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*s*C Clusters are (almost always) coda-initial

Abstract: This article defends the position that syllables have internal structure, through an examination of *s*C clusters. Although perceptual factors will be shown to account for why it is sibilants that pattern in unexpected ways in clusters, it will be argued that the behavior of *s*C clusters cannot be explained solely by functional considerations. Among structural approaches to the syllable, it is argued that *s*C clusters are best analyzed as coda+onset, not as appendix+onset. The typological patterns of *s*C cluster well-formedness on the sonority dimension and *s*C cluster repair are shown to follow only from a coda analysis of *s*: the patterns follow from constraints on syllable contact. In view of this, it will be shown that the two most commonly defended options for the organization of *s* as an appendix, the syllable and the prosodic word, can be straightforwardly captured under a coda approach, through a comparative examination of English and Italian. It will further be shown that the distribution of aspiration in English is amenable to a coda analysis of *s*. Finally, it is argued that some languages require an analysis of *s*C other than coda+onset. This situation holds in Acoma: an empty nucleus interrupts putative *s*C clusters in this language.

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1 Introduction*

*s*C clusters defy many of the phonotactic constraints that hold of true branching onsets: they do not require a rising sonority profile (*sp* vs. *pl*); they do not respect constraints against identical place (*sl* vs. **tl*); and they happily permit a range of place contrasts in C_2 position (*sp*, *st*, *sk*) in contrast to branching onsets which

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instead display a parallel range of place contrasts in C_1 position (*pr*, *tr*, *kr*).[1] Observations such as these have typically led to the proposal that *s* is outside of the onset constituent to which the following consonant belongs. A variety of options exist concerning the prosodic organization of *s*: in non-linear phonology, *s* is most commonly represented as an appendix, which is linked to some higher level of prosodic structure (e.g., Goldsmith 1990; van der Hulst 1984); in Government Phonology, *s* is represented as a coda (Kaye 1992). Although these proposals differ in considerable ways, they share the view that phonological relations are highly articulated and, more pointedly, that syllables have internal structure. A growing body of recent research, however, has challenged this view (e.g., Steriade 1999a; Côté 2000). Fleischhacker (2001, 2005), in particular, has argued that the differences between *s*C clusters and true branching onsets can be explained by perceptual considerations alone, that is, without recourse to syllable constituency.

My general goal in this paper is to defend an articulated view of the syllable, through an examination of *s*C clusters. Concerning the two options mentioned above for *s* – appendix versus coda – I advocate the coda view. I argue that the typological patterns of *s*C cluster well-formedness on the sonority dimension, as well as *s*C cluster repair, follow only from a coda analysis of *s*. Although perceptual factors will be shown to account for why 'appendices' are so often limited to *s*, I will demonstrate that these patterns are not amenable to explanatory treatment by appealing to functional considerations alone, contra Fleischhacker. I will also show that they cannot be explained by other syllable-based approaches, where *s* is analyzed as an appendix. In light of this, a second goal of the paper is to expand on the coda approach to *s* advanced by Kaye (1992), through a comparative examination of English and Italian. It will be shown that the two most commonly forwarded options for the organization of appendixal *s* – licensing by the syllable and licensing by the prosodic word – can be straightforwardly captured under a coda approach, critically then without reference to appendices. Finally, the title of the paper leaves open the possibility that some languages may call for an analysis of *s*C other than coda+onset. It will be shown that this situation holds in Acoma, a language without codas. I will argue that an empty nucleus interrupts putative *s*C clusters in this language, an analysis that finds support in the presence of laryngeal contrasts after *s* and in a surprising pattern of *s* allophony in *s*C clusters.

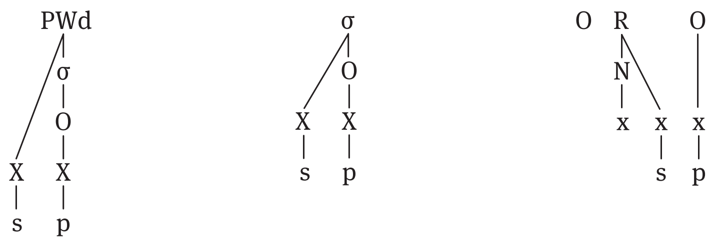
1 Italicized *s* stands for the class of sibilants that pattern as 'appendices' in *s*C clusters. In most of the languages under focus, this sibilant is [s]. In European Portuguese (Section 2.2) and German (Section 3), it is [ʃ]; in Acoma (Section 5), it is [ʃ] and [ʂ]. Voiced counterparts of *s*, arising through assimilation, are also found in some of the languages under examination.

2 Representations

I begin by briefly presenting the three structural approaches to *s*C clusters that will be under scrutiny in this paper. As mentioned, in non-linear phonology, word-initial *s* is most commonly represented as an appendix in *s*C clusters, that is, as a segment organized into prosodic structure at some higher level than would normally be expected, given the segment's position in the string. *s* has most commonly been proposed to be directly linked to the prosodic word (PWd) as in (1a) (e.g., Goldsmith 1990) or to the syllable as in (1b) (e.g., van der Hulst 1984).[2] In Government Phonology (GP), *s* is instead represented using the same inventory of syllable constituents available for "ordinary" consonants: it is a rhymal dependent (henceforth coda) (Kaye 1992); see (1c). What makes *s*C clusters in initial position special in this approach is the presence of a preceding empty nucleus (see further Section 4.1).

(1) *s*C clusters:

a. Appendix licensed by PWd: b. Appendix licensed by σ: c. Rhymal dependent:



In all three proposals in (1), sC clusters are *de facto* right-headed clusters. Branching onsets, by contrast, are left-headed constituents (e.g., Kaye et al. 1990); see (2). In all structures provided, heads are marked by a vertical line between a skeletal position and the prosodic constituent that organizes it; non-heads, by an oblique line.

2 Another body of work considers *s*+stop to form complex segments (e.g., van de Weijer 1996). For a critique of this position, and of various representations for *s*C more generally, see Goad (2011). For discussion of alternative licensers for appendixal *s*, see Vaux and Wolfe (2009).

(2) Branching onsets:

Let us briefly return to the statement that *s*C clusters flout many of the phonotactic constraints that hold of true branching onsets. Concerning place, with *s* organized outside of the onset in all of the representations in (1), the observation that *s*C clusters do not ban place identity is captured.[3] The parallel between C_2 in an *s*C cluster and C_1 in a branching onset on the place dimension is similarly captured, as both are located in the head of the onset. However, although we can use these observations to motivate the general proposal that *s*C clusters are not represented in the same fashion as true branching onsets, we cannot use place to arbitrate between the appendix and coda analyses for *s*.

Consider, in contrast, sonority (which roughly corresponds to relative intensity). With *s* located outside of the onset, there is appropriately no expectation that *s*C clusters should rise in sonority, like branching onsets. The appendix and coda representations, however, make different predictions about the potential role that sonority plays in determining *s*C cluster well-formedness. If *s* is represented as an appendix, no predictions are made one way or the other about the role of sonority. With *s* represented as a coda, by contrast, we expect *s*C cluster well-formedness to be the opposite of that of branching onsets: branching onsets prefer to rise in sonority while *s*C clusters with rising sonority should be dispreferred, as these clusters should instead respect the constraints that hold in situations of syllable contact. We will see in Section 3.2 that the latter prediction is supported.

2.1 *s*C clusters ≠ branching onsets

Before we address the role of sonority in further detail, we must first demonstrate more concretely that *s*C clusters pattern differently from branching onsets, in order to support an articulated view of the syllable along the lines of (1) and (2). For this, we briefly examine Italian. Italian was one of the languages used by Kaye

3 Place identity is not respected in branching onsets with [r]. In languages with coronal [r], coronal+[r] clusters are well-formed, as are dorsal+[r] clusters in languages with dorsal [r]. This may suggest that [r] permanently lacks place (Rice 1992; Goad and Rose 2004).

et al. (1990) and Kaye (1992) to motivate a coda analysis of *s*. However, both papers only contrast the coda analysis of *s* with one where all left edge clusters are organized as branching onsets.[4] We will expand the discussion to compare the coda and appendix analyses of *s*.

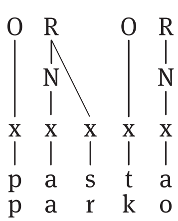
The data in (3) show that rhymes of stressed syllables must branch in Italian (Chierchia 1986). When the stressed syllable has no coda, the vowel is lengthened, as shown in (3b–c). No lengthening is observed in (3d), revealing that *s*C clusters do not pattern in the same fashion as branching onsets (3c) (Chierchia 1986; Davis 1990; Kaye et al. 1990; Kaye 1992).

(3) Medial *s*C in Italian (Chierchia 1986):

a.	[pár.ko]	'park'
b.	[fáː.to]	'fate'
c.	[káː.pra]	'goat'
d.	[pás.ta], *[páː.sta]	'pasta'

For those researchers who consider [s] in Italian left-edge clusters to be an appendix, they analyze it as a coda in word-internal contexts (Chierchia 1986; Davis 1990), similarly thus to how it would be represented in GP; see (4). Evidence for the coda analysis of word-internal [s] is that this consonant largely respects the same distributional constraints as other codas in Italian and, importantly, in words of both types, maximally binary branching rhymes are observed.

(4) Word-internal [s] as an ordinary coda:



Raddoppiamento sintattico provides further support that *s*C clusters and branching onsets pattern differently in Italian. In *raddoppiamento sintattico*, the first consonant in an onset geminates when the preceding word ends in a stressed vowel; see (5a–b). However, the first consonant in an *s*C cluster resists gemination (5c), in contrast to how the first consonant in a branching onset behaves (cf. (5b)).

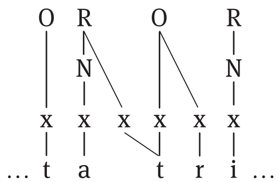
4 Kaye (1992: 311, note 12) does, however, briefly argue against an appendix analysis of *s* for Ancient Greek.

(5) Initial *s*C in *raddoppiamento sintattico* (Chierchia 1986; Davis 1990; Kaye et al. 1990; Kaye 1992):

a.	*paltò pulito*	[paltóppulíto]	‘clean coat’
	città santa	[tʃittássánta]	‘holy city’
b.	*città triste*	[tʃittáttríste]	‘sad city’
c.	*caffè spesso*	[kaféspésso], *[kafésspésso]	‘thick coffee’

The structure in (6) shows that in GP, as well as in non-linear phonology, onset [t] geminates back into the preceding syllable to satisfy the requirement that stressed syllables branch in Italian.

(6) Word-initial branching onset (5b):



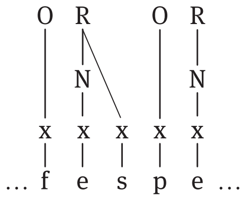
In GP, the lack of gemination of [s] in *s*C clusters follows from its analysis as a coda: [s] fulfills the requirement that the stressed rhyme at the right edge of the preceding word branch (Kaye et al. 1990); see (7a).[5] The appendix view of [s] can similarly account for the absence of gemination in *s*C clusters: the representation in (7b) would be illicit if geminates are in the unmarked case represented as coda+onset structures.[6] Note that (7b) reveals that I am assuming that [s] would be linked to the PWd rather than syllable in Italian (option (1a) above); this is because [s] does not display appendix-like behavior word-internally in Italian, unlike in English-type languages. We return to this in Section 4.

5 Kaye et al. (1990) and Kaye (1992) do not address the question of what happens to the empty onset and nucleus of the syllable containing *s*, once the noun and adjective are bound together in examples like [kafé]+[spésso]. If Harris's (1990) proposal that an empty nucleus deletes adjacent to another nucleus (i.e., when no melody intervenes) is combined with a version of Parasitic Delinking (Hayes 1989), that syllable structure is deleted when a syllable contains no nuclear projection, an explanation for the deletion of the empty onset and nucleus emerges. See further Section 4.1.

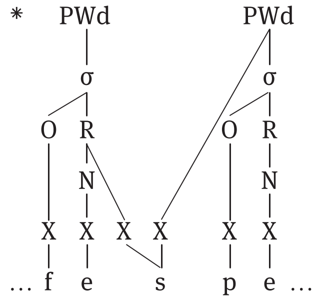
6 Reference to the unmarked case here is to accommodate alternative representations for geminates. For example, José and Auger (2005) have argued for both appendix+onset and coda+appendix geminates in Vimeu Picard.

(7) Word-initial *s*C cluster (5c):

a. *s* as coda:



b. *s* as appendix:



On an empirical level, both the coda and appendix analyses of word-initial [s] account for the lack of gemination in (5c), in contrast to the branching onset analysis which would incorrectly predict *[kafésspésso]. We might be tempted to conclude, then, that Italian shows only that branching onsets and *s*C clusters do not have the same representation, that the data from this language do not discriminate between the appendix and coda analyses of *s*. Government phonologists would take issue with this claim. The GP analysis, where Italian *s*C clusters always involve *s* as a coda, is consistent with the Uniformity Principle which requires that syllabification be held constant for a given string of segments (Kaye 1992). This clearly does not hold when *s* forms an appendix because, as mentioned above, there is no evidence for an appendix-initial structure for word-medial *s*C in Italian. The observation that *s*C clusters show uniform behavior in word-initial and word-internal position strongly suggests that they should be analyzed in a uniform manner, regardless of position. Only the coda analysis allows for this. We will return to this issue in Section 3.2.

2.2 Coda versus appendix analysis of *s* in *s*C

For those who advocate the appendix view of *s*, violating the Uniformity Principle in the analysis of Italian will not be considered a grave offence. In view of this, we turn to European Portuguese as, here, the coda and appendix analyses of *s* make vastly different predictions. As in the case of Italian, Kaye (1992) uses European Portuguese to support a coda analysis of *s*, in contrast to the alternative where *s* forms a branching onset with the following consonant. The possibility that *s* is organized as an appendix is not considered.

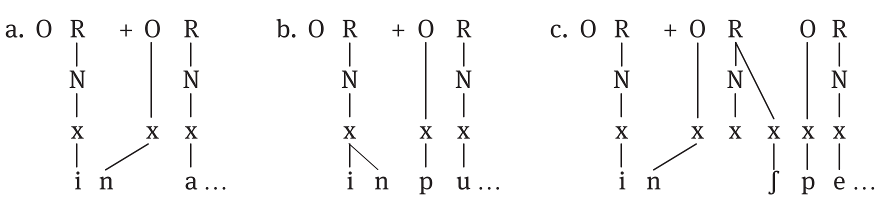
The data in (8a–c) reveal that, in European Portuguese, nasal consonants cannot close syllables (Mateus and d'Andrade 2000). [n] can surface intact before vowel-initial bases, (8a). From (8b–c), it would appear that before consonant-initial bases, nasality surfaces on the preceding vowel. The data in (8d), however, reveal that *s*C clusters do not pattern with other consonants but, instead, with vowels.

(8) European Portuguese (Kaye 1992):

a.	[in]admissivel	'inadmissable'
b.	[ĩ]pureza	'impurity'
	[ĩ]satisfeito	'dissatisfied'
c.	[ĩ]tratavel	'unsociable'
d.	[inʃp]erado	'unexpected'
	[inʃk]rupuloso	'unscrupulous'

At first glance, the behavior of *s*C is seemingly unexpected, yet it can be straightforwardly expressed in GP where *s*C clusters are analyzed as coda+onset sequences (see also Mateus and d'Andrade 2000; Freitas and Rodrigues 2003). The following conditions, both independently proposed in GP, are necessary for the analysis: (i) the coda containing [ʃ] is preceded by an empty nucleus; and (ii) all syllables contain an onset constituent, regardless of whether this position has melodic content. In light of (i) and (ii), consider the representations in (9). The variable behavior of [n] suggests that this segment lacks its own skeletal slot. In (9a), [n] links to the empty onset of the first syllable in the vowel-initial base. In (9b), this position is already occupied, so nasality is preserved on the preceding vowel. The correct result obtains in (9c), where [n] surfaces as a full-fledged consonant, precisely because the syllable containing *s*C contains an onset position which can serve as its host.

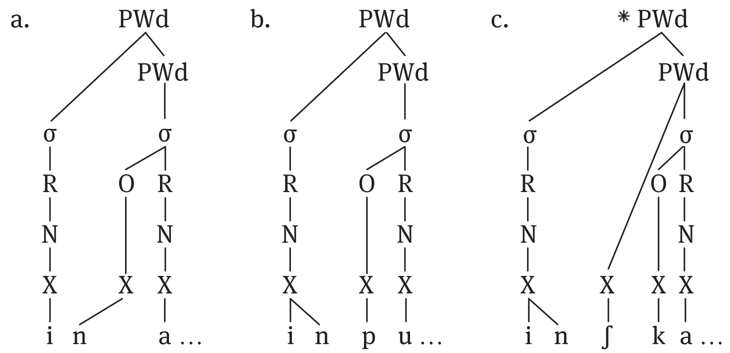
(9) Coda analysis of *s*:



It is not at all clear how to formally capture the behavior of *s*C clusters in Portuguese in a principled way in a theory that treats *s* an as appendix. (10) shows that bases with initial *s*C clusters are incorrectly predicted to pattern with ordinary consonant-initial bases, because there is no empty onset position in (10c) to host [n]. Note that I am assuming that the appropriate licenser for initial [ʃ] in

(10c) is the PWd, typical of *s* in other Romance languages (including Italian, as mentioned above). In the interest of completeness, I assume further that the prefix *in-* is adjoined to the PWd of its host (see Peperkamp 1997).

(10) Appendix analysis of *s*:



Before we abandon the appendix analysis for European Portuguese, we must consider the fact, not evident from (8d), that *s*C clusters in this language can be preceded by a schwa-like vowel ([ɨ]). Mateus and d'Andrade (2000: 52) provide the following pair of words: [ʃpɨɾádu] 'expected' – [iniʃpɨɾádu] 'unexpected', the latter in contrast to the form in (8d). Christophe dos Santos (p.c.) notes that words like [ʃpɨɾádu] can also be produced with an initial [ɨ] in slow speech: [ɨʃpɨɾádu]. In short, *s*C clusters, whether word-initial or following the prefix *in-*, can be preceded by [ɨ] or not, determined by factors such as speech rate and level of formality. If [ɨ] were analyzed as part of the underlying representation and were deleted late in the derivation in colloquial speech, could the appendix analysis be resurrected? The answer is no. /iniʃperado/ would initially be syllabified as [i.niʃ.pe.ra.do], with [ʃ] in coda position. Assuming the standard view that ill-formed syllables are repaired as soon as they arise (Itô 1986), once [ɨ] deletes, [ʃ] would be resyllabified as an appendix which, in turn, would trigger reanalysis of [n] as nasalization on the preceding [i], incorrectly yielding *[ĩʃperado].

To sum up, the data from European Portuguese build on those discussed earlier for Italian. Italian served to show that *s*C clusters pattern differently from true branching onsets, but it did not – on an empirical level – arbitrate between the coda and appendix analyses for *s*. European Portuguese revealed that the appropriate analysis for *s*C involves *s* organized as a coda. Given that the Portuguese data require a coda analysis for *s* and that the Italian data are perfectly amenable to this analysis, we opt for the coda analysis more generally, as the most restrictive theory is the one that treats *s*C in a uniform manner, both within languages (in initial and medial position in Italian) and across languages (in European Portuguese and Italian).

3 Perceptual considerations

Although the literature on structural approaches to cluster representation can formally capture the peculiarities of *s*C clusters, there is little attempt in this literature to explain why it is *s* that displays unorthodox behavior. If perceptual considerations are factored in, however, the behavior of *s* becomes less puzzling. Specifically, if segments are ordered so as to maximize their perceptibility (see Wright 2004), the relatively free distribution of *s* in relation to what follows can be explained: strident fricatives have robust internal cues for place and manner, thereby ensuring their perceptibility, even in non-optimal contexts, notably when followed by stops.

Although the presence of robust internal cues is a critical element for explaining why appendices are so often limited to *s*, isolating the factors that determine exactly which sibilants can show appendix-like behavior in a given language is a more difficult question, one that requires cross-linguistic comparison of a variety of phonetic measures (see Brannen 2011 for discussion of possible phonetic correlates of the feature [strident]). What, for example, favors [s] in English but [ʃ] in German (e.g., English [spɛnd] vs. German [ʃpɛndən] 'to donate')? The answer may lie in the phonetic characteristics of [s] in the two languages. Fuchs and Toda (2010) observe that German [s] involves greater constriction width than English [s], which results in a lowered spectral mean. Coupled with the results of Narayanan et al. (1995), who find greater constriction width for English [θ] than for [s], and Jongman et al. (2000), who report lower spectral means for English [θ] than for [s], Fuchs and Toda conclude that German [s] is more [θ]-like, which is possible, precisely because there is no chance for perceptual confusion between [s] and [θ] in this language. These results indicate that German [s] is less strident than English [s]; and this, in part, may explain why it is [ʃ], rather than [s], that shows appendix-like behavior in German.

If the perceptual properties of *s*, namely its stridency, hold the solution to the unusual distribution of *s*, we must consider whether the differences between *s*C clusters and true branching onsets can be explained solely by perceptual considerations. This position, taken by Fleischhacker (2001, 2005), questions the claim that a structural approach to the syllable is necessary. In the following section, we turn to examine some of the evidence that leads Fleischhacker to this conclusion.

3.1 A typology of epenthesis site

The discussion in Section 2 suggested that a firm line is being drawn between (1) and (2) regarding the types of clusters that fall under the scope of each representation. Indeed, I assume that all *s*C clusters, regardless of the sonority of the following consonant, are always organized with an initial coda; other obstruent-initial clusters are analyzed as branching onsets.[7] This view is challenged by Fleischhacker's (2001) cross-linguistic survey of epenthesis site in the repair of ill-formed clusters in second language (L2) acquisition and loanword adaptation. Fleischhacker's data are drawn from findings in the literature, supplemented through consultation with native speakers for some of the languages under examination. Figure 1 (adapted from Fleischhacker 2001) reveals that the survey is consistent with Broselow's (1983) conclusion that speakers are reluctant to epenthesize into *s*+stop and outside of stop+sonorant. What is surprising, though, is that *s*C clusters do not behave uniformly: many languages draw the boundary between prothesis and anaptyxis internal to the *s*+sonorant class. (Catalan is in parentheses because only prothesis is attested; *s*+glide and stop+sonorant do not undergo epenthesis.)

There are two critical elements to Fleischhacker's explanation for the patterns in Figure 1. First, following from her assumption that the non-epenthesized inputs are accessible to borrowers and L2 learners, Fleischhacker proposes that the epenthesis site is chosen to maximize the perceptual similarity between the target and output forms. She adopts Steriade's (1999b) position that individuals have detailed knowledge of the relative similarity of pairs of segments, contained in a distinct component of the grammar called the P-map. Fleischhacker proposes a fixed ranking of context-dependent Dep-V constraints penalizing anaptysis

more prothesis	*s*+stop		*s*+m		*s*+n		*s*+l		*s*+r		*s*+glide		stop+son	more anaptyxis
		↑ Egyptian Arabic		↑ Hindi		↑ Kazakh		↑ Farsi		↑ (Catalan)		↑ Wolof		

Fig. 1: Epenthesis in L2 acquisition and loanword adaptation.

7 Reference to 'all *s*C clusters' does not necessarily include *s*+glide (nor *s*C clusters that are interrupted by an empty nucleus; see Section 5). Glides are omitted from all discussion in this paper because they are subject to a variety of analyses across languages. In addition to the options for left-edge clusters considered here, glides may be syllabified in the nucleus as part of a rising diphthong or they may be analyzed as secondary articulations. Evidence against the proposal that other rising sonority sC clusters form branching onsets (see, e.g., Hall 1992; Fikkert 1994; Booij 1995) will be provided in Section 3.2.

whose source is the P-map. These constraints formally express the observations in (11).

(11) a. Anaptyxis over prothesis in stop+sonorant sequences;
b. Prothesis over anaptysis in *s*+stop sequences;
c. Among *s*+sonorant sequences, more anaptyxis as C_2 increases in sonority;
d. More anaptyxis in stop+sonorant sequences than in fricative+sonorant sequences.

The second element of Fleischhacker's proposal concerns the formalization of the finding in Figure 1 that languages draw the boundary between prothesis and anaptyxis in different places. The cross-linguistic variation attested is expressed through the relative ranking of the DEP-V constraints and CONTIGUITY, which requires that segments that are adjacent in the input be adjacent in the output.

Concerning the empirical validity of the perceptually-grounded observations in (11), those in (11a–c) are robustly supported. (11d) poses a challenge for Fleischhacker's approach, as fricative in fricative+sonorant collapses both *s* and non-strident fricatives. Non-strident fricatives, in fact, pattern with stops, which we return to in Section 3.5.

Clearly, the position taken by Fleischhacker is significantly different from the syllable-based approach adopted here. For Fleischhacker, perceptually-motivated constraints, in combination with other constraints (e.g., CONTIGUITY), account for the ability of a cluster to be split apart. My analysis of these patterns, which will be provided in Section 3.5, is consistent with the position taken in this paper: obstruent-initial and *s*-initial clusters have different representations; and *s*-initial clusters are coda+onset. As will be seen, my analysis critically relies on syllable contact. In view of this, I first show that syllable contact plays an important role in accounting for the typology of word-initial *s*C clusters and that an analysis based purely on perceptual factors does not make the right predictions.

3.2 A typology of word-initial *s*C clusters

In the preceding section, we observed that a purely perceptual account of cluster well-formedness has significant merit in predicting the differential behavior of clusters of various profiles. In this section, we show that the approach faces considerably more challenges when we attempt to explain cross-linguistic preferences on the sonority profile of C_2 in languages that permit *s*C clusters (Goad

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

Table 1: *s*C cluster well-formedness in word-initial position.

2011). I will argue, in fact, that the sonority profile of *s*C well-formedness follows straightforwardly only from a coda analysis of *s*.

Consider the typology of word-initial *s*C clusters in Table 1. What we observe is a cline: as the sonority of C_2 increases, the well-formedness of the cluster decreases.[8] No language that permits *s*C clusters forbids *s*+stop. French does not permit *s*+sonorant clusters at all, except for in a handful of loanwords; Greek may fall into this group as well, depending on the status of marginal *s*+nasal clusters; if *s*+nasal is considered to be productive, then this language permits *s*+sonorant clusters of lower sonority than those of higher sonority. Dutch follows the same trend, although it is more permissive than Greek in permitting *s*+lateral and, in some dialects, possibly *s*+rhotic.[9] English is the next most permissive, assuming that [ʃr] is derived from /sr/ (Clements and Keyser 1983; Goldsmith 1990). Finally, Russian is the most permissive; in addition to not having any constraints on the well-formedness of *s*+sonorant, it also permits *s*+fricative.[10]

Before we compare the predictions of a purely perceptually-based account of *s*C cluster well-formedness with those of a coda+onset account, it must be pointed out that we do not expect there to be an exact parallel between the inventory of *s*C

8 In the interest of completeness, *s*+fricative clusters are included in Table 1. Given their low sonority, however, they do not pattern as expected. *s*+fricative must instead be ruled out on perceptual grounds: it is cross-linguistically dispreferred because there is not enough perceptual distance between the two consonants (see Wright 2004: 51).

9 *s*+rhotic strings are attested for some Dutch speakers, as a reduced version of /sXr/ (Waals 1999). If this represents a reanalysis of /sXr/ (van der Torre 2003), then *s*+rhotic is licit for these speakers.

10 English has *s*+fricative in a handful of loanwords (e.g., *sphere, svelte, sthenia*). The presence of a laryngeal contrast after [s] in [sf]*ere* vs. [sv]*elte* and, thus, the lack of voicing assimilation in the latter form suggests that *s* and the following fricative are separated by an empty nucleus (for more on this representation, see Section 5 on Acoma). Thanks to an anomymous reviewer for bringing this contrast to my attention.

clusters found word-initially and word-medially in any particular language. This is because, in the former case, an empty nucleus precedes the cluster while, in the latter, a melodically-filled nucleus precedes the cluster. To demonstrate the types of variation observed, let us briefly compare Spanish and English. Although Spanish lacks word-initial *s*C clusters altogether, a wide range of word-internal *s*C clusters is found, parallel to the Dutch pattern in Table 1 (e.g., [pɛskar] 'to fish', [frɛzno] 'ash tree', [izla] 'island', *[VzrV]). English has the opposite profile in terms of how restricted these two positions are: initial position is relatively unconstrained, while medial position follows the French pattern in Table 1: clusters are confined to *s*+stop (*whisper*); aside from *grisly* and *grizzly*, *s*+sonorant appears to be found only in loanwords (*asthma*), proper names (*Whistler*), historical compounds (*Christmas*), and affixed forms that I assume contain an empty nucleus when [ə] is not realized ([lɪs(ə)nər] *listener*).

Critically, what we do not find, to my knowledge, is a language that permits *s*C clusters where C_2 is of relatively high sonority without *s*C clusters where C_2 is of lower sonority, as per Table 1 (fricatives aside; see note 8). Furthermore, this pattern holds for both initial and medial position, thereby motivating the claim in Section 2.1 that *s*C clusters show uniform behavior in both initial and medial positions. Given that *s*C clusters in medial position are coda+onset in perhaps all theories that advocate an articulated view of the syllable,[11] this uniform behavior, I contend, warrants a coda treatment of *s* in both positions. Differences between initial and medial position are taken up again in Section 4, through a detailed examination of Italian and English.

We now turn, in Sections 3.3 and 3.4, to compare the predictions of a purely perceptually-based account of *s*C cluster well-formedness with those of a coda+onset account.

3.3 Predictions of a purely perceptually-based account

The typology in Table 1 suggests the following scale of *s*C cluster well-formedness: *s*+stop > *s*+nasal > *s*+lateral > *s*+rhotic (where > means is more harmonic than). This is quite nearly the opposite of the profile of branching onset well-formedness: obstruent+liquid > obstruent+nasal > obstruent+stop (where obstruent ≠ *s*).[12] If segments are ordered so as to maximize their perceptibility (Wright 1996, 2004)

11 Minimally, this holds of *s*C clusters after short stressed vowels. See Section 4 for further discussion.

12 Note that obstruent+nasal and obstruent+stop would not be considered branching onsets in Government Phonology. In other syllable-based frameworks, they would.

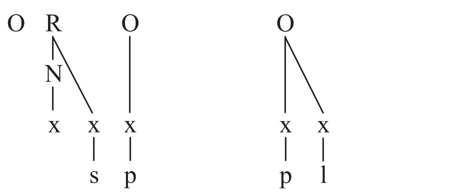
and cluster well-formedness reflects this, then *s*C clusters have an unexpected distribution across languages. When considered from the perspective of perceptual robustness, we should expect *s*C cluster well-formedness to mirror the profile observed for branching onset well-formedness, where C_2 of higher sonority is favored over C_2 of lower sonority.

Let us examine the problem more concretely. A purely perceptually-based approach to cluster profile predicts that the most perceptible of consonants should occur after *s*. This is because the perceptibility of C_2 will be partly compromised by the preceding *s*. The results of Byrd's (1994) experimental work suggest that it is the duration of C_2 that will be compromised. Byrd observes that in #sk, [s] has the longest duration and [k] the shortest when compared to both s#k and sk#. If the short duration of [k] relative to [s] in #sk can be extended to other consonants in initial *s*C clusters, then segments with robust internal cues should be preferred in C_2 position. This predicts the following scale: *s*+liquid > *s*+nasal > *s*+stop. Liquids should be favored because they have clear formant structure throughout. Nasals should be preferred over stops since their manner (and to some extent their place) properties are present in the nasal spectrum. Stops should be the least optimal because they have weak internal cues. In short, it appears that a purely perceptually-based account of *s*C cluster well-formedness fails to make the correct predictions. In view of this, we turn to consider the predictions of a structurally-based account and one, in particular, where *s* is analyzed as a coda.

3.4 Predictions of a structurally-based account: *s* as coda

In the following lines, I will argue that the typology in Table 1 follows straightforwardly from a structurally-based account of cluster representation if two additional considerations are factored into the analysis: (i) all *s*C clusters are head-final; (ii) *s*C clusters, regardless of the segmental profile of C_2, are never syllabified as branching onsets. The structures I assume are repeated in (12).

(12) a. *s*C cluster: C_2 as onset head: b. Branching onset: C_1 as onset head:



The predictions are as follows. First, if C_2 in an *s*C cluster is in onset position, this consonant should respect the preferred options holding of singleton onsets. Since obstruents are the most favorable onsets (Clements 1990), stops should be the optimal consonants in C_2 position in an *s*C cluster (not obstruents more generally because of the perceptual cost associated with *s*+fricative; see note 8). This prediction is consistent with what is observed in Table 1.

Second, the well-formedness of *s*C should worsen as C_2 increases in sonority. This is because, if *s*C clusters are syllabified as coda+onset, their profile should respect the preferences observed for optimal syllable contact. Syllable contact will favor C_2 with lower sonority: V*s*.TV > V*s*.NV > V*s*.lV > V*s*.rV (T = stop, N = nasal). As C_2 increases in sonority, the cluster would prefer to be syllabified as a branching onset, but if this option is simply not available for *s*C clusters, then higher sonority *s*C clusters will be illicit, regardless of where they occur in the word. This is consistent with the typology in Table 1.

3.5 Fleischhacker's epenthesis results revisited

In the preceding section, we observed that *s*C cluster well-formedness is the inverse of branching onset well-formedness, something which a purely functionally-based approach fails to capture. Although this difference between cluster type was shown to follow straightforwardly from a coda+onset analysis of *s*C clusters, to support the validity of the approach taken here, we must test it against Fleischhacker's results on preferred epenthesis site in L2 acquisition and loanword adaptation in Figure 1. On the face of it, her survey seems to challenge a unified approach to *s*C cluster representation. Counter to appearances, however, I suggest that the profile observed in Table 1 exactly parallels Fleischhacker's typology in Figure 1. Consider Fleischhacker's predictions in (11b–c), that *s*C favors prothesis when C_2 has lower sonority. Under a coda+onset analysis of *s*C, this is explained as follows: when C_2 is of low sonority, good syllable contact will result through prothesis (e.g., sTV → Vs.TV), but as the sonority of C_2 increases, prothesis will result in poor syllable contact (e.g., slV → *Vs.lV) and anaptyxis will thus be a better repair (slV → sV.lV). That anaptyxis is preferred for stop+sonorant sequences (see (11a)) is consistent with syllable contact as well: heterosyllabic stop+liquid, which would result from prothesis (e.g., TlV → *VT.lV), yields bad syllable contact.

There is one cluster profile for which the current approach and Fleischhacker's approach make different predictions: *s*+sonorant. Recall from (11d) that Fleischhacker predicts that *s*+sonorant and fricative+sonorant should pattern the same as far as epenthesis is concerned: more anaptyxis should be observed in stop+

sonorant sequences than in fricative+sonorant sequences, regardless of the quality of the fricative. The prediction under the coda+onset analysis of *s*C is rather that *s*+sonorant and fricative+sonorant should pattern differently from each other, as only the latter clusters can form branching onsets. The data below from Farsi-speaking L2 learners of English support the coda+onset approach: fricative+sonorant (13b) patterns with stop+sonorant (13a) and not with *s*+sonorant (13c), which patterns with *s*+stop (13d).

(13) L2 Farsi English (Karimi 1987):

a. p[e]lastic	b. f[i]loor	c. [e]smoke	d. [e]sp[i]ring
p[e]roud	F[e]red	[e]snow	[e]statistic
d[i]rink	th[i]ree	[e]slide	[e]ski (loanword)

4 Capturing different licensers for *s* in Government Phonology

Thus far, we have provided evidence for a structural approach to the differences between *s*C clusters and true branching onsets. Among structural approaches to the syllable, we have, in addition, argued for a coda analysis of *s* over the option that *s* is represented as some type of left-edge appendix, the standard view in non-linear phonology. Recall from Section 2, however, that in the literature on left-edge appendices, different licensers have been proposed for *s*, most commonly the PWd and the syllable; see (1a) and (1b) respectively (see Goad and Rose 2004, Ewen and Botma 2009, and Vaux and Wolfe 2009 for arguments that *s*C clusters cannot be represented identically in all languages).

If we are to dispense with appendices, we must ensure that the behavior that motivates both the PWd and syllable as licensers can be accommodated under a coda analysis of *s*. To do this, we compare Italian and English, two languages whose distribution of *s* is consistent with the representations in (1a) and (1b) respectively. For English, Levin (1985), Giegerich (1992), Kenstowicz (1994), and Ewen and Botma (2009) are among the many researchers who have argued that *s* is organized as a syllable-level appendix.[13]

For Italian, Chierchia (1986) and Davis (1990) both analyze word-initial *s* as a stray consonant, that is, as a consonant not incorporated into the onset constituent

13 The proposals cited in the text differ in ways that do not affect the overall argument but in the interest of completeness, note that Levin adjoins, rather than directly links, *s* to the syllable; Giegerich analyzes *s* as an onset-internal appendix; and Ewen and Botma organize *s* into the specifier position of the onset.

as part of the regular syllable parse. Davis (1990) assumes that stray adjunction applies late in the derivation, to incorporate *s* into the syllable at the left edge of the word; this is equivalent to a PWd-level appendix. Chierchia (1986) similarly assumes that stray adjunction applies late in the derivation, instead, to incorporate word-initial *s* into the syllable at the left edge of the phrase. Chierchia argues that the relevant domain is the phrase rather than the word to allow *s* to syllabify as a coda phrase-internally. Consider definite article constructions. *s*C-initial words do not select *il*, the form of the article normally required for consonant-initial words. Rather, they select *lo*. If *s* is not syllabified as a PWd-level appendix, then it will correctly become the coda of the syllable containing *lo*, once this syllable is cliticized onto the noun, e.g. /lo sposo/ → [los.po.so] 'the spouse'. Whether *s* is a PWd- or PPh-level appendix in Italian does not impact the arguments to follow. What is critical is that, in English, *s* is a syllable-level appendix while in Italian, the constituent that licenses *s* is higher in prosodic structure. For convenience, I will call this constituent the PWd.

Drawing on distributional evidence to determine what level of representation is the appropriate licenser for *s*, we will see that the conclusion that English *s* is a syllable-based appendix and Italian *s* a PWd-based appendix is warranted. In view of this, our principal goal is to show that the difference between these types of appendices can be straightforwardly captured in GP. A second goal is to show that GP correctly permits a finer distinction among the types of words that follow the (1b) pattern than the appendix-initial structure does.

In both English and Italian, *s*C clusters can appear word-initially (see (14a,e)) and as a regular coda after short vowels (14b,f).[14] However, in English, unlike in Italian, *s* can also appear after codas (14c,g) and long vowels (14d,h). That is, English permits *s* to have appendix-like status in word-internal contexts as well as at the left word edge. Concerning the absence of (14g), medial C*s*C clusters in Italian cannot be ruled out based on the phonotactics of medial C*s* and *s*C clusters: words like *morso* 'bite', *mensa* 'canteen' and *pasta* 'pasta' exist, but the combination of consonants, as in **morsto* or **mensta*, is ill-formed (Chierchia 1986). CsC is restricted to loanwords and prefixed forms (e.g. *perspicace* 'perceptive', *constatare* 'to certify'). Concerning the absence of (14h), this is not at all surprising, as vowel length is not contrastive in Italian (Chierchia 1986). Recall that vowels are lengthened to ensure that rhymes branch in stressed syllables, shown earlier in (3c).

14 Thanks to Brian Buccola, Andria De Luca, Connie Di Giuseppe, Andrea Gualmini and Esther Horowitz for discussion of some of the data from Italian.

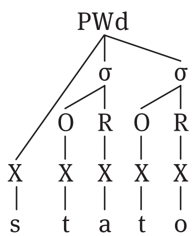
(14) English: Italian:

a.	[stɛm]	'stem'	e.	[stato]	'state, condition'
b.	[næsti]	'nasty'	f.	[pasta]	'pasta'
c.	[mɑnstər]	'monster'	g.	*VC*s*CV	
d.	[ɔistər]	'oyster'	h.	*VV*s*CV	

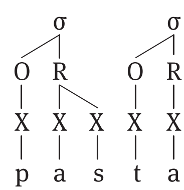
As mentioned above, in non-linear phonology, where *s* is analyzed as an appendix, this difference in distribution would be captured by appealing to different licensers for *s*, the PWd in Italian (15) and the syllable in English (16). (The representations in (15) and (16) are somewhat truncated for space reasons.)

(15) Italian: Appendix licensed by PWd:

a. Word-initial appendix:

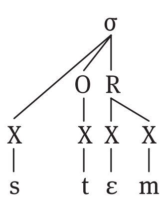


b. Word-internal coda:

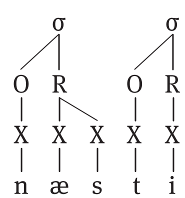


(16) English: Appendix licensed by σ:

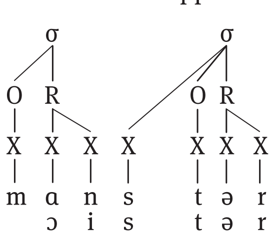
a. Word-initial appendix:



b. Word-internal coda:



c. Word-internal appendix:



With the structure for Italian in (15a), *s* cannot inadvertently appear as a word-internal appendix, on the view that appendices are restricted to domain edges, here the PWd. In English, by contrast, with *s* licensed lower down in the structure, by the syllable, it can appear word-internally, as shown in (16c). This solution, however, requires the unorthodox position that the domains for the licensing of appendices be prosodically-determined: although the *s* in *stato* is at the left edge of the morphological word, at no stage in the derivation will the *s* in *monster* or *oyster* be at a morphological edge and, thus, the structure for word-internal *s* in English violates the Peripherality Condition (Harris 1983), the requirement that extraprosodic material be at the edge of a morphological domain (see van der Hulst 1984 and Scheer 2004 for related discussion).

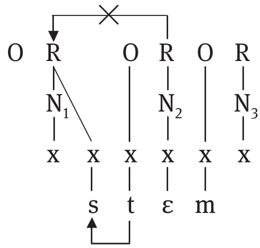
Turning to (15b) and (16b), regardless of the status of word-initial *s*C, medial *s* after a short vowel will be syllabified as a regular coda in non-linear phonology. This is because *s* in this position respects the same constraints that hold of other word-internal codas, and these constraints are different from those observed for word-initial *s*. For example, while in both Italian and English, *s*C in CV*s*CV words is restricted to *s*+stop, *s*+sonorant is perfectly well-formed in initial position (e.g., Italian: *snello* [znɛllo] 'slim', *slittare* [zlittare] 'to skid, slip'; English: *snow*, *slip*).

4.1 Magic licensing

In the following sections, I show that the difference between types of appendices in (15) and (16) can be captured in Government Phonology, where *s*C clusters are always coda-initial. We must first consider how the empty position before word-initial coda *s* is licensed in GP. The Empty Category Principle requires empty nuclei to be p[rosodically]-licensed in order not to be phonetically interpreted (Kaye 1990; Kaye et al. 1990). To be p-licensed, an empty nucleus must either be domain-final or be properly governed: it must be followed by an overtly realized nucleus, with no governing domain intervening between governor and governee (Kaye 1990).

Consider the English word *stem* in (17). The empty nucleus, N_1, is clearly not domain-final, nor is it properly governed: although N_1 is followed by the overtly realized N_2, a governing domain intervenes between N_2 and N_1, the transconstituent governing domain holding between [t] and [s]. Accordingly, Kaye (1992) rejects the position that it is proper government that p-licenses N_1. Because it is not evident how N_1 is licensed, at present, it can only be asserted that *s*C acts as a p-licenser in some languages, like English and Italian, in contrast to others, like Farsi (13c–d) and Spanish (e.g., /skribir/ → [ɛ̠skriβir] 'to write'). Kaye refers to this type of p-licensing as *magic licensing*.

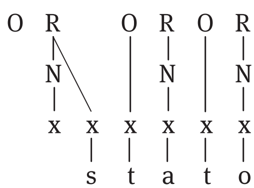
(17)



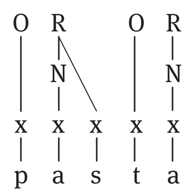
Let us turn to examine the representations required for Italian and English more concretely. The structures in (18) and (19) parallel those provided earlier from non-linear phonology in (15) and (16). Consider first (18a) and (19a). As can be seen, there is no difference in the representation for word-initial *s*C in Italian and English in GP: both are word-initial codas preceded by an empty nucleus (Ø*s*C). This contrasts with non-linear phonology where the licenser for *s* – PWd in (15a) and syllable in (16a) – depended on the (in)ability of *s* to show appendix-like behavior word-internally.

(18) Italian under coda analysis:

a. Word-initial coda (Ø*s*C):

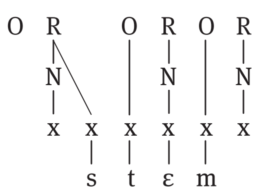


b. Word-internal coda (V*s*C):

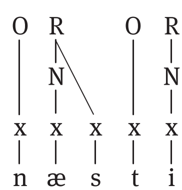


(19) English under coda analysis:

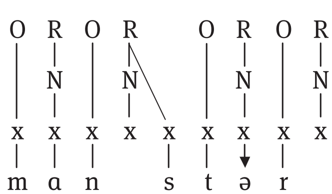
a. Word-initial coda (Ø*s*C):



b. Word-internal coda (V*s*C):



c. Word-internal coda (Ø*s*C):

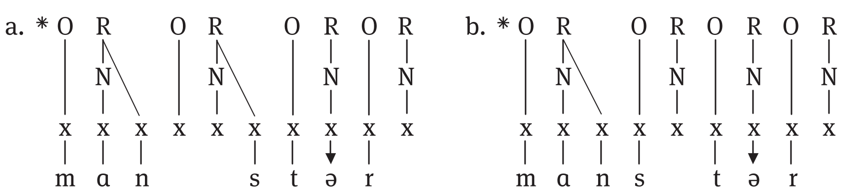


Turning to the word-internal contexts, there is no significant difference between the GP representations in (18b) and (19b) and the non-linear representations in (15b) and (16b): in both cases, *s* is an ordinary coda when it follows a phonetically-realized short vowel (V*s*C). The structure in (19c), where *s*C is preceded by an empty nucleus, corresponds to the word-internal appendix position in (16c).[15]

The presence of (19c) for English and the absence of the corresponding structure in (18) for Italian reveal that the contexts where magically-licensed empty nuclei are permitted must be parameterized: Italian-type languages are more restrictive in only permitting Ø*s*C strings word-initially, that is, at a left edge of a morphological domain, while English-type languages are unconstrained in this respect. Because there do not appear to be any languages with the inverse profile of Italian, the parallel with extraprosodicity should be pointed out, namely, the requirement that extraprosodic material be at the edge of a morphological domain.

Before we can accept the analysis presented in (19c) for word-internal Ø*s*C strings, two alternatives must be considered. In the proposed structure for *monster* in (19c), [n] is the onset of the syllable containing [s]. In the two alternatives in (20), [n] is instead a coda.

(20) Illicit alternatives to (19c):



The first alternative, the analysis in (20a), can be universally ruled out. In this structure, coda [n] and the following empty onset enter into a transconstituent governing relation. For the onset to govern the preceding coda, however, the onset must be more complex, where complexity is defined in terms of the number of elements (segment-internal primitives) that it contains. See (21).[16]

15 The final empty nucleus is *monster* is licensed because it is domain final and so receives no phonetic interpretation. Because of this, the preceding nucleus cannot be properly governed – it is not followed by an overtly realized nucleus – and it must therefore be phonetically realized (as [ə] in English).

16 *s*+sonorant clusters do not necessarily respect the Complexity Condition, as high sonority segments have fewer elements than *s*. Kaye (1992: 307) attributes the well-formedness of these clusters to the special properties of *s*: “not only does *s* have the property of combining with its

(21) Complexity Condition (Harris 1990: 274):
Let α and β be segments occupying the positions A and B respectively. Then, if A governs B, β must be no more complex than α.

Effectively, in order to govern a preceding coda nasal, the onset must be an obstruent.

The structure in (20b) is a more plausible alternative to (19c). First, the empty nucleus between [s] and [t] correctly remains unpronounced: the following phonetically-realized schwa is an eligible proper governor for it. Second, the Complexity Condition is satisfied: [n] is either less complex or equal in complexity to [s], depending on whether [s] contains a voicing element. When *s* is analyzed as a coda in *s*C clusters, it is assumed not to have a voicing element (see Kaye 1992). This is presumably because, in *s*C clusters, *s* is either uniformly voiceless or else it assimilates in voicing to a following voiced obstruent or sonorant, depending on the language. In (20b), however, *s* is analyzed as an onset, a position where voicing is normally contrastive in English: it should thus bear H (stiff vocal folds).

As mentioned, under either situation, the Complexity Condition is respected. The question of whether *s* should be specified for voicing, however, leads to the first argument against the representation in (20b). The presence of a voicing contrast for sibilants after [n] in ordinary coda+onset clusters (e.g., *fancy* vs. *pansy*) suggests that we should similarly find a voicing contrast in *monster*-type words, if the representation for such words is as in (20b). Yet, no voicing contrast is permitted in words of this profile. This is clearly tied to the presence of the following voiceless stop, yet *s* and the stop are interrupted by an empty nucleus. Thus, no transconstituent governing domain holds between them, which effectively means that there is no explanation for the voicing agreement observed. This clearly casts doubt on the analysis in (20b).

If the type of words that fall under the *monster* pattern is expanded somewhat, a second argument against (20b) emerges, one which again suggests that there is no transconstituent governing domain holding between [s] and the consonant preceding it. Consider the forms in (22). The consonant+*s* clusters here do not agree in voicing, an impossible state of affairs for transconstituent sequences in English.

(22) a.	[əbstéin]	'abstain'	b.	[ǽbstrækt]	'abstract'
	[əbstrʌ́kt]	'obstruct'		[ɑ́bstəkəl]	'obstacle'

'governor' to license a preceding empty nucleus, it also has the power to confer on the following onset the ability to govern it (the *s*)".

One could reject the claim that the words in (22) speak to the analysis of *monster*-type words; they could have a different structure, as they all involve Latinate prefixes, which could be adjoined to the PWd of the *s*-initial base that follows and, thus, their final consonant would not be adjacent to *s*: $[\text{əb}[\text{stéin}]]_{\text{PWd}}]_{\text{PWd}}$. These prefixes, however, are not synchronically productive. Critically, the examples in (22b) show that they fall within the same stress domain as the putative stems to which they attach and, thus, they must be contained inside the lower PWd: $[\text{ǽbstrækt}]_{\text{PWd}}$, $*[\text{ǽb}[\text{strækt}]_{\text{PWd}}]_{\text{PWd}}$. This analysis is supported by a comparison of the derivationally-related $[\text{ǽbstrækt}]_{\text{PWd}}$ and $[\text{əbstrǽkʃən}]_{\text{PWd}}$, which show that the location of stress varies, constitent with the regular stress rules of English that apply within the lower PWd. In short, *abstract*-type words form one domain, as do *monster*-type words. The representation in (20b) for domain-internal Ø*s*C clusters must therefore be rejected in favor of (19c), where no transconstituent relation holds between *s* and the preceding consonant.

4.2 *s*C after VV versus VC in English

In the discussion on the licensing of *s* in non-linear phonology, the same representation was provided for *oyster*-type words as for *monster*-type words in English: *s* was assumed to be a syllable-level appendix, to express the observation that *s*C can follow what seem to be heavy rhymes that are both VV and VC in shape (see earlier (16c)). A closer examination of the data, however, reveals that English words in which *s*C follows different types of heavy rhymes, VV versus VC, do not have the same profile, suggesting that different analyses are warranted for each. In this section, it will be shown that this distinction can be straightforwardly captured in Government Phonology, even though, in both, *s* will be analyzed as some type of coda.

We begin by examining *s*C clusters after long vowels. The data in (23) reveal that $\text{VV}s\text{C}_{\text{obs}}$ strings respect the same constraints that hold of $\text{VVC}_{\text{son}}\text{C}_{\text{obs}}$ strings: place sharing between the coda and following onset is observed and place is furthermore restricted to coronal (Goldsmith 1990; Harris 1994); compare, for example, ill-formed *[ʃoulbər] and *[iːspər] with well-formed [ɛlbou] and [wɪspər] where the vowel preceding the cluster is short and, thus, no sharing of coronal is required.

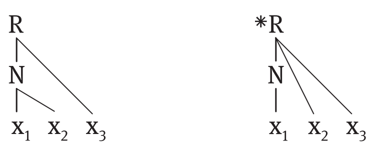
(23) $\text{VVC}_{\text{son}}\text{C}_{\text{obs}} = \text{VV}s\text{C}_{\text{obs}}$

a. $\text{VVC}_{\text{son}}\text{C}_{\text{obs}}$			b. $\text{VV}s\text{C}_{\text{obs}}$		
	[ʃouldər]	'shoulder'		[iːstər]	'Easter'
	*[ʃoulbər]			*[iːspər]	
cf.	[ɛlbou]	'elbow'	*cf.*	[wɪspər]	'whisper'

	[mauntən]	'mountain'		[ɔistər]	'oyster'
	*[mauŋkən]			*[ɔiskər]	
cf.	[mʌŋki]	'monkey'	*cf.*	[hʌski]	'husky'

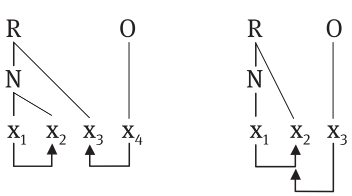
The parallels between (23a) and (23b) suggest that both $VVC_{son}C_{obs}$ and $VVsC_{obs}$ have the same analysis. Harris (1994) convincingly argues that both involve three-position rhymes, as do the parallel forms with four positions at the right edge: [boul.dØ] 'bold', [maun.tØ] 'mount', [iːs.tØ] 'east', [hɔis.tØ] 'hoist'. See (24a), which is the maximum structure consistent with binary branching. For Harris, three-position rhymes of the shape VCC in (24b) are ill-formed because they violate rhyme binarity.

(24) Three-position rhymes:
a. VVC rhymes: b. *VCC rhymes:



Neither (24a) nor (24b) is licit in standard GP (see Kaye et al. 1990). This is because the head, x_1, is not adjacent to every member of the rhyme, contravening strict locality: under constituent licensing, x_3 is thus unlicensed. Departing from standard GP, however, Harris argues that the well-formedness of (24a) relies on the transconstituent licensing relation that holds between x_3 and the following onset, as shown in (25a). The coda of a VC syllable, in contrast, is licensed twice, through constituent licensing (by the preceding nuclear head) and through transconsituent licensing (by the following onset), as shown in (25b).

(25) a. VVC rhyme: b. VC rhyme:



Adopting Harris's proposal for the case at hand, Italian forbids VVC rhymes; it thus requires codas to be doubly licensed, as in (25b). English is marked on this dimension: it does not insist on double licensing and thereby permits VVC rhymes. As we have seen, however, the segmental content of the coda and following onset in VVC rhymes is severely constrained, in contrast to VC rhymes.

In view of the well-formedness of VVC rhymes in English, alongside the universally ill-formed VCC rhymes in (24b), we predict that VC*s*C words like *monster* will abide by different constraints than those that hold of VV*s*C words like *oyster*. The forms in (26) reveal that this is indeed the case. Place sharing is not required: neither the consonant before *s*, (26a), nor that following *s*, (26b), is restricted to coronal. (See Section 4.1 on the status of the Latinate prefixes in (26).)

(26) VC*s*C ≠ VV*s*C

a. Non-coronal consonant before *s*:

[ɛ́kstrə]	'extra'
[ɑ́bstəkəl]	'obstacle'

b. Non-coronal consonant after *s*:

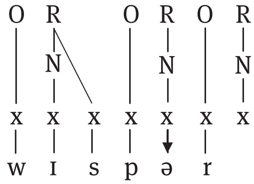
[ɛ̀kspəzíʃən]	'exposition'
[kɑ́nskrɪpt]	'conscript' (N)

The lack of constraints observed in (26), in concert with the data provided in (22), supports the analysis provided earlier for VC*s*C, that an empty nucleus interrupts VC and *s*C. This stands in contrast to the analysis adopted from Harris for VV*s*C, where V_2 and *s* are adjacent.

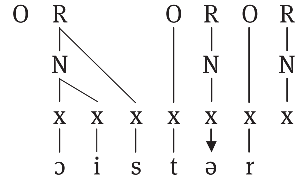
4.3 Summary of representations for *s*C clusters in English

The discussion thus far leads us to conclude that English permits *s*C clusters to arise under four different conditions. When word-medial *s*C follows a short vowel, as in *whisper*-type words, *s* is analyzed as a coda following an overtly-realized vowel; see (27a). When *s*C follows a long vowel, as in *oyster*-type words, *s* is similarly analyzed, as shown in (27b). Whether languages permit such three-position rhymes, however, is parameterized (English: yes; Italian: no). When *s*C appears word-initially, it is analyzed as a coda preceded by an empty nucleus, (27c). The empty nucleus is magically licensed by *s*C. Whether languages permit magic licensing is also parameterized (English and Italian: yes; Farsi and Spanish: no). Finally, when *s*C appears word-medially after VC, it is similarly analyzed as a coda preceded by an empty nucleus, (27d). Whether languages permit an empty nucleus to be magically licensed word-internally is also subject to parameterization (English: yes; Italian: no).

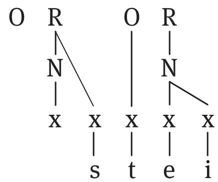
(27) a. Regular coda (V*s*C):



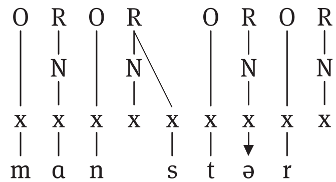
b. Coda in three-position rhyme (VV*s*C):



c. Word-initial coda (Ø*s*C):



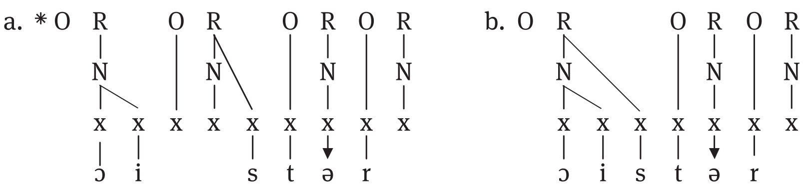
d. Word-internal coda (Ø*s*C):



Recall that in non-linear phonology, words of the types in (27b) and (27d), where VV/VC precedes *s*C, would be permitted in an English-type language because *s* is licensed by the syllable, shown earlier in (16c). However, the data discussed in Section 4.2 have revealed a lack of parallel between *oyster*-type words and *monster*-type words that is unexpected on the view that *s* is an appendix to the syllable in both cases. We have shown here that the difference between these types of words can be straightforwardly captured in GP, if the theory admits ternary rhymes of the shape VV*s* but forbids ternary rhymes of the shape VC*s*, thereby requiring VC*s* to have a different analysis.

We must ensure, however, that the representation for VC*s*C words will not inadvertently be available to *oyster*-type words, which would significantly weaken the proposal forwarded here. Consider (28a). This structure is parallel to that provided earlier for *monster*-type words. The critical element that distinguishes these two structures is the presence of a vowel, not a consonant, before *s*. Clearly, we need to motivate this structure as ill-formed, leading to the loss of the medial empty onset and nucleus to arrive at the appropriate representation for *oyster*-type words in (28b).

Harris (1990) faces a similar problem in his account of cross-word lenition in English. He proposes that the Obligatory Contour Principle (OCP) is responsible for deleting an empty nucleus adjacent to another nucleus (i.e., when no melody intervenes). If this proposal is coupled with a version of Parasitic Delinking (Hayes 1989), that syllable structure is destroyed when a syllable contains no nuclear projection, deletion of the empty onset and rhyme projection will automatically follow (see earlier note 5). The coda will survive because it is not melodically empty and the preceding syllable can accommodate it. In short, (28b) can be derived from the ill-formed structure in (28a) and, as a result, *oyster*-type words are safely protected from having the representation for *monster*-type words available to them.

(28)


Returning to (27), the representations provided predict that V*s*C words (27a) and VV*s*C words (27b) should either respect the same constraints (in both, *s* is a coda following an overtly realized nucleus) or that those that hold of VV*s*C should be stricter (ternary rhymes are marked). In English, the two contexts are parallel as far as manner is concerned: aside from limited contexts, for example proper names (e.g., [wɪslər] ‘Whistler’, [peizli] ‘Paisley’), sonorants are absent from C_2 position. On the place dimension, however, the data are consistent with the latter prediction: the onset following *s* in *oyster*-type words (27b) is restricted to coronal, in contrast to that in *whisper*-type words (27a).

Concerning the contexts where empty nuclei are magically licensed, the representations again predict two possibilities: *stay*-type words (27c) and *monster*-type words (27d) should either respect the same constraints (both contexts require magic licensing) or the constraints holding of *monster*-type words should be more severe (word-internal magic licensing is marked). The two contexts are parallel for place: any type of place can be found after *s* in both types of words; but they differ on the sonority dimension: the consonant in word-initial *s*C clusters can be a stop, nasal or liquid whereas the consonant in *s*C in *monster*-type words must be a stop, aside from a handful of exceptions in rhotic dialects ([pɑrsli] ‘parsley’, [pɑrsnɪp] ‘parsnip’).

Although the data from English motivate four different analyses for *s* in *s*C clusters, all analyses involve *s* being represented as a coda. We turn now to address a potential problem that arises from this approach, whether the lack of aspiration after *s* can be captured. On the analysis proposed, *s* is heterosyllabic with the stop targeted by aspiration which, on the face of it, appears to be problematic.

4.4 Is aspiration in English a problem for the coda analysis of *s*?

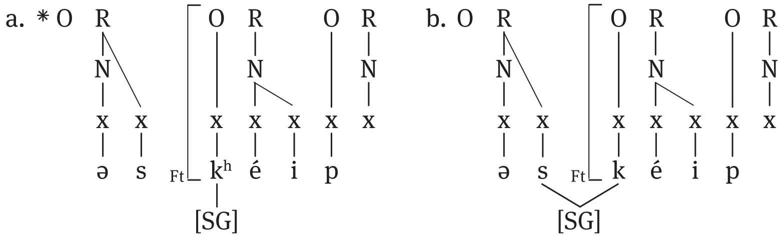
In this section, we consider the distribution of aspiration in English, which appears to challenge the representations posed in (27). The data in (29a) show the principal context for aspiration in English: voiceless stops are aspirated at the left edge of a stressed syllable. Voiceless stops in *s*C clusters are not aspirated (29b), which follows straightforwardly from an analysis where they are analyzed as branching onsets ($_σ$[stV́) or with a syllable-level appendix ($_σ$[s[tV́). Under the analysis proposed here, where *s* is in coda position, we must ensure that aspiration does not inadvertently target the post-*s* stops in (29b), all of which are at the left edge of a stressed syllable.

(29) a.	[pʰɪn]	'pin'	b.	[spɪn],	*[spʰɪn]	'spin'
	[əkʰléim]	'acclaim'		[əskéip],	*[əskʰéip]	'escape'
	[ɪmpʰlái]	'imply'		[ɪnspáiər],	*[ɪnspʰáiər]	'inspire'
	[ɑktʰóubər]	'October'		[ɪkstɛ́nd],	*[ɪkstʰɛ́nd]	'extend'

I assume that aspiration in (29a) involves the association of [spread glottis] with voiceless stops at the left edge of a foot (e.g., Kiparsky 1979; Nespor and Vogel 1986; Jensen 2000; Davis and Cho 2003).[17] If [SG] is linked solely to the post-*s* stop, as in (30a), aspiration will overapply. If, instead, we adopt the approach of Iverson and Salmons (1995), that a single [SG] specification is shared between *s* and the following stop, the correct result will obtain. Iverson and Salmons (1995) motivate this representation based on the findings of Kim (1970) who proposes that aspiration is a function of the spread glottis present in voiceless stops in English-type languages. In singleton stops, it takes until after the release of the closure for the vocal folds to attain the adducted state required for voicing, and this results in aspiration. However, if the glottis is open for the same period of time in *s*+stop clusters as in singleton stops, it will have sufficiently narrowed in *s*+stop by the time the stop closure is released and, as a result, voicing will begin simultaneous with the release. Iverson and Salmons formally capture Kim's observations through a single [SG] specification shared between *s* and the following stop, which they propose to be a consequence of the OCP. This is shown in (30b), adapted to the representations assumed here.

17 I use traditional (monovalent) features here and in Section 5, not the feature set employed by government phonologists. Nothing rests on this.

(30) *escape:*

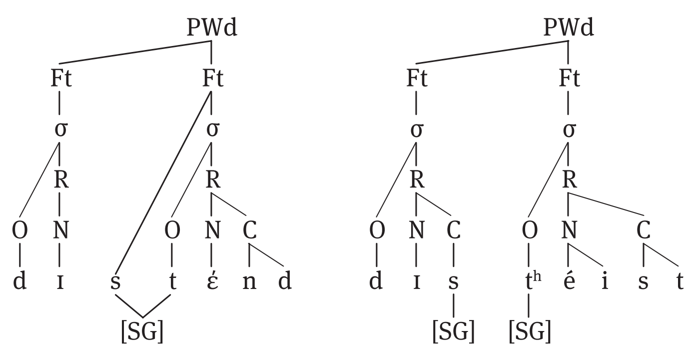


Importantly, Iverson and Salmons's feature-sharing account for the absence of aspiration after *s* holds independently of how *s* is prosodified. Thus, no problem arises for the coda analysis of *s* advocated here, even though it places the voiceless stop in foot-initial position. This solution, however, only partly solves the problem, as Vaux and Wolfe (2009) observe that there are minimal pairs such as *distend* and *distaste* which differ in the absence or presence of aspiration after *s*, respectively. Consider the dataset in (31).

(31) a. dis[t]énd b. dis[t^h]áste
mis[t]áke mis[t^h]rúst
ex[p]réssion ex[p^h]résident

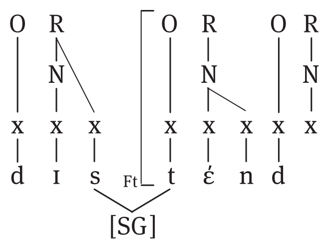
Vaux and Wolfe propose that pairs such as these motivate a representational difference between appendix *s* and coda *s*, as shown in (32) (representations slightly modified from the original, pp. 117–118). In their analysis, words like *distend* contain a foot-level appendix *s* which shares [SG] with a following voiceless stop. Appropriately, no aspiration results, as can be seen in (32a). In words like *distaste*, by contrast, *s* is analyzed as a coda; there is no sharing of [SG] with the following stop, as each segment links to an independent syllable and foot. With *t* bearing its own specification for [SG], the segment surfaces as aspirated, as shown in (32b).

(32) a. *distend*: b. *distaste*:

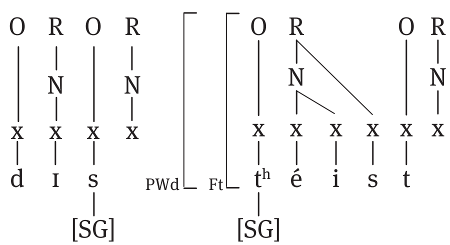


The analysis proposed here is in the spirit of Vaux and Wolfe in that the *s*C cluster in (32a) involves a shared [SG] specification while that in (32b) does not. However, the difference between the absence versus presence of aspiration is argued to arise from the morphological difference that holds between the words in (31a) and those in (31b). In the former examples, the *s*C cluster is root-internal, while in the latter, *s* it is at the right edge of a prefix. Prefixes are loosely bound to their hosts, expressed here through their being adjoined to the PWd of their host (Peperkamp 1997). If a PWd boundary interrupts *s* and *t* in *distaste* (see (33b)), then *s* must be analyzed as the onset of an empty-headed syllable; the coda option is not available, as a coda must be licensed by a following (domain-internal) onset (Kaye 1990). With *s* and *t* in *distaste* interrupted by an empty nucleus, they are clearly not adjacent and their [SG] specifications need not fuse to satisfy the OCP. Consequently, [SG] is singly-linked to *t* in *distaste* and aspiration results.[18] Compare (33b) with (33a) where a single [SG] is shared by the tautomorphemic *s* and *t*.

(33) a. *distend*:



b. *distaste*:



In sum, the lack of aspiration in English *s*C clusters can be accommodated within a coda analysis of *s*. Although voiceless stops in *s*C clusters begin a stressed

18 Even if *s* were a coda in *distaste* (in a different theory), no aspiration would be predicted. If the prefix is adjoined to the PWd, the specifications for [SG] on *s* and the following stop would not be in the same domain and, thus, would not be required to fuse to satisfy the OCP.

syllable, no aspiration is predicted if [SG] is shared between *s* and the following stop. Further, the presence or absence of aspiration after *s* can be straightforwardly captured. Although *s* is a coda in *distend*, for independent reasons, it must be the onset of an empty-headed syllable in the morphologically-complex *distaste*, which, in turn, enables stem-initial *t* to surface as aspirated.

5 Acoma: A language with *s*C clusters but no codas

In the English *s*C^{h} clusters discussed in the preceding section, I argued that there is an empty position between *s* and the following voiceless stop, which was motivated by the presence of a particular type of morpheme boundary internal to the cluster. In this section, we examine another situation where an *s*C cluster must be interrupted by an empty nucleus, one that arises in Acoma, a Keres language spoken in New Mexico.

Acoma permits initial and medial *s*C clusters but otherwise lacks codas in its native vocabulary (Miller 1965). If *s* in word-initial *s*C clusters is analyzed as a coda preceded by an empty nucleus, the absence of codas preceded by melodically-filled nuclei seems highly improbable. This casts doubt on the coda analysis of *s* and may, instead, seem to support an analysis of *s* as an appendix for this language. In the following lines, I argue that the lack of word-internal codas, coupled with other patterns of behavior in Acoma, instead motivates an analysis where *s*C clusters are separated by an empty nucleus.

The data in (34) show that *s*C clusters can occur in both initial and medial position in Acoma.[19] According to Miller, *s* is realized as [s̬] before labial and velar stops + /u,ə,a/ and as [ʃ] elsewhere (this will be returned to below). Medial *s*C clusters can occur after short vowels, as shown in (34b), perhaps suggesting that *s* is a coda. Their occurrence after long vowels (34c), which are contrastive in Acoma, casts some doubt on this analysis, under the assumption that three-position rhymes are marked across languages (see earlier Sections 4.2–4.3).

(34) a.	#*s*CV		b.	V*s*CV	
	[s̬púuná]	‘pottery’		[j̓út͡s’is̬p̓ətʰini]	‘backbone’
	[ʃt͡ʃa̓it͡sʰi]	‘it is muddy’		[suʃt’á]	‘I took water’
	[s̬kút͡s̬úw̓a]	‘tadpole’		[ʔés̬ká]	‘rawhide’

19 Miller’s transcriptions have been converted into IPA to ensure no uncertainty as to the interpretation of any given symbol.

c. VV*s*CV
[w̓iiʃp̓i] ‘cigarette’
[ʔúuʃt͡ʃúut͡sʰi] ‘drum’
[s̓úuʃkʰi̓it͡sʰi] ‘I am brave’

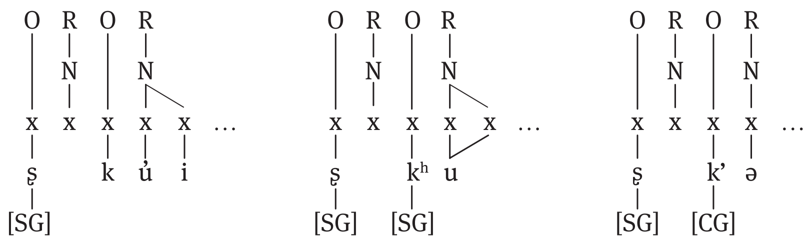
A solution to the problem comes from the observation that laryngeal contrasts are maintained after *s* in Acoma; see (35). This is cross-linguistically marked. Indeed, the forms with aspirated stops after *s* are unexpected in view of the observations of Kim (1970) and Iverson and Salmons (1995) discussed in the preceding section.

(35) Laryngeal contrasts after *s*:

a. [s̺ku̓itʰaaʔa]	‘he asked me’	b. [ʔiʃtûwá]	‘arrow’
[s̺kʰúuju̓]	‘giant’	[m̓a̓aʃtʰu]	‘silver fox’
[s̺k’ət͡s̺ə́əná]	‘crumbs’	[na̓aʃt’ém̓i]	‘starry eyes’

The presence of a laryngeal contrast after *s* would not be surprising if an empty nucleus interrupted *s* and the following consonant. No sharing of laryngeal features would be expected because the two segments are not adjacent under this analysis, as shown in the partial representations in (36) for the forms in (35a). The parallel with the earlier seen *dist*ʰ*aste* in English is evident, although the analysis in Acoma is arising under quite different motivating conditions: no morpheme boundary interrupts *s* and the following stop in Acoma.[20]

(36) a. [s̺ku̓itʰaaʔa] b. [s̺kʰúuju̓] c. [s̺k’ət͡s̺ə́əná]



20 Consideration of loanwords with codas supports the analysis in (36) as well. Codas in loanwords are restricted to nasals. Unlike medial *s*, coda nasals cannot follow long vowels, nor can they be followed by glottalized consonants. This suggests that medial *s* is not analyzed in the same fashion as are coda nasals in this language.

We turn now to examine the allophonic variation observed for *s* in *s*C clusters. It will be argued that the attested patterns follow directly from the representations proposed in (36). As mentioned earlier, *s* is realized as [s̺] before labial and velar stops + /u,ə,a/ and as [ʃ] "elsewhere" (p. 14). An examination of the data and inventory of contrasts reveals that "elsewhere" is effectively before dental and palato-alveolar occlusives and before labial and velar stops + /i,e/. In prevocalic position, all three sibilants are contrastive.

Several problems must be addressed, the first of which involves determining the underlying representation of the sibilant in *s*C clusters. Miller notes that the orthography represents this sibilant as *s* but no arguments are provided for its underlying status. Although *s* never surfaces as [s] in *s*C clusters, there is reason to believe that this represents the underlying form. Miller notes that /s/ in Acoma is dental (p. 7) and that it is followed by a "theta offglide" (p. 13). This suggests that /s/ is only weakly strident in this language, like German /s/ (see Section 3). If [s] were to surface in *s*C clusters, it would risk being imperceptible, particularly in Acoma where the only type of *s*C cluster attested is *s*+stop. /s/ thus becomes fully strident [s̺] or [ʃ], depending on the context. I suggest that /s/ → [ʃ] involves assimilation (see below); /s/ → [s̺] involves augmentation of /s/ to the more perceptible [s̺] in contexts where assimilation cannot take place.

The second problem seemingly stems from the representation for *s*C clusters provided in (36): if an empty nucleus separates *s* and the following consonant, how can the feature involved in the assimilation spread from this consonant back onto *s*, that is, non-locally? Place assimilation between consonants normally involves a coda being targeted by an immediately following onset, which may suggest that *s*C clusters in Acoma instead involve a coda+onset analysis, as proposed for the other languages under examination in this paper. The solution to this question, I argue, lies in the third problem. Even if no empty position were to separate *s* and the following consonant, the assimilation targeting *s* still applies non-locally when it is triggered by [i,e]: recall that this process applies over labial and velar stops, as exemplified in (37).

(37) Assimilation over labial and velar stops:

[hîuʃpéʼju]	'cry baby'
[ʼśúuʃkʰʼiit͡sʰi]	'I am brave'

The problem in (37) would appear to hold under any analysis of *s*C clusters.

I propose that an answer to the latter two problems can be found in the representation for *s*C clusters I have provided for Acoma. Assimilation, which I will assume for convenience involves the feature [coronal], does not target /s/ but, instead, the empty nucleus that follows it.[21] However, because this position lacks all other features, the phonetic effect of [coronal] spread is perceived on the preceding consonant. Under this analysis, the assimilation is local in both cases: it applies between string adjacent segments in words like [ʔiʃtûwá] 'arrow' where the trigger is the coronal consonant immediately following the empty nucleus (see (38a)) and it applies nucleus-to-nucleus in words like [hîuʃpéj̓u] where the trigger is the coronal vowel to the right of labial and velar consonants (see (38b)).

(38) a. . . . s Ø t û . . . → [. . . ʃtû . . .]   b. . . . s Ø p é . . . → [. . . ʃpé . . .]

[cor]   [cor]

In sum, the patterns of behavior in Acoma – including the allophonic variation observed for *s* – reveal that *s*C clusters in this language are not coda+onset clusters (nor, for that matter, appendix+onset clusters); instead, an empty nucleus interrupts the cluster. In note 10, we saw that this analysis likely holds for English *s*+fricative clusters in loanwords as well; just like in Acoma, a voicing contrast is maintained in the consonant following *s*: [sf]*ere* vs. [sv]*elte*. The data from Acoma and English loanwords thus indicate that another typological possibility for the analysis of morpheme-internal *s*C must be permitted, in addition to the coda+onset option motivated earlier in the paper. Importantly, in both analyses, *s* belongs to the syllable preceding the consonant, rather than being analyzed as an appendix.

6 Conclusion

In this paper, I have argued for a structural approach to cluster representation and, in particular, for a coda+onset analysis of *s*C clusters. I have shown that this approach captures both the preference for low sonority onsets after *s* in left-edge clusters as well as preferred epenthesis site in the repair of ill-formed *s*C clusters. I proposed that both patterns follow from cross-linguistic observations about optimal syllable contact. In contrast to a purely perceptual approach, the syllable contact approach correctly predicts that *s*C clusters where C_2 is low in sonority

21 Without further detail on the articulatory properties of coronals and front vowels in Acoma, exactly what feature is involved in the assimilation is not evident. I have called it [coronal], recognizing that although retroflex consonants involve the underside of the tongue tip or blade, across languages, they often fail to pattern with the group of coronal consonants that form a natural class with front vowels (e.g., Goad and Narasimhan 1994 on Malayalam).

will be preferred over those where C_2 is high in sonority, the opposite profile observed for branching onset well-formedness. It also correctly predicts that fricative+sonorant and *s*+sonorant clusters will pattern differently in whether they prefer anaptyxis or prothesis, in contrast to the perceptual approach which predicts that they should pattern together.

Although I argued for a structural approach, perceptual considerations were not considered to be irrelevant to syllable well-formedness. On the contrary, it is precisely the perceptual properties of *s*, namely its stridency, that hold the solution to its unusual distribution. Consistent with this, I hypothesized that the low stridency of [s] in German and Acoma may be responsible for why German selects [ʃ] and Acoma selects [ʃ] and [ʂ] in *s*C clusters. Further work on this topic, however, is clearly required.

The latter half of the paper focused on demonstrating that the coda analysis for *s* was flexible enough to accommodate languages which seem to require different licensers for *s* in *s*C clusters, the syllable in English versus the PWd or PPh in Italian. I argued that, although English requires four different analyses for *s*C, all can be accommodated under a coda view of *s*. Each context was furthermore shown to abide by different phonotactic constraints. However, the coda+onset analysis was proposed not to hold for *s*C clusters in all languages. Acoma, in particular, was argued to require a representation where *s* and the following consonant are onsets interrupted by an empty nucleus, a representation that was supported by the maintenance of laryngeal contrasts after *s* and by the surprising pattern of *s* allophony in *s*C clusters.

A particular challenge that the analysis of Acoma raises that was not addressed is why *s*C clusters in this language are limited to *s*+stop. Earlier in the paper, I argued that the well-formedness of *s*C clusters worsens as the sonority of C_2 increases. This was used to support the coda+onset analysis of such clusters, as the sonority constraints on C_2 were argued to be due to considerations of syllable contact. Clearly, this explanation for the limitation to *s*+stop in Acoma cannot hold. Exactly why only the most optimal of onsets (stops) are found after *s* in this language cannot, at present, be explained. Additional *s*ØC languages must be examined to come to some understanding of the constraints that hold of C_2 in such languages.

Although two analyses were proposed for *s*C clusters in this paper, the analyses share the feature that they do not involve any appeal to formal devices, such as the appendix, that are not required for ordinary syllabification: *s* in an *s*C cluster in Acoma is an onset; *s* in an *s*C cluster in the other languages under examination is a coda. Although one might object that this comes at the cost of including phonetically empty nuclei, *s*ØC for Acoma and Ø*s*C for the other languages under focus, empty nuclei must, in fact, be included in all theories that appeal to an articulated view to the syllable. Consider, in particular, fast speech rules that delete schwa. It is highly unlikely that examples such as [knuː], fast speech for [kənuː] 'canoe', which yield phonotactically ill-formed sequences in English and which involve no evidence of adjacency (i.e., no devoicing on [n]), involve resyllabification of [kn] as a branching onset.

Aside from *s*C clusters that are interrupted by an empty nucleus, as in Acoma, no analyses for *s*C other than coda+onset were considered. It is my wish, of course, that *s*C clusters in all languages where *s* and C are truly adjacent will be analyzable as coda+onset. Several challenges for this, however, are present in the literature. On one hand, there are researchers who have argued that there are languages where *s* in *s*C clusters must be licensed by some constituent other than the syllable or PWd. Green (2003), for example, argues that the appropriate licenser for *s* in Munster Irish is the Foot. The PPh alternative to the PWd, proposed by Chierchia (1986) for Italian, must also be examined more concretely, for example in Vaux's (1998) analysis of Armenian. On the other hand, there are analyses of *s*C clusters that do not involve an appendix (or equivalent): where rising sonority *s*C clusters are analyzed as branching onsets, as has been proposed by Fikkert (1994) based on the patterns present in child Dutch and by Hall (1992) and Booij (1995) for adult German and Dutch respectively; or where *s*+stop clusters are argued to form complex segments (e.g., van de Weijer 1996). Exploration of these alternative approaches to *s*C clusters must be left to future research.

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