+sonorant and *s*+obstruent clusters may be organized differently, *s*+sonorant clusters as branching onsets and/or *s*+stop as complex segments.

In the preceding section, we observed that obstruent+sonorant clusters have a profile consistent with the prototypical syllable, one that rises in sonority toward the peak. This indicates that clusters of this shape (modulo language-specific constraints on place identity and sonority distance) are organized as branching onsets; see (4).

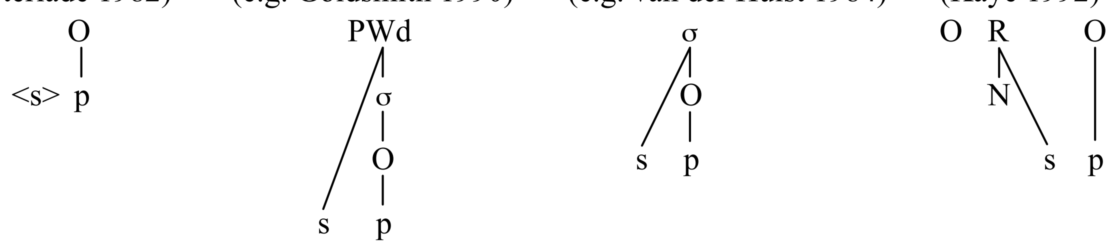
(4) Branching onset:



Following Kaye, Lowenstamm & Vergnaud (1990), I assume that onsets are universally left-headed. Heads can host a range of segmental contrasts; dependents are segmentally restricted. Considering place contrasts, earlier discussion of C_2 place profile revealed that there is more in common between C_1 in a branching onset and C_2 in an sC cluster. This suggests that sC clusters are right-headed. If onsets are left-headed, this de facto places *s* outside of this constituent, as reflected in the representations in (5). In (5), skeletal slots have been suppressed to facilitate comparison across theories; PWd abbreviates Prosodic Word (see Chapter 51: The Phonological Word).

(5) sC cluster:

a. Extraprosodic: (e.g. Steriade 1982)
b. Licensed by PWd: (e.g. Goldsmith 1990)
c. Licensed by σ: (e.g. van der Hulst 1984)
d. Coda: (Kaye 1992)



In (5a), *s* is extraprosodic. I am using this term in its narrowest sense, to refer only to the situation where an element is licensed but not organized into higher structure; compare (5b-c). (5b-c) share with (5a) the idea that *s* is an appendix: *s* is not organized by any sub-syllabic constituent, in contrast to (5d) where *s* is a coda (technically, in Kaye's model, a rhymal dependent).

Two predictions follow from the difference in representation and headedness in (4) versus (5). One, there should be languages that permit dependents in branching onsets but not sC clusters and vice versa. This prediction holds true. Spanish is a language with branching onsets but lacking initial sC clusters (Harris 1983). Acoma, spoken in New Mexico, has the opposite profile: initial clusters are restricted to sC (Miller 1965). Relatedly, Fikkert's (1994) study on the acquisition of Dutch reveals that some children acquire branching onsets first, parallel to Spanish, while others acquire sC clusters first, parallel to Acoma. Two, languages permitting both types of structures should not prevent them from being combined. To my knowledge, this prediction always holds. In languages that have branching onsets and sC clusters, three-member clusters of the shape *s*+branching onset are also well-formed. However, these clusters may be restricted to a subset of what would be expected from a free combination of sC clusters and branching onsets in the particular language (e.g., Greek: ✓/sx/, ✓/xr/, */sxr/; English: ✓/sk/, ✓/kl/, */skl/ (loans aside)).

Further, an explanation emerges under (5) for why the constraints against place identity and for rising sonority do not hold of sC clusters. It is not enough for two consonants to be adjacent; they must be sisters, as in (4).

Finally, we demonstrate that the difference in headedness between branching onsets and sC clusters can account for a commonly-attested pattern of cluster reduction in acquisition illustrated in (6) from two learners of German and English respectively, Annalena (Elsen 1991) and Amahl (Smith 1973).[8]

(6)

	Annalena (age 1;4-1;9)			Amahl (age 2;2-2;6)	
	Output	Target	Gloss	Output	Gloss
obs+son	[daɯbɛ]	[tr]aube	'grape'	[b̥eːt]	'plate'
	[fɪkə]	[fl]iege	'fly'	[ġiːm]	'cream'
s+obs	[pɪġəl]	[ʃp]iegel	'mirror'	[b̥aidə]	'spider'
	[daɪnə]	[ʃt]ein	'stone'	[ġɪp]	'skipping'
s+son	[mɪṡən]	[ʃm]eißen	'to throw'	[niːd]	'sneezed'
	[lɑːfə]	[ʃl]afen	'to sleep'	[lʌg]	'slug'

In (6), the head of the cluster survives, regardless of its position in the string or its relative sonority. This suggests that some learners recognize that branching onsets are left-headed and sC clusters right-headed, even though left-edge clusters are altogether absent from their outputs (Goad & Rose 2004).

Alternative representations for sC clusters

Thus far, we have motivated different representations for branching onsets and sC clusters, based on evidence from phonotactics and cluster reduction in acquisition. We turn now to critique the various options for sC clusters in (5).

In (5a), *s* is extraprosodic.[9] Although it is unaffiliated to any syllable constituent (at least at early levels of the phonology), it is licensed and thus not subject to stray erasure. This structure is motivated by, for example, Steriade (1982) with data from Attic Greek, Sanskrit, Latin and English; Vennemann (1982) and Wiese (1988) from German; Kager & Zonneveld (1985/86) from Dutch; Chierchia (1986) and Davis (1990) from Italian.

Although (5a) captures the unique behaviour of sC clusters, it cannot easily express the observation that some languages have different types of extraprosodic segments. In English, for example, the same status should not be assigned to /s/ in sC clusters as to inflectional /s/ in (7a), yet both fall outside of core syllabification. Further, on the face of it, some languages permit adjacent extraprosodic segments. English allows an extra morpheme-internal position at the right

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[8] [b̥ d̥ ġ] indicate voiceless unaspirated lenis stops in Amahl's data (Smith 1973). Overdots are used by Elsen (1991) to indicate ambisyllabic consonants in Annalena's data.

[9] (5a) disregards the fact that scholars working with this type of representation hold different views on whether the syllable is internally structured.

edge of words that is not permitted word-internally which some researchers have analysed as extrarhymal (e.g., Myers 1987). Since such words can also be inflected, (7b), the result would appear to be two adjacent extraprosodic positions (see also Chapter 35: Final Consonants).[10]

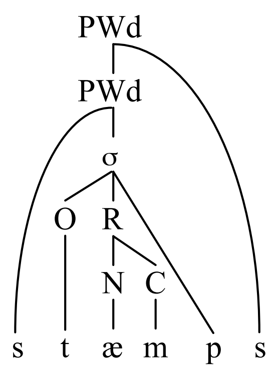
(7) English:
a. <s>træp<s> 'straps'
b. tæk<s><t> 'taxed'
træm<p><s> 'tramps'

If the final two positions in (7b) are both licensed as extraprosodic at the same point, the result would violate the Peripherality Condition: extraprosodic status can only be assigned to elements in peripheral positions (Hayes 1981, Harris 1983). The alternative that is typically adopted, therefore, is that these two types of extraprosodic segments are extraprosodic at different points in the derivation. Extraprosodic /s/ in 'taxed' and /p/ in 'tramps' are incorporated as codas in the postlexical phonology before inflectional /t/ and /s/ are added (cf. Borowsky 1986). Initial /s/ in (7a) similarly loses extraprosodic status in the postlexical phonology where lexical constraints on sonority profile are no longer assumed to hold. The problem with this approach, however, is that it fails to show that extraprosodic elements ever function as members of the constituents that ultimately come to organize them, the onset in (7a) and the coda in (7b) (Piggott 1991).

This problem is resolved once the Strict Layer Hypothesis is abandoned, the requirement that elements be dominated by the immediately higher category in the prosodic hierarchy (Nespor & Vogel 1986). Extraprosodic segments on this view are technically not *extra*prosodic (unaffiliated); instead, they are organized by some higher constituent in the prosodic hierarchy.

One possible representation for <s>tæm<p><s>, consistent with this approach, is in (8): initial /s/ is organized by the PWd, extrarhymal /p/ is organized by the syllable and inflectional /s/ is adjoined to the PWd. This representation is consistent with the Peripherality Condition: extrarhymal /p/ and inflectional /s/ are each at the right edge of a separate PWd (Goad & White 2006).

(8)



Returning specifically to sC clusters, the representation for /st/ in (8) involves *s* linking directly to the PWd (see, e.g., Goldsmith 1990 drawing on evidence from English; Trommelen 1984 and Fikkert 1994 from Dutch; Goad & Rose 2004 from German). An alternative involves *s* linking directly to the syllable, the inverse of extrarhymal /p/ in (8) (see, e.g., van der Hulst 1984 with evidence from Dutch; Levin 1985 and Kenstowicz 1994 from English; Barlow 1997 and Gierut 1999 from English in phonologically-delayed children; Drachman 1989 and Tzakosta &

[10] More troubling are words like [nɛkst] 'next' with two morpheme-internal extraprosodic positions; we return to such cases when we examine the possibility that *s*+stop form complex segments.

Vis 2009 from Greek; Tzakosta 2009 from child Greek)).[11] These two proposals were provided earlier as (5b-c).[12]

The alternatives in (5b-c) make different predictions concerning the distribution of sC clusters. I show that both options (or their equivalents) are needed, indicating that sC clusters cannot be represented identically across languages (Goad & Rose 2004, Vaux 2004, Ewen & Botma 2009). In languages with (5b), sC is only licensed PWd-initially. German has this profile (Goad & Rose 2004). (9) shows that sC clusters only occur stem-initially; word-internal tautosyllabic sC clusters are actually stem-initial, (9b). If stem-initial corresponds to PWd-initial, this restriction on sC distribution can be captured through (5b).

(9) German:

a.	$[$ʃpɪnə$]_{\text{PWd}}$	'spider'
	$[$ʃteːən$]_{\text{PWd}}$	'to stand'
b.	$[$bə$[$ʃteːən$]_{\text{PWd}}]_{\text{PWd}}$	'to insist'
	$[$gə$[$ʃteːən$]_{\text{PWd}}]_{\text{PWd}}$	'to confess'
	*$[$CV.ʃCV$]_{\text{PWd}}$	

Hall (1992) argues against (5b) for German on grounds that it incorrectly predicts aspiration in *s*+stop clusters as the stop is syllable-initial in this representation. However, Iverson & Salmons (1995), following Kim (1970), offern an explanation for the absence of aspiration in *s*+stop that holds independently of how *s* is organized: because *s* is voiceless, the peak of glottal width that characterizes aspiration is internal to *s*, not the following stop. Thus, we do not see the absence of aspiration in *s*+stop as reason to reject (5b).

In contrast to German, sC clusters in Dutch and English have a wider distribution requiring (5c). Both languages contain monomorphemic examples where the rhyme preceding sC appears unable to accommodate *s* (e.g., Dutch [ɛkstər] 'magpie', English [ɛkstrə] 'extra' (van der Hulst 1984, Levin 1985)). (5c), however, freely permits violations of the Peripherality Condition. Accordingly, before we definitively conclude that it is required for morpheme-internal sC, we must examine the following alternative: PWd-initial sC clusters involve appendices organized as in (5b); in word-medial clusters, *s* is a coda. If this analysis could be supported, we could dispense with (5c).

To show that (5c) is truly needed, we examine word-medial sC clusters in English in detail. Harris (1994) discusses the constraints governing three-position rhymes shaped VVC in this language. As (10a) reveals, coda sonorants in these superheavy syllables are confined to coronals which share place with the following onset (*[ʃowlbər], *[mawmpən]). PWd-internal rhymes shaped VCC are not considered by Harris (they are not well-formed in Government Phonology, the framework in which he works). (10b) reveals that the onset is similarly constrained to coronal and the preceding consonants must be homorganic nasal+stop (*[vɪltnər], *[dʒʌlkʃən]).

(10) English:

a.	VVC rhymes:		b.	VCC rhymes:	
	[ʃowldər]	'shoulder'		[æntlər]	'antler'
	[mawntən]	'mountain'		[vɪntnər]	'vintner'
	[kawnsəl]	'council'		[dʒʌŋ(k)ʃən]	'junction'

[11] Note that Levin (1985) adjoins, rather than directly links, *s* to the syllable. To the list in the text we can add Giegerich (1992), Hall (1992) and Booij (1995) who analyse *s* as an onset-internal appendix, using data from English, German and Dutch respectively; and Ewen & Botma (2009) who organize *s* into the specifier position of the onset for Germanic.

[12] Other less commonly proposed licensers for *s* will not be considered due to space constraints: the Foot (Green 2003 on Munster Irish); the Phonological Phrase (Vaux 2008 on Armenian).

With these constraints in mind, we turn to cases where the consonant following VV/VC is *s*. Parallel to (10a), (11a) shows that only coronal *s* is permitted after VV (*[iːftər]) and the following consonant must be coronal (*[iːspər]).[13] This leads Harris to conclude that *s* in (11a) is syllabified as the coda of a three-position rhyme. The forms in (11b) are similarly parallel to those in (10b), seemingly leading to the same conclusion.

(11) a. VVs rhymes:
[iːstər] 'Easter'
[ɔjstər] 'oyster'

b. VCs rhymes:
[mɑnstər] 'monster'
[mɪnstrəl] 'minstrel'

Problems arise, however, in (12). (12a) show that VCs does not always respect the constraints holding of (11b): the consonant preceding *s* is not restricted to place-sharing sonorants. (12b) reveals that the onset following *s* can be other than coronal, in contrast to (11a-b). One could object on grounds that, *extra* aside, the words in (12) involve Latinate prefixes. However, these prefixes are not synchronically productive: they fall within the stress domain and must therefore be contained inside the lower PWd (['ɑbstəkəl]$_{\text{PWd}}$, *['ɑb[stəkəl]$_{\text{PWd}}$]$_{\text{PWd}}$).

(12) Appendixal *s*:

a. Non-coronal codas:
['ɛkstrə] 'extra'
['ɑbstəkəl] 'obstacle'

b. Non-coronal onsets:
[ˌɛkspə'zɪʃən] 'exposition'
['kɑnskrɪpt] 'conscript'

If the forms in (12) truly involve appendixal *s*, we expect to find *s* occurring after three-position rhymes of the shape in (10). (13) shows that such words are well-formed, albeit rare. *bolster* and *holster* are monomorphemic, and while *-ster* in *upholster* is historically a class 2 suffix (C17: *uphold-ster* 'small furniture dealer'), this analysis no longer holds, as revealed by the fact that *upholster* is now a verb and *-y* can attach outside (*upholstery*).[14]

(13) VVC rhymes followed by *s*:
[bowlstər] 'bolster'
[howlstər] 'holster'
[ʌp(h)owlstər] 'upholster'

In short, while some instances of medial sC in English may involve *s* as coda, appendixal *s* is required to capture the data in (12) and (13). This thereby supports the postulation of (5c) where *s* is licensed by the syllable.

Although some languages like English appear to require (5c), this analysis cannot straightforwardly capture the fact that these same languages syllabify *s* as a coda after short stressed vowels. If the appendix representation is available word-medially, why do native speakers judge sC as heterosyllabic (*pés.ter*) rather than as appendix+onset (*pé.ster*)? It cannot be due to sonority profile, as will be seen shortly for Dutch. Heterosyllabicity of medial sC is handled more elegantly in Kaye's (1992) Government Phonology approach to sC clusters which we consider now.

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[13] Neither constraint holds in dialects with lengthened [ɑː]/[æː]: *aːfter*, *baːsket* (Harris 1994).

[14] Hayes (2009:210-211) considers the vowel in such words to be monophthongized (so presumably short) in some dialects. However, this does not hold of all dialects; witness, for example, RP [bəwlstə].

Kaye (1992) proposes that sC clusters are syllabified as coda+onset sequences, shown earlier in (5d).[15] He provides support from Italian, Ancient Greek, European Portuguese and British English; see further Brockhaus (1999) on German and Cyran & Gussmann (1999) on Polish. We consider first Italian where the coda+onset pattern observed for *péster*-type words is illustrated more concretely. In Italian, rhymes of stressed syllables must branch (Chierchia 1986). When a stressed syllable lacks a coda, the vowel lengthens; see (14a-b). (14c) shows that sC clusters do not trigger lengthening as do branching onsets; instead, they pattern with coda+onset sequences, (14d), revealing that medial *s* is a coda.

(14) Medial sC in Italian:

a.	[fáːto]	‘fate’
b.	[káːpra]	‘goat’
c.	[pásta]	‘pasta’
d.	[párko]	‘park’

Turning to word-initial position, Kaye proposes that *s* in this position is also a coda; the difference between the initial and medial environments is that, in the former, *s* is the coda of an empty-headed syllable. Word-initial coda *s* follows from the Uniformity Principle in Government Phonology which requires syllabification to be constant for a given string of segments, within and across languages. Kaye provides empirical support for Uniformity from Italian masculine definite article allomorphy and *raddoppiamento sintattico*. In the former, vowel- and sC-initial words pattern together, in contrast to words beginning with (branching) onsets; compare (15a-b) with (15c). Since the representation for *s* in an sC cluster in (5d) includes a preceding nucleus, there is a structural parallel with vowel-initial words.

(15) Masculine definite article allomorphy (Davis 1990):

a.	l’est /lo est/	‘the east’
b.	lo studente	‘the student’
c.	il burro	‘the butter’
	il clima	‘the climate’

In *raddoppiamento sintattico*, the first consonant in an onset geminates when the preceding word ends in a stressed vowel, while the first consonant in an sC cluster resists gemination; see (16). The pattern in (16b) follows directly from the view that *s* is a coda: as coda+onset, sC already has precisely the structure that holds of geminates.

(16) Raddoppiamento sintattico (Chierchia 1986):

a.	paltó pulíto	[paltóppulíto]	‘clean coat’
	cittá tríste	[tʃittáttríste]	‘sad city’
b.	cittá straniéra	[tʃittástraniéra], *[tʃittásstraniéra]	‘foreign city’

Although it is evident from (15) and (16) that sC clusters in Italian cannot be analysed in the same fashion as branching onsets, the proposal that they contain an initial appendix can also handle these data (see Chierchia 1986, Davis 1990). Of the cases Kaye considers, the construction that poses a particular challenge for appendixal *s* is European Portuguese vowel nasalization. We turn to this case now.

[15] A precursor to this appears in Vennemann (1988). Vennemann proposes that initial *s* is ‘quasi-nuclear’ in some languages, a type of degenerate syllable. He argues that this analysis of Latin *s* explains its development into a regular Vs syllable in some Romance languages, notably Spanish.

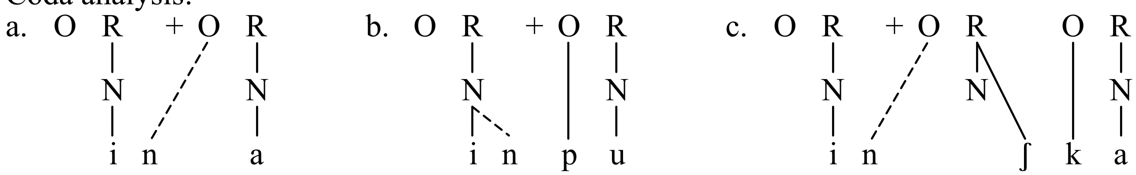
In European Portuguese, nasal consonants cannot close syllables. While /n/ is realized intact before vowel-initial bases, (17a), before onset-initial bases, nasality surfaces on the preceding vowel, (17b-c). Interestingly, sC-initial bases pattern as vowel-initial, (17d).

(17) European Portuguese:

a.	[in]admissivel	'inadmissable'
b.	[ĩ]pureza	'impurity'
	[ĩ]satisfeito	'dissatisfied'
c.	[ĩ]tratavel	'unsociable'
d.	[in][ʃk]apavel	'inescapable'

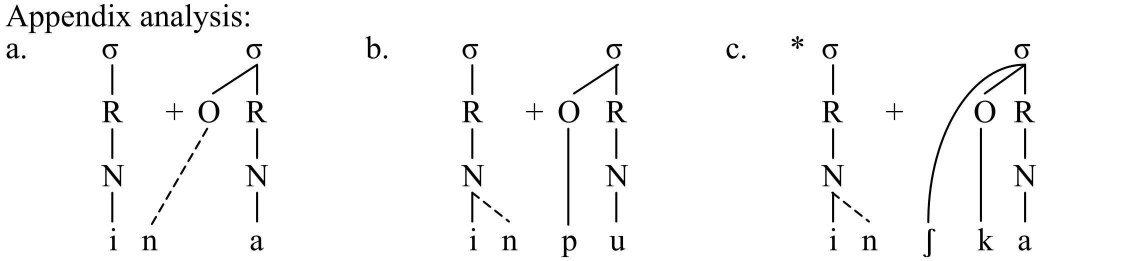
(17d) can be straightforwardly expressed under Kaye's view that sC clusters are coda+onset because, for independent reasons, all syllables in Government Phonology contain an onset constituent. Consider the representations below.[16] In (18a), /n/ associates to the onset of the first syllable in the base. In (18b), this position is occupied, so nasality is preserved on the preceding vowel. The right result obtains in (18c) precisely because the syllable containing *s* includes an empty onset.

(18) Coda analysis:



An appendix analysis of *s*, it seems, cannot formally capture (17d). See (19c) where bases with initial sC are incorrectly predicted to pattern with onset-initial bases because there is no empty constituent to host /n/.

(19) Appendix analysis:



Kaye's paper compares the coda+onset analysis of sC clusters to the alternative that they form branching onsets; the option that *s* is analysed as an appendix is not discussed. We have seen that appendixal *s* cannot straightforwardly capture European Portuguese. It also goes against the Uniformity Principle: Italian *s* is an appendix in *straniéra* but a coda in *pásta*; this would likely be considered a weakness by proponents of Government Phonology. However, there are contexts where word-internal *s* maintains its appendix status, in contrast to the pattern observed for Italian; sC can follow a rhyme that is already full, so *s* cannot be accommodated as an ordinary coda. We have already observed this for English, but we have also seen that English permits word-internal three-position rhymes under limited circumstances and most of the problematic sC data are in words that historically involve prefixes. To ensure that there is nothing unusual about English concerning the distribution of sC clusters, let us turn to Acoma (Miller 1965).

[16] No representations are provided by Kaye. (18) reflects my best guess (minus X slots) based on his discussion.

Two-position rhymes in Acoma are limited to VV and seemingly Vs (loans aside); see (20a-b). If word-internal *s* were always a regular coda, as it appears to be in (20b), we would expect it to be restricted to occurring after short vowels, like in Italian. (20c) reveals that this is not the case.

(20) Acoma:

a.	[spúuná]	'pottery'
	[jaʔái]	'sand'
b.	[sustʼá]	'I took water'
	[ʔéská]	'rawhide'
c.	[ʔúusc̨úut͡sʰi]	'drum'
	[kủiscʰaṣa]	'knot'
	[w̓i̓ isp̓i]	'cigarette'

It appears that *s* is an appendix to the syllable in Acoma, rather than a regular coda. Before we accept this, however, an alternative analysis must be considered, that sC clusters are not actually clusters in Acoma but are, instead, adjacent onsets interrupted by an empty nucleus. This analysis would, of course, allow *s* to occur after long vowels and it could be motivated by the observation that the plain-aspirated contrast is maintained after *s* ([ʔúu.sØ.cúu.t͡sʰi] vs. [kủi.sØ.cʰa.ṣa]). Evidence from the right word edge, however, reveals a potential challenge: word-final consonants, which are always onsets of empty-headed syllables in Government Phonology (Kaye 1990), are not permitted in Acoma: *[…CV.sØ].

In sum, we have critiqued four representations for sC clusters. While we can likely dispense with the extraprosodic representation for *s* in (5a) in favour of the alternatives in (5b-d), choosing between these alternatives is no easy task. On one hand, there are languages like Acoma and English that are most compatible with the position that *s* is an appendix to the syllable; on the other are languages like European Portuguese and to a lesser extent Italian that seem to require a coda analysis for *s*. When German is compared with English and Dutch, it becomes clear that languages also differ in where sC can occur, stem-initially only or also morpheme-internally, revealing that appendixal *s* must be licensed by the PWd in the former case and by the syllable in the latter.

Are all sC clusters represented in the same manner in a given language?

Thus far, we have treated all sC clusters as a single class. Given that these clusters fall into two groups concerning their sonority profile, several researchers have proposed different representations for each group within a given language. One body of work considers rising sonority sC clusters to be structured as branching onsets while *s*+obstruent clusters are appendix-initial (see, e.g., Hall 1992 with data from German; Fikkert 1994, Booij 1995 from Dutch; Gierut 1999 from English in phonologically-delayed children). Another body of work motivates a different analysis for *s*+stop clusters: they are not actually clusters but, instead, form complex segments (see, e.g., van de Weijer 1996 drawing on data from several languages; Fudge 1969, Fujimura & Lovins 1982, Ewen 1982, Selkirk 1982 from English; Broselow 1983 from L2 English; Wiese 1996 from German; Barlow 1997 from English in phonologically-delayed children). Since all of this research draws a boundary between rising sonority clusters and *s*+stop clusters, much of the data effectively show evidence for either position.

The section on cluster phonotactics revealed that, when place of articulation is examined, end-state grammars challenge the view that *s*+sonorant clusters form branching onsets. Evidence from acquisition (Chapter 108: The Interpretation of Phonological Patterns in First Language Acquisition), however, suggests that some learners disregard place, relying solely on sonority in their analysis of left-edge clusters: all rising sonority clusters –both obstruent+sonorant and *s*+sonorant– pattern together. Consider the Dutch children in Fikkert's (1994) study: all follow the same developmental path for fricative+liquid and *s*+lateral clusters. The stages through which learners pass are exemplified in (21) with data from Jarmo.

(21) Jarmo's cluster development:

Stage	Pattern	Examples			Age
1	stop	/ˈvlɪndər/	[ˈkɪnʉ]	'butterfly'	2;2.6
		/ˈslaːpə(n)/	[ˈtaːpə]	'to sleep'	2;0.28
2	liquid	/ˈvlɪndər/	[ˈlɪŋʉ]	'butterfly'	2;2.27
		/ˈslaːpə(n)/	[ˈlaːpə]	'to sleep'	2;3.9
3	fricative	/ˈχlɛiˌbaːn/	[ˈχɛiχaːn]	'slide'	2;4.1
		/ˈslaːpə(n)/	[ˈsaːpə]	'to sleep'	2;3.9
4	stop+liquid	(skipped by Jarmo)			
5	fricative/*s*+liquid	/ˈflɛs͡jə/	[ˈslɛs͡jə]	'bottle' (dim)	2;4.1
		/slɑk/	[flɑk]~[slɑk]	'snail'	2;4.1

Further, all children in Fikkert's study master *s*+stop clusters at a different point in time from rising sonority clusters. As all rising sonority clusters pattern together in Dutch acquisition, in contrast to *s*+obstruent, Fikkert concludes that *s*+sonorant clusters are represented in the same manner as branching onsets. For her, *s*+obstruent clusters involve *s* licensed by the PWd, (5b) above.

While sonority plays a decisive role in Fikkert's data, this is not the case for all children. Indeed, we observed in (6) that when only one member of a cluster is produced by Annalena and Amahl, it is the cluster head that survives, regardless of its relative sonority. To show that this pattern extends past the deletion stage, consider the developmental path for Amahl in (22).

(22) Amahl's cluster development:

Stage (Age)	obstruent+liquid	/sl/	/sm sn/	/sp sk/	/st/
1-8 (2.60-2.175)	reduction to head	reduction to head	reduction to head	reduction to head	reduction to head
13-14 (2.233-2.256)	branching onset acquired				
15-19 (2.261-2.333)		fusion	fusion	vacuous fusion	vacuous fusion
20-22 (2.345-3.38)					fusion
24 (3.78-3.96)		appendix acquired			
25 (3.104-3.128)			appendix acquired		
26-29 (3.133-3.355)				appendix acquired	appendix acquired

All clusters reduce to the head through stage 8. Branching onsets are acquired first, emerging at stage 9 and being fully mastered at stage 13. sC clusters are reduced to the head until stage 15 at which point the two consonants undergo fusion. Fusion is overt for *s*+sonorant (e.g., /sn/→[n̥]), but not initially for *s*+stop since both consonants are voiceless (e.g., /st/→[t]). At stage 20, when stridency is acquired, fusion becomes overt for /st/ (/st/→[t^{s}~s~s̪]). Importantly, at this stage, no target *s*+sonorant clusters are realized as [s]; thus, earlier reduction to the head cannot have been due to the unavailability of [s] in Amahl's productions. Appendices are not acquired until 210 days later than branching onsets, first for /sl/. The remaining sC clusters are then acquired over a period of 55 days.

The developmental profiles for Jarmo and Amahl are completely different for *s*+sonorant clusters. It truly appears that these clusters are analysed as branching onsets in Jarmo's grammar and with an initial appendix/coda in Amahl's grammar. We briefly consider the consequences of this.

In the section on phonotactics, we observed that place identity and C_2 place profile suggests that, in end-state Dutch, all sC clusters are represented differently from branching onsets. If learners like Jarmo initially only consider sonority in assigning clusters to categories, then some unlearning must take place to arrive at the target representations. These children must discover that: (i) place identity is respected in branching onsets (*/tl/) but not in *s*+sonorant clusters (✓/sl/); (ii) *s*+sonorant is represented in the same fashion as *s*+obstruent. The implication is that, prior to this, sonority pattern learners do not attend to place identity. Fikkert provides some data consistent with this (e.g., Jarmo's /ˈdrɪŋkə(n)/→[ˈtlɪŋkɑ] 'to drink' (2;4.1)).

Positive evidence for (i) and (ii) comes from medial clusters following stressed vowels: as (23) shows, /tl/, /sl/ and /st/ are syllabified as coda+onset while /tr/ forms a branching onset (Trommelen 1984, Kager & Zonneveld 1985/86).[17] (The initial vowel in (23d) is not underlyingly long which could have prevented heterosyllabification of medial /tr/; it is lengthened because rhymes are minimally bipositional in Dutch.)

(23) Dutch:
   a. [ˈɑt̚.lɑs] 'atlas'
   b. [ˈɔs.loː] 'Oslo'
   c. [ˈpɑs.taː] 'paste'
   d. [ˈmaː.trɪks] 'matrix'

Although data such as these reveal that *s*+sonorant clusters do not pattern as branching onsets, words of the profile in (23a-b) are largely restricted to borrowings and proper names (van der Torre 2003) and are likely infrequent in child-directed speech (Fikkert 1994). Thus, the analysis that *s*+sonorant clusters are not actually branching onsets may be unlearnable under the scenario that children begin assigning clusters to classes based solely on sonority. Does this mean that adult Dutch is a language where *s*+sonorant clusters are analysed as branching onsets? This is Fikkert's (1994) position but it leaves unexplained the differences in place profile of true branching onsets and *s*+sonorant clusters, as well as the syllabification of *s*+sonorant with *s*+obstruent in word-medial position.

We have just observed that some researchers consider sonority decisive in assigning clusters to categories with the result that rising sonority *s*-initial clusters are analysed as branching onsets. Consequently, it is *s*+obstruent that is singled out as formally different. Another approach to the different behaviour of *s*+stop has been to treat these strings as complex segments (Chapter 27: Secondary Articulation and Doubly Articulated Consonants). This view is autosegmentally expressed in (24).

(24) *s*+stop as complex segment:

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  X
 / \
s   p
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Many of the arguments for a single segment analysis of *s*+stop are distributional. Indeed, most researchers who motivate this analysis begin with the observation that all left-edge three-member clusters in the languages under examination are *s*+stop initial (e.g., Fudge 1969, Selkirk

[17] Thanks to Janet Grijzenhout and Stephanie Schreven for help with the phonetic detail in (23).

1982, Wiese 1996, van de Weijer 1996). The position that branching onsets contain a maximum of two consonants can be maintained if *s*+stop form complex segments. As Selkirk (1982) asserts, similar problems can be resolved at the right edge if the single segment analysis holds independent of position (see earlier Fudge 1969). On one hand, words like *next* violate the finding that, inflection aside, English codas are maximally binary. On the other, words such as *wasp* and *task* violate the constraint that C_2 in an obstruent coda cluster is always coronal. If these words are segmented as [n-ɛ-k-st], [w-ɑ-sp] and [t-æ-sk], these problems are resolved.

Following on this, Ewen (1982) observes for English that, unlike other clusters which appear in mirror-image order in syllable-initial versus -final position (*clip, silk*), sC clusters occur in the same order in both positions (*skip, task*). He notes that similar observations were made earlier by Vogt (1942) for Norwegian and Sigurd (1965) for Swedish.

A different sort of distributional argument is made by Wiese (1996) for German. He shows that *s*+stop and other complex segments, namely affricates, have similar distributions. Alongside [ʃplɪt] 'chippings' and [ʃpriːsən] 'to sprout', we find words like [pflɪçt] 'duty' and [pfriːm] 'awl'.

Turning to other types of phonological behaviour, most of the evidence that van de Weijer (1996) forwards involves languages where *s*+sonorant behaves differently from *s*+stop and together with true branching onsets, thereby supporting a branching onset analysis for *s*+sonorant and another analysis for *s*+stop. Reduplication in Gothic provides the most compelling evidence that the appropriate analysis for *s*+stop is as a complex segment (see also Cairns & Feinstein 1982, Wiese 1996).

Gothic has a class of verbs where the preterite is formed through reduplication. The data in (25a-b) (from van de Weijer) reveal that singleton onsets and the first member of branching onsets are copied. (25c-d) show that sC clusters do not behave uniformly. Those with rising sonority pattern with branching onsets –only C_1 is copied– while *s*+stop is copied as a unit.

(25) Gothic reduplication:

a.	haita	'I am called'	hai-hait	'I was called'
	h^wopa	'I boast'	h^wai-h^wop	'I boasted'
b.	fraisa	'I try'	fai-frais	'I tried'
c.	slēpan	'to sleep'	sai-slēp	'I slept'
d.	skaida	'I sever'	skai-skaiþ	'I severed'

The pattern in (25d) is entirely as expected if *s*+stop forms a complex segment; indeed, accounting for it through an appendix/coda+onset representation is challenging at best. Somehow, the analysis would have to copy the segments up to and including the cluster head.

We turn now to examine some challenges for the complex segment approach to *s*+stop. Although we have provided distributional evidence for this proposal, another look reveals problems on this front. Van der Hulst (1984) rejects the analysis for Dutch on grounds that *s*+stop does not have the same distribution as singleton obstruents. Putative complex segments can follow a vowel but not a consonant, unlike non-complex obstruents: [ʋɛsp] 'wasp' but *[ʋɛlsp], cf. [ʋɛlp] 'lion cub'. The same problem holds for English: [wɑsp] 'wasp', [wɑrp] 'warp', *[wɑrsp]. If *s*+stop forms a two-consonant string, this observation follows straightforwardly.

Consider next patterns of epenthesis in cluster repair in L2 acquisition and loanword adaptation (Chapter 100: Loanword Phonology). (26) presents four patterns of repair for learners/borrowers whose native grammars lack both branching onsets and sC clusters (<u>V</u> = epenthetic vowel). Although there are languages where the position of the epenthetic vowel is constant (26a-b), in languages where both prothesis and anaptyxis are observed, two general patterns are found (26c-d): *s*+stop is never interrupted, obstruent+sonorant always is, and *s*+sonorant is variably interrupted.[18]

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[18] As Fleischhacker (2001) shows, more divisions among *s*+sonorant are actually observed. We return to this below.

(26) Patterns of cluster repair:

a. Japanese (Lovins 1974)	s-V-stop	obstr-V-son	s-V-son
b. Iraqi Arabic (Broselow 1983)	V-s-stop	V-obstr-son	V-s-son
c. Egyptian Arabic (Broselow 1983)	V-s-stop	obstr-V-son	s-V-son
d. Farsi (Karimi 1987)	V-s-stop	obstr-V-son	V-s-son

Broselow (1983) proposes that the reluctance of L2 learners to epenthesize into *s*+stop motivates their analysis as complex segments (see also van de Weijer 1996). While this analysis helps to explain the patterns in (26b-d), it cannot straightforwardly account for the Japanese pattern. Clearly, absence of strings of the shape VsTV (T=stop) in Japanese makes prothesis an impossible repair. Given this, under the view that *s*+stop forms a single segment, the expected pattern for Japanese is simplification of the complex segment, as in van der Weijer's (1996) analysis of Sanskrit reduplication: C_1 is normally copied ([snih]-[si-ṣnih] 'to be sticky' (root-perfect), [dru]-[du-druv] 'to run'), but complex segments are reduced to their head (the stop): [skand]-[ka-skánd-a], *[ska-skánd-a] 'to leap'.

Finally, the single segment hypothesis for *s*+stop is challenged by Byrd (1994) on articulatory grounds. Byrd experimentally examines /sk/ strings in English in three contexts: word-initially, cross-word and word-finally. She observes that #sk involves less overlap than s#k (as well as sk#), and sk# less overlap than gd#. If *s*+stop form single segments, we would expect to find a higher degree of overlap than is observed in strings of consonants that clearly do not form single segments (s#k and gd#).

To sum up, the goal of this section was to examine whether all sC clusters pattern as a class, in contrast to branching onsets. On one hand, we observed that *s*+sonorant sometimes patterns with obstruent+sonorant, suggesting that they may have the same representation. Supporting evidence was provided from the developmental path for left-edge clusters in Dutch. On the other hand, we examined evidence in favour of the position that *s*+stop clusters form complex segments. The strongest evidence for this comes from Gothic reduplication. However, both positions were challenged as well, the analysis for child Dutch by the observation that end-state Dutch treats *s*+sonorant together with *s*+obstruent. Perhaps the most damaging evidence against the complex segment analysis is that the articulatory evidence available does not support it.

Perceptual considerations

Throughout the paper, it has been assumed that a structural difference holds between true branching onsets and (at least some) sC clusters. We have observed, however, that languages do not always draw a clear line between these two cluster types: *s*+sonorant sometimes patterns with *s*+stop and at other times with obstruent+sonorant. When we consider Fleischhacker's (2001) survey on epenthesis in L2 and loanword phonology, the problem becomes even more acute: some languages draw the boundary between cluster type *internal* to the *s*+sonorant class, as shown in (27), in contrast to what was observed in (26).[19]

[19] Farsi2 refers to the data collected by Fleischhacker. Although Karimi (1987) reports that all *s*+sonorant clusters pattern together, as per (26d), she provides no *s*+rhotic nor *s*+glide examples. The data collected by Fleischhacker show a different pattern for these clusters, as revealed in (27). Since this may reflect a dialect difference, I have labelled the language from which Fleischhacker collected data Farsi2. In addition, Catalan is in parentheses because although it draws a division between *s*+rhotic and *s*+glide, only prothesis is attested; *s*+glide and stop+sonorant do not undergo epenthesis.

(27) more prothesis ⟵⟶ more anaptyxis

s+stop	<	*s*+m	<	*s*+n	<	*s*+l	<	*s*+r	<	*s*+glide	<	stop+son
	↑		↑		↑		↑		↑		↑	
	Egyptian Arabic		Hindi		Kazakh		Farsi2		(Catalan)		Wolof	

Results like these have led Fleischhacker to abandon a structural approach to cluster representation, putting her in the company of others who advocate eliminating the syllable (e.g., Steriade 1999).[20] She argues instead for a perceptually-motivated approach to cluster behaviour. Epenthesis site, in particular, is chosen to maximize perceptual similarity between the target (non-epenthesized) form and the output. In view of this, we consider in this section whether the differences that hold between sC clusters and true branching onsets can be explained by perceptual considerations alone; this, of course, would challenge the claim that a structural approach to cluster behaviour is necessary.

We do not have space to examine Fleischhacker's proposal in detail but the predictions she motivates are as follows: (i) anaptyxis is preferred to prothesis in stop + sonorant; (ii) prothesis is preferred to anaptyxis in *s* + stop; (iii) among *s* + sonorant, more anaptyxis is expected as C_2 increases in sonority; and (iv) more anaptyxis is expected in stop + sonorant than in fricative + sonorant. Concerning (iv), note that Fleischhacker's account does not distinguish *s* from other fricatives; that is, no explanation is provided for the observation that fricatives other than *s* pattern with stops in preferring anaptyxis to prothesis ((26) above). We return to this shortly. First, let us examine the role of perception in sC well-formedness in more detail (Chapter 104: Perceptual Effects).

As alluded to earlier, the acoustic properties of *s*, unlike other obstruents, enable it to appear in positions where it is not followed by a sonorant: strident fricatives have robust internal cues for both place and manner ensuring their perceptibility in all contexts, even before stops (Wright 1996, 2004). Clearly, then, the view that segments are ordered to yield a rise in sonority toward the peak does not extend to *s*. Indeed, in spite of the sonority reversal, (strident) fricative+stop is superior to both stop+stop and stop+fricative,[21] even though the latter two contain a sonority plateau and minimal rise respectively, because (strident) fricatives are less dependent on formant transitions for their identification than stops (Wright 1996, 2004).[22]

However, while the acoustic properties of *s* explain why appendices are so often limited to *s* on one hand and why these segments can be followed by stops on the other, they cannot, as far as I can tell, explain cross-linguistic preferences on sC profile. (28) shows that sC clusters have a rather unusual distribution across languages when viewed from the perspective of perceptual robustness. We focus on word-initial position. Since the perceptibility of all consonants in C_2 position in an initial sC cluster will be partly compromised by the preceding *s*, we would expect consonants that are most perceptible to be positioned after *s*. Masking should not be too severe in this context: as mentioned earlier, Byrd (1994) observes that #sk clusters involve less overlap than s#k and sk#. The problem may rather be one of duration: Byrd finds that /s/ is longer in #sk than in both s#k and sk#, while /k/ is shorter in #sk than in both s#k and sk#. If the relatively short duration of C_2 can be generalized to other #sC clusters, we would expect segments with

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[20] Steriade's arguments include the absence of clear evidence for word-internal syllable boundaries. Some of the evidence concerns the syllabification of *s*+stop clusters in English when the following vowel is stressed (e.g., *mystérious*). Speakers' judgements vary on where to draw the boundary in such words because neither parse is sanctioned at word edge: V_1.stV_2 is problematic because V_1 is illicit word-finally; V_1s.tV_2 is problematic because [t] is not aspirated, as it would be word-initially.

[21] Evidence that this observation is not restricted to *strident* fricative+stop comes from Greek: the stop+stop clusters in (3a) are often replaced by fricative+stop.

[22] See Morelli (1999) for an alternative explanation of obstruent cluster well-formedness that appeals to markedness constraints on segment sequencing.

robust internal cues to be favoured in this position. Liquids should be optimal since they have clear formant structure throughout. Nasals should be favoured over stops since their manner (and to a lesser extent their place) properties are present in the nasal spectrum. Stops, which have weak internal cues, should be the least optimal.

What we observe in (28), by contrast, is that *s*+stop is favoured. French and Acoma do not permit *s*+sonorant clusters at all (French has *s*+sonorant in loanwords), and depending on the status of marginal *s*+nasal clusters, Greek may fall into this category as well. Otherwise, it permits *s*+sonorant clusters of lower sonority than those of higher sonority.

(28) sC cluster profile across languages:

s +	Spanish	French, Acoma	Greek	English	Dutch	German	Russian
stop	*	✓	✓	✓	✓	✓	✓
fricative	*	*	✓	*	✓	*	✓
nasal	*	*	(*)	✓	✓	✓	✓
lateral	*	*	*	✓	✓	✓	✓
rhotic	*	*	*	*	(*)	✓	✓

Although a larger typology of languages is required before firm conclusions can be drawn, (28) suggests that *s*+stop ≻ *s*+nasal ≻ *s*+lat ≻ *s*+rhotic (≻ = is more harmonic than). The favoured profile in sC clusters is thus the opposite of that observed for branching onsets. This is not unexpected on a structural account if all sC clusters are head-final, in contrast to branching onsets. In sC clusters, C_2 is the onset head; thus, it should respect the preferences holding of singleton onsets. Since obstruents are the optimal onsets (e.g., Clements 1990), a parallel should be observed between obstruents in C_1 position in branching onsets and stops in C_2 position in sC clusters (not fricatives more generally because of the preceding *s* (see Wright 2004:51)).

While the C_1C_2 asymmetry in branching onsets versus sC clusters follows from the status of *s* as an appendix, it is best captured, I suggest, under Kaye's proposal that *s* is a coda. Recall from (14) and (23) that medial sC clusters in Italian and Dutch are heterosyllabic. If sC clusters are *always* syllabified as coda+onset clusters, then their profile should respect cross-linguistic preferences for optimal syllable contact. Syllable contact will favour C_2 with lower sonority: Vs.TV ≻ Vs.NV ≻ Vs.lV ≻ Vs.rV. As C_2 increases in sonority, the cluster prefers to be syllabified as a branching onset, but if this option is never available for sC clusters, then higher sonority sC clusters will be forbidden, regardless of their position in the word.

The profile in (28) closely parallels Fleischhacker's typology in (27) for preferred epenthesis site in sC clusters. Prothesis occurs more commonly when C_2 has lower sonority. As the sonority of C_2 increases, prothesis will result in poor syllable contact. Note as well that the proposed syllable contact account of sC well-formedness leads to a distinction between *s*+sonorant and fricative+sonorant, as only the latter can form branching onsets. Thus, the fact that fricative+sonorant patterns with stop+sonorant in epenthesis follows, in contrast to under Fleischhacker's account (see (iv) above).

In sum, I contend that both perceptual and structural considerations must be factored into our understanding of cluster well-formedness. While perceptual considerations can explain why appendices are so often limited to *s* and why *s*+stop is well-formed in spite of its sonority profile, it is the structural differences between sC clusters and branching onsets that explain the preference for sC profile on the sonority dimension as well as some observed differences in epenthesis site.

Conclusion

In this paper, we have examined several alternative analyses for sC clusters. On the empirical front, we have seen that *s*+stop clusters reliably pattern differently from true branching onsets.

Not surprisingly, then, the proposals we have examined for *s*+stop all share an important property: *s*+stop clusters are head-final, whether *s* is unaffiliated, an appendix organized by some prosodic constituent above the onset, a coda, or the first member of a complex segment. Branching onsets, by contrast, are head-initial. This difference in headedness helps to explain parallels on the place dimension between C_2 in an *s*+stop cluster and C_1 in a branching onset, as well as syllabification preferences in word-medial contexts.

Beyond that, however, details of the proposals differ, and following on this, each proposal is both supported and challenged by the available evidence. There are languages like Acoma, English and Dutch where *s* can appear medially after rhymes that are 'full', thereby providing support for the analysis that *s* is linked to the syllable and potentially challenging the coda analysis. However, in some of these same languages, namely English and Dutch, as well as in languages like Italian, the observation that sC clusters are heterosyllabic after stressed vowels supports the coda analysis and thereby questions the proposal that *s* is licensed by the syllable or that *s*+stop form a complex segment. The complex segment analysis, in turn, is supported by the reduplication pattern in Gothic which both the appendix and coda analyses fail to elegantly capture.

At present, then, it seems that multiple representations for sC clusters may be required. If the number of parametric options is limited and there is robust evidence available for learners to determine the appropriate representation for the language being acquired, this is far from problematic. For example, the fact that sC clusters have a more limited distribution in some languages (German) than in others (English, Dutch) can be captured if licensing by the PWd represents the least marked option and therefore the starting point for learners. There will then be positive evidence available to signal learners of some languages that sC clusters are licensed lower down, by the syllable. However, we have also seen that this type of scenario may not always work. If Dutch learners initially assume that *s*+sonorant clusters form branching onsets, the evidence available to undo this analysis in favour of one where all sC clusters pattern as a class is far from robust and may present a learnability challenge.

The problem with *s*+sonorant more generally is that they are phonotactically ambiguous and, following from this, they pattern ambiguously across languages. While one could fail to be surprised by this, on grounds that these clusters are both *s*-initial and rise in sonority, exactly how their ambiguous behaviour should be formally expressed is far from clear. They appear to be analysed as branching onsets in some languages (e.g. Jarmo's Dutch grammar) and as appendix/coda-initial in others (e.g. Amahl's English grammar), but in this particular case, this finding is surprising, in view of the otherwise high degree of similarity between the two target languages.

The solution that languages employ different analyses for *s*+sonorant is far from optimal and may lead some researchers to abandon a structural approach to the syllable altogether in favour of a perceptually-grounded account of segmental contact. Indeed, the latter may find support in the observation that even within the class of *s*+sonorant, languages show different patterns of behaviour; we have seen that the division between prothesis and anaptyxis can be drawn anywhere internal to this class. At the same time, however, a purely perceptually-based account seems to be challenged by the finding that preferences for sC cluster profile are virtually the inverse of those observed for obstruent+sonorant clusters. While an appeal to syllable contact was made to capture both of these observations, the analysis follows most straightforwardly from the proposal that sC clusters are always syllabified as coda+onset strings. We have already seen that this proposal may be challenged by languages such as English, Dutch and Acoma.

In spite of the quantity of research that had been undertaken on sC clusters, it is perhaps most evident that more needs to be done before the issue of their representation can be resolved (if ever). A sampling of questions at the two extremes includes the following. At one end of the spectrum, can a more detailed examination of perceptual factors capture differences in the behaviour of fricative+sonorant and *s*+sonorant clusters, thereby further questioning the need for a structurally-based approach to segmental contact and syllabification behaviour? At the other end, if a structural account of behaviour based on syllable contact proves fruitful to pursue, with judicious use of abstract representations, can the coda+onset analysis be motivated for all languages? I leave these and many other questions in between to future research.

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