The Voiceless Alveolar Fricatives in English as Sub-Syllabic Segments

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1. Introduction

The voiceless alveolar fricative /s/ is a big challenge to the English syllable theory because, due to its relatively high sonority, this segment may constitute acoustic peaks inside a syllable, if not as prominent as the nuclear vowel (e.g., *speak* and *street* (=Onset) and *tax* and *fax* (=Coda)). Since this fact is a serious counterexample to the "syllable-as-one-sonority-peak" theory, Giegerich (1992) proposes to displace the voiceless alveolar fricatives from the syllable core with what he dubs "appendices." Although Giegerich captures the distribution of segments inside a monosyllable descriptively, his analysis does not explain why additional sonority peaks can exist inside the syllable or why the phoneme /s/ is involved in this phenomenon. Giegerich's analysis leaves the behavior of the segment unexplained. Instead, it treats it as a mere exception. He also fails to explain the fact that this phoneme can constitute a syllable core with a nuclear vowel, as in *task* and *risk*.

This study argues that the occurrence of /s/ in appendices as a sub-peak, as well as its occurrence immediately after the nuclear vowel inside the syllable core, is relevant to its intrinsic properties of being continuant and having a relatively high sonority, which enables this segment to play an important role inside the syllable even though it is consonantal. Other reasons as to why only /s/ is selected include: the suspension of semantic contrast between voiced and voiceless obstruents inside the consonant cluster, and the fact that /s/ belongs to the category of coronal consonants that have the largest members in English phonology. Further, this study argues that this segment does have significant linguistic functions. The separation of appendices from the syllable core helps to clarify the functions of the voiceless alveolar fricative

as an affix. Specifically, the segment may signal the initial position of the word and enhance the possibility of word-formation in the Onset. At the same time, it can also play grammatical roles as an inflection marker in the Coda. The sub-peaks of the phoneme /s/ indicate that this segment is a significant linguistic unit, just like the syllable core of a monosyllable corresponds to the semantic unit as a word. Further, the segment helps to sustain the short nuclear vowel inside a syllable core position like sonorants—as a [+continuant] segment with a relatively high sonority. This characterization not only avoids treating the voiceless alveolar fricative segment as a mere counterexample to the syllable theory, but it also contributes to highlighting the significant phonological status and linguistic functions of the segment in question.

The structure of this article is as follows. The next section reviews the structure of a stressed monosyllable in English as well as some important notions relevant to the well-formedness conditions such syllables must satisfy. This section also explores Giegerich's treatment of the syllable and a few conceptual problems that his theory raises but leaves unexplained. The third section proposes an analysis of treating the seemingly exceptional behavior of /s/ and refines Giegerich's framework by explicating the sub-syllabic properties and linguistic functions of voiceless alveolar fricatives. Finally, the fourth section summarizes the analysis and argument developed in this study and puts forward issues of concern for further research.

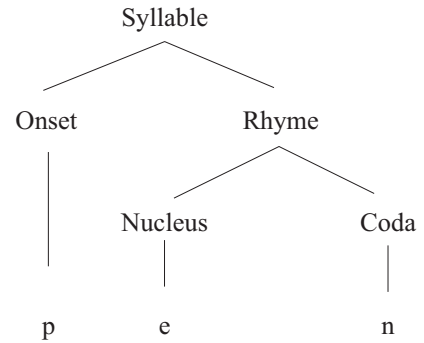
2. Syllable in English

2.1. Well-Formedness Conditions for Monosyllables

2.1.1. Branching inside Rhyme

Let us first review some well-formedness conditions for monosyllables in English. In a monosyllabic word, such as *pen*, none of the three phonemes is linearly aligned. Instead, they are composed of an Onset, filled by the syllable-initial phoneme /p/ and a Rhyme that includes a Nucleus (filled by the vowel /e/) and a Coda (filled by /n/). This is illustrated in (1):

(1)



Evidence for this structure comes from alliteration, where some words in a poem or proverb are used together with the ones that have the same phoneme in the onset position (e.g., *Care killed the cat*) or from rhyming, where several lines of a poem end with words that have the same phonemes except in the onset (e.g., *cloud* & *crowd* and *hills* & *daffodils* in *I wandered lonely as a cloud That floats on high o'er vales and hills, When all at once I saw a crowd, A host, of golden daffodils*).

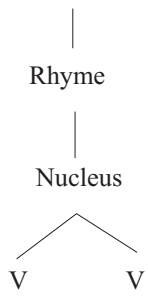
The division of a syllable into the Onset and the Rhyme can also be observed in morphological blending, where a part of one word and that of another are combined to make a new word, as in *smog* (from *smoke* & *fog*) and *spork* (from *spoon* & *fork*). Kubozono (1990: 10) points out that this division is the most preferred type in English blending, whether the blends are morphologically well-established ones, such as *smog* and *spork*, or whether they are spontaneously formed as blend errors (Fromkin, 1973), such as *clear* (from *close* & *near*) and *Frax* (from *Fritz* & *Max*).

Another important condition for a well-formed syllable is the number of phonemes that can be accommodated in each node. Lass (1984: 252–255) argues that it is the number of phonemes or morae in the Rhyme that determines whether a given monosyllable is well-formed. In fact, the Onset is optional and irrelevant to the well-formedness of a monosyllable. This is considered as another reason why Onsets and Rhymes branch in the syllabic configuration. In an English monosyllable, the Nucleus must contain two morae (i.e., a long vowel or a diphthong), as in (2a). The Rhyme containing

either a long vowel or a diphthong can be followed by a consonant in the Coda, as in (2b). If the Nucleus contains only one vowel, it must also have at least one consonant in the Coda, as in (2c).

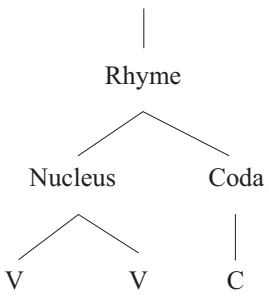
Therefore, the Rhyme with only one short vowel and no consonant in Coda, as in (2d), is judged as ill-formed in English. According to Lass (1984: 255), a well-formed monosyllable must have at least one branching constituent inside its Rhyme. Thus, either Nucleus (=(2a, b)) or Rhyme itself must branch (=(2b, c)):

(2a)



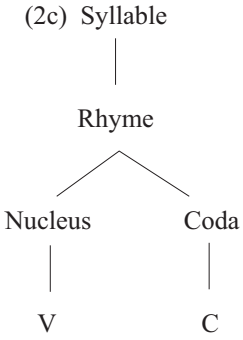
(e.g., *eye*, *buy*, *E*, *see*)

(2b)



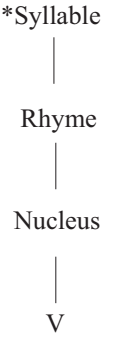
(*ice*, *slice*, *eat*, *seat*)

(2c)



(*at*, *pat*)

(2d)



(*/æ/, */bæ/)

V: Vowel, C: Consonant

It is important to also note that this condition implies that well-formed syllables need at least two segments inside the Rhyme (either two segments in the Nucleus or one for the Nucleus and another for the Coda) and that each node in the Rhyme is dependent on the other. The mutual dependency between the Nucleus and the Coda in terms of the required number of segments also indicates that the Nucleus and the Coda form a structure together.

2.1.2. Possible Consonants inside Onset and Coda

In the Onset, single (except /ŋ/), double, or even triple consonantal segments may appear. The latter two patterns are cases of consonant clusters. In contrast to the single-consonant-onset patterns, the permissible patterns of the alignment of two consonants in the Onset is restricted. Most obstruents (i.e., oral stops such as /p/, /b/, /t/, /d/, /k/, and /g/ and fricatives such as /f/, /v/, /θ/, /ʃ/, and /h/) can occupy the first node in the Onset, but they must be followed by non-nasal sonorants (i.e., either of /l/, /r/, /w/, or /j/). Examples are *play*, *bring*, *tweet*, *dry*, *cute*, *glove*, *fly*, *view*, *throw*, *shrink*, and *hue*. On the other hand, in the case of two-consonant clusters only made up of obstruents, the voiceless alveolar fricative /s/ always occupies the initial position, which is followed by voiceless obstruents (/p/, /t/, /k/, and /f/) or sonorants (except /r/ and /j/), as in *speak*, *stand*, *sky*, *sphere*, *sling*, and *swift*.

Syllable-initial three-consonant clusters are more strictly regulated. They must always be headed by the voiceless alveolar fricative /s/, which must be followed by the voiceless, non-continuant and non-nasal stops (i.e., either /p/, /t/, or /k/), with the final segment in the Onset occupied by non-nasal sonorants.[1] Examples include *splash*, *street*, and *sclerosis*. Note that the sequence of the segments can be characterized as: [+continuant] → [−continuant] → [+continuant].

Let us turn our attention to the syllable-final two consonants in Coda. As far as obstruents are concerned, only limited types can be the first elements, such as /pt/, /ps/, /dz/, /kt/, /ks/, /ft/, /sp/, /st/, and /sk/. Examples are *apt*, *lapse*, *adze*, *fact*, *fax*, *loft*, *wasp*, *cast*, and *risk*. Except for /dz/,[2] a voiceless segment is followed by another voiceless consonant. Consequently, it can be observed that the final segment in Coda is likely to be coronal or either of

the two segments is at least a coronal segment. As for the syllable-final three consonants, the final segment must always be a coronal (either voiceless stop /t/ or fricative /s/). Examples are *text*, *midst*, *prompt*, *glimpse*, *against*, *jinx*, *mulct*, *calx*, *sculpt*, and *whilst*.

2.1.3. Suspension of Voiced/Voiceless Opposition in Onset and Coda

Clusters as in *speak*, *stick*, *ask*, and *risk* reflect some constraints on the occurrence of obstruents. Importantly, the voiced/voiceless opposition of obstruents utilized for the semantic purpose, as illustrated in the distinction between *pat* and *bat* or *pat* and *pad*, is suspended in a non-trivial manner (Giegerich, 1992: 243). Therefore, strings, such as */sbi:k/, */zpi:k/, */zbi:k/, */æzk/, */æsg/, or */æzg/, cannot be generated where voiceless and voiced segments are alternated or voiced segments are repeated. Whereas voiceless obstruents may form a cluster, voiced obstruents cannot. This is related to the fact that only the voiceless /s/ can play an important role in the formation of consonant clusters, not the voiced /z/. It should be noted that the preference of the voiceless segment, especially the voiceless alveolar fricative, in the discussion of the syllable structure is motivated by the independent phonological convention of English.

Since voiced segments do not appear in two-consonant or three-consonant clusters made up of obstruents, the voiceless Coda serves to highlight the sonority peak of the nuclear vowel. Note that, with other things being equal, voiced segments are more sonorous than their voiceless counterparts. However, it is not clear whether suspension can occur solely for the purpose of highlighting the Nucleus or whether some other factors, such as articulatory ones, have a role to play. Another point is that Onset clusters, such as /sp/, /st/ or /sk/, are possible where a more sonorous segment precedes a less sonorous one but the alternation of the segments is not permitted (/ts/ is disallowed in the syllable-initial position, except for a foreign word like *tsetse*). The segment pattern in the Onset may serve to keep the distance between /s/ and the most sonorous nuclear vowel in the Rhyme.

2.1.4. On the Status of Coronal Consonants

Taylor (2003: 261–262) points out that a short vowel (=(2c)) can be followed by two or more consonants (e.g., *elf*, *realm*, *tank*, *text*, etc.), while "after a long vowel or diphthong (=(2b)), two or more consonants are permitted only if the second and any following consonants is [sic.] a coronal" (p. 261). Thus, words such as *east*, *wound*, *find*, *faint*, *hound*, and *coast* are permitted where the second and final consonants underlined are coronal. Note that these monosyllabic words, irrespective of the vowel length, can be followed by a morpheme, which happens to be coronal (i.e., plural form *-s*, possessive *-'s*, past form *-ed*, suffix *-th* indicating ordinal number, etc.).

For a possible explanation on the high frequency of coronal segments, it is important to pay attention to the outstandingly many kinds of coronal segments in the phonology of English. There are at least 11 kinds of coronal consonants, including sonorants (i.e., alveolar fricatives (/s/, /z/), dental fricatives (/θ/, /ð/), palato-alveolar fricatives (/ʃ/, /ʒ/), alveolar nasal (/n/), alveolar stops (/t/, /d/), alveolar lateral approximant (/l/), and alveolar approximant (/r/). Since there are many coronal segments and the English syllable tends to end with a consonant, it is likely that the syllable-final positions may be utilized by coronal segments, although there may be some additional important motivations.

2.1.5. The Nucleus as a Sonority Peak inside a Syllable

The way in which segments or phonemes are aligned inside a syllable can be characterized in terms of the relative sonority of each phoneme. Sonority is defined here as a relative difference in loudness between phonemes. According to Jones (1960: 23), the relative sonority of phonemes is the difference in the distance at which they can be heard "when pronounced with the same length, stress, and voice-pitch." The sonority scale is proposed by a number of phonologists and acoustic phoneticians. Following Gimson, Cruttenden (2014: 50) states that a scale or hierarchy of phonemes based on the relative degree of sonority can be established. In the present study, the following scale, illustrated in Giegerich (1992), is adopted for discussion. See Table 1 below:

Table 1. Sonority Scale (from Giegerich (1992: 152, Table 6.3))

Oral stops		Fricatives		Nasals	Liquids		Semivowels	Vowels	
voiceless	voiced	voiceless	voiced					high	low
p	b	f	v	m					
t	d	θ	ð	n			j	i	a
k	g	s	z	ŋ	l	r	w	u	ɑ
sonority →									

As illustrated in many studies (e.g., Lass, 1984: 264; Giegerich, 1992: 131–134; and Taylor, 2003: 257–259), a syllable is assumed to consist of a sonority peak in the Nucleus (i.e., vowel(s)), with less sonorous segment(s) distributed in the Onset and the Coda. If the Onset contains two consonants, a less sonorous one is likely to be placed away from the peak, and a more sonorous segment is assumed to occur closer to the nuclear vowel. Therefore, the Onset and the Nucleus make an upward slope in terms of sonority.

Obstruents (i.e., oral stops and fricatives) are, due to their low sonority, likely to be placed in the initial and final positions of the syllable. In the Onset, such segments will be followed by more sonorous ones, such as nasals, liquids, and semivowels, until the most sonorous segment (vowel) occupies the Nucleus. The succession of segments in the Coda, on the other hand, is a mirror-image of the Onset. If there are two consonants, the more sonorous one of the two is assumed to immediately follow the nuclear vowel. The Rhyme (the Nucleus and the Coda) is assumed to constitute a downward slope in sonority.

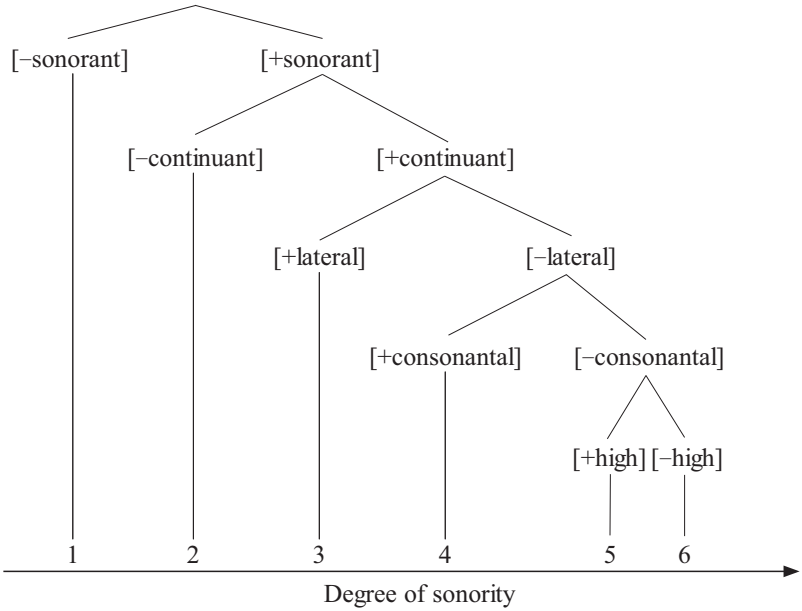
2.2. A Problem: Sonority Violation inside Syllables

2.2.1. Giegerich's (1992) Treatment

It must be underscored that if we assume that one syllable must correspond to one sonority peak, then a monosyllabic word containing the voiceless alveolar fricative syllable-initially and/or syllable-finally will be the best counterexample to this characterization. As indicated in Table 1, the voiceless alveolar fricative is more sonorous than oral stops. Thus, in words such as *speak*, *street*, and *tax*, the more sonorant segment /s/ precedes the less

sonorant one (i.e., /p/ and /t/) in the Onset, while it follows the less sonorant one in the Coda (i.e., /k/ in *tax*). These examples indicate that there will be two peaks inside *one* syllable. In the case of a plural form, such as *sticks*, there are as many as three peaks inside a single syllable (i.e., /s/ in the Onset and the Coda and the nuclear vowel). It should also be underscored that this kind of "violation" frequently happens in English, whether in the Onset or the Coda. Therefore, this cannot be overlooked or treated as a mere and rare exception.

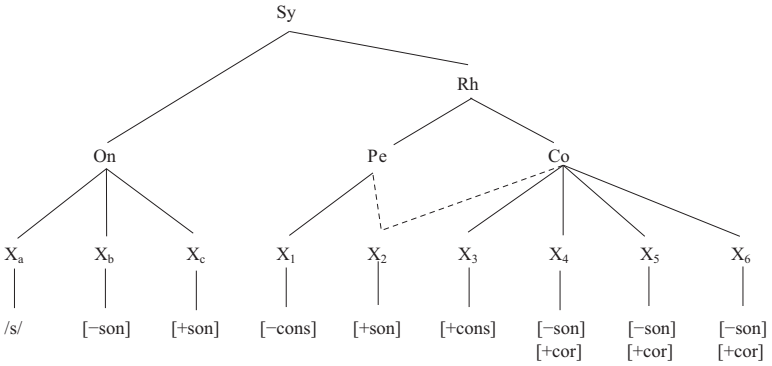
To resolve this problem, Giegerich (1992: 147–150) proposes that the voiceless alveolar fricative and other coronal consonants must be given an exceptional status inside a syllable. Specifically, such segments should be allocated to what he dubs "appendix," a slot outside the syllable core position. In Giegerich's framework, the sonority scale is dependent on Figure 1, where stops and fricatives are packed into one category as [−sonorant] segments, unlike his old version in Table 1, where both categories were clearly distinguished from each other.



Degree 1: /p b f v/ etc.
2: /m n ŋ/
3: /l/
4: /r/
5: /j w i u/ etc.
6: /e o a ɑ/ etc.

Figure 1. Sonority Scale (from Giegerich (1992: 161, Figure 6.3))

Giegerich then proposes a comprehensive analysis of the possible distributions of phonemes (his “Syllable Template”), as illustrated in Figure 2:



Conditions: (1) X_1 plus one $X_{>1}$ are obligatory.
(2) X_2 is associated with the peak if [-cons], otherwise with the coda.
(3) Further features of X_{1-3} are such that X_{1-3} decrease in sonority from left to right, in accordance with the sonority scale (figure 6.3 [1992: 161]).

Figure 2. Syllable Template
(from Giegerich (1992: 167, Figure 6.4))

In Figure 2, "X" represents a position in which a single phoneme or segment can be inserted. "Pe" stands for Peak, and it is equivalent to the Nucleus in the present study. Giegerich sets forth three conditions for the well-formedness of this template. Thus, the minimum number of segments in the Rhyme is two (i.e., X_1 and X_2, or X_1 and X_3), which, together with X_b and X_c, constitute the syllable core. X_1 must be a vowel, while X_2 can be filled by either a vowel or a sonorant (i.e., semivowels, glides, and nasals). If the segment following X_1 is a non-sonorant, then it will be associated with the Coda. Positions X_a, and X_4 to X_6 are considered as belonging to appendices. They can be utilized for accommodating segments of sonority violation.

Specifically, in *street* (/s t r i : t/), each of the segment is accommodated in X_a, X_b, X_c, X_1, X_2, and X_3, respectively.[3] For *fax* (/f æ k s/), each segment corresponds to X_b, X_1, X_3, and X_4, respectively. For *help* (/h e l p/), it will be X_b, X_1, X_2 and X_3, respectively. In a word involving a plural suffix such as *texts* (/t e k s t s/) it will be X_b, X_1, X_3, X_4, X_5, and X_6, respectively.

2.2.2. A Critical Assessment of Giegerich (1992)

The syllable template proposed by Giegerich reflects the characteristics of English monosyllables that have been developed in 2.1.1 through 2.1.5. It is considered to be a comprehensive and precise framework for analyzing English monosyllabes. However, this subsection will explore a few conceptual problems in his framework, and then propose an improvement to his approach in Section 3, so as to capture important properties of the voiceless alveolar fricatives in a more natural way.

First, the syllable template (Figure 2) is based on a feature-based version of the sonority scale (Figure 1), in which Giegerich crucially distinguishes [−sonorant] segments (both oral stops *and* fricatives) from [+sonorant] segments. This distinction looks elegant but, unfortunately, obscures the crucial feature of fricatives as [+continuant]. With this classification, the distribution of the voiceless alveolar fricatives remains to be a unique and mysterious exception in the syllable theory. The syllable template, although seemingly adequate descriptively, fails to explain why only the voiceless alveolar fricatives can be placed in appendices. Giegerich does not discuss significant linguistic functions that the voiceless alveolar fricatives may have.

Second, in the syllable template, X_2 is considered as [+sonorant], which excludes the fricatives. This allows syllables such as *out* /a͟ʊ͟t/ and *ant* /æ͟n͟t/, where the underlined relevant segment is situated in this position. However, under the syllable template, the voiceless alveolar fricative in *disk* must also fill this position. This contradicts Giegerich's framework because he regards /s/ as a non-sonorant segment. The voiceless alveolar fricative cannot occupy X_3 because that would put the final segment /k/ in the word *disk* into X_4, which is exclusively reserved for the [+coronal] segment. By narrowing down the permissible segment for X_2 to the [+sonorant] segment and excluding the voiceless alveolar fricative from this category, Giegerich (1992: 162) is forced to treat examples such as *disk*, *risk*, and *task* as unexplained exceptions.

Giegerich (ibid.) insists on treating the voiceless alveolar fricative as an exception because "only /s/ can occur before voiceless stops in rhymes – and

the number of attested examples is, after all, rather small." However, it should be noted that what he regards as exceptions to his framework includes such words as *brisk*, *disk*, *frisk*, *risk*, *whisk*, *ask*, *bask*, *cask*, *flask*, *mask*, *task*, *desk*, *busk*, *dusk*, *husk*, *rusk*, *tusk*, and so on, while we only focus our attention on monosyllabic words with a short vowel followed by /-sk/. Contrary to his remarks, this seems to be a rather productive process. It is also important to note that several frequently used words (i.e., *disk*, *risk*, *ask*, *mask*, *task*, and *desk*) are included. Soon after the above remark, Giegerich (ibid.) also asserts that "[i]t is worth noting, however, that these exceptions once again involve the coronal obstruent /s/."

In the case of appendices, the segment /s/ is standing out as an exception in his treatment, without any substantive characterization. Keep in mind that this segment is also used frequently in English, whether syllable-initially or syllable-finally. The voiceless alveolar fricatives are not the sort of segment that can be left outside the major domain of the syllable theory. Rather, they form the very segment that needs an explanation most.

3. A Solution

3.1. Voiceless Alveolar Fricatives as Semi-Sonorant and Sub-Syllabic Segments

This article proposes that more light must be shed on the voiceless alveolar fricatives because their behavior inside a syllable is not as exceptional as Giegerich assumes it to be. It can in fact be generalized if we rethink the segmental status of the voiceless alveolar fricatives in the phonology of English. Specifically, this article argues that the status of /s/ must be upgraded from a mere obstruent to a semi-sonorant and sub-syllabic phoneme, whose intrinsic properties enable the segment to stand as a sub-peak and to motivate several linguistic functions.

The reasons as to why /s/ is selected as a sub-peak include the following: First, due to the fact that the voiced/voiceless contrast of obstruents is suspended (Giegerich, 1992: 243) in the consonant clusters, the choice

of the voiceless segment /s/ rather than /z/ is a natural consequence of this phenomenon. Second, although other candidates are available for the same positions and functions, /s/ has a relatively high sonority in the category of voiceless obstruents (i.e., /f/, /ʃ/, and /θ/).[4] Third, the segment is [+continuant], which is, together with the high sonority, argued to play a role as a sub-syllabic segment. Fourth, the segment is a coronal, which is the most easily accessible and available type of consonant in English. Given that there are a few other candidates, the choice of the voiceless alveolar fricative /s/ as a sub-syllabic element with a semi-sonorant property is not as exceptional or extraordinary as it might look. However, it still remains unclear why only /s/ has the status that it does. By virtue of having a sub-peak in the appendices, the phoneme is argued to have some important functions, which will be discussed in the next subsection.

3.2. Phonological Sub-Peaks as Linguistic Sub-Domains

The characterization of /s/ as a semi-sonorant and sub-syllabic segment is not an ad hoc treatment because by treating the phoneme this way, some significant linguistic and phonological functions become clear. In other words, the relatively high sonority and existence of additional peaks inside a syllable indicate several non-trivial functions.

3.2.1. Word Boundary and Word-Formation in Onset, and Inflection in Coda

In the Onset of the two- (e.g., *spy*, *stone*, *sky,* and *sphere*) and three-consonant clusters (e.g., *street*, *splash*, and *sclerosis*), the voiceless alveolar fricative /s/ signals the initial word boundary; i.e., no obstruent can precede the phoneme /s/ in these environments. Further, this segment is considered as a contributing factor to word-formation because it enhances phonotactic patterns and enables a wider range of possible syllables than otherwise, through addition of this segment to the following consonant(s) in the Onset position.

In the Coda, the coronal consonants, including /s/, can function as an affix or inflectional morpheme. Keep in mind that /s/ is a prominent phoneme in

this respect because it can be utilized as plural, genitive, and third person singular present markers. The voicing phenomenon that happens when the voiceless alveolar fricative immediately follows the voiced segment (e.g., *bags*, *John's*, and *smiles* (as in *Mary always smiles at me*.)) is considered a case of progressive assimilation.[5] Therefore, we can regard voiceless segments as a basic input for phonological processes.

These facts indicate that the phonological sub-peaks produced by the voiceless alveolar fricatives may function as a linguistic or grammatical subdomain, just as the syllable core corresponds to the chief domain of the word meaning. Both types of domain may constitute a monosyllable, where the sub-peaks should be considered as affixes that have a phonological sub-structure inside the monosyllable. On the other hand, in polysyllabic words, affixes or combining forms with robust syllable structures may be attached to their head either as an unstressed syllable (e.g., *un-do* and *price-less*) or the one that carries a secondary stress (e.g., *over-done* and *self-help*).

3.2.2. Nucleus Support in the Syllable Core

Last but not least, is the availability of /s/ in the X_2 position in the syllable template (Figure 2), as in *task* and *risk*. If we suppose that /s/ is sub-syllabic and semi-sonorant (if not as fully sonorant as typical [+sonorant] segments), then the necessity of treating /s/ as exceptional will vanish. If we upgrade the status of /s/ to a semi-sonorant segment, then we can explain why /s/ can fill the X_2 position—it is exactly due to its sonority that it can immediately follow the nuclear vowel as a supporting element, just like the second element of a diphthong (e.g., *take* (/teɪk/) and *loud* (/laʊd/) and a sonorant immediately following a short vowel (e.g., *shrimp* (/ʃrɪmp/) and *milk* (/mɪlk/)).

According to Giegerich, the X_2 position is reserved for [+sonorant] segments, which are less sonorant than the segment in X_1. This characterization seems to reveal that the X_2 position is indeed suitable for a semi-sonorant element. The example *ask* is possible just like *out* and *ant* because /s/ is qualified for the X_2 position for its semi-sonority. Although Giegerich (1992) assumes that "fricatives and oral stops cannot be syllabic" (p. 166), regarding /s/ as similar to typical sonorants will enable us to handle

its distribution naturally, without regarding it as a mysterious counterexample to the syllable template.[6]

The proposed refinement does not drastically change the syllable template, which is essentially correct and succeeding in sub-dividing segment strings based on the sonority scale. However, in Giegerich's framework (Figure 1), obstruents have to be divided to [+continuant] and [−continuant] segments to highlight the important property of /s/ and other fricatives. This is because the crucial factors for sub-syllabicity include [+continuant] and [+coronal] features, together with the relatively high sonority among obstruents.

Further, if we consider the roles that the segment /s/ plays in the Onset and the Coda, this segment should be called an affix rather than an appendix (cf. Fujimura (1979)) because it plays important supportive roles for the syllable core rather than merely being an appendix. The functions are relevant to word boundary and word-formation in the Onset and to inflection in the Coda.

3.3. Summary

The sub-peaks produced by /s/ in the Onset and the Coda, on both sides of the Nucleus, serve some important morphological functions. They can also assist the nuclear vowel inside the Nucleus. The functions of the voiceless alveolar fricatives are illustrated in Table 2:

Table 2. Linguistic Functions of Sub-Syllabic and Semi-Sonorant /s/

	Sub-Syllabic Affix	Syllable Core	Sub-Syllabic Affix
Example: *streets*	/s/	/t r i: t/	/s/
Functions	Signals initial boundary Enhances word-formation possibility		Plural marker
Example: *Kate's*		/k e ɪ t/	/s/
Function			Genitive marker
Example: *puts*		/pʊt/	/s/
Function			3rd person singular present marker

3.4. Evidence for Sub-Syllabicity of Voiceless Fricatives

Voiceless fricatives are classified as consonants, but some can stand as a sub-peak due to the feature [+continuant] and their relatively high sonority. This seems to not only apply to the voiceless alveolar fricative but also to the voiceless palato-alveolar fricative /ʃ/ and the voiceless labiodental fricative /f/.

For example, in *ps(s)t* (/pst/), the voiceless alveolar fricative is considered as filling the Nucleus, with the voiceless stops on both sides in the Onset and the Coda, respectively. In addition, in expressions like *shh* and *s(s)h* (/ʃ/), the voiceless palate-alveolar fricative is considered as a sole constituent of the syllable.[7] Even though examples such as *shh*, *s(s)h* and *pst* may not have a robust syllable structure, they nevertheless seem to convey certain meanings in English. In the case of a one-obstruent "syllable," the fricative may have to be regarded as a Nucleus because any linguistic unit is to be regarded as a syllable or word as long as it conveys a certain conceptual meaning or illocutionary force, which contrasts to certain dependent and more abstract inflectional morphemes.

The next point is the transfer of voiceless fricatives to the Nucleus. Lass (1984: 139, 262, 264) points out that voiceless fricatives /f/ and /s/ as well as nasals may get syllabic in fast speech inside unstressed syllables, as in (3) and (4), where the schwa following the fricative segment is elided:

(3) phonetics [fənetɪks] → [f̩netɪks]
(4) university [juːnəvə̆sərɪ] → [juːn̩və̆s̩rɪ]

Giegerich (1992: 287) also illustrates an interesting example (=(5)), where the /s/ segment may get syllabic after the stressed syllable. The schwa in the first weak syllable is elided before a sonorant /l/, and further, in fast speech, the unstressed vowel is elided and taken over by /s/:

(5) solicitor /səlɪsɪtə/ → [sl̩ɪsɪtə] → [slɪs̩tə]

These examples indicate that when the weak syllable loses the schwa or the

unstressed vowel /ɪ/, its duration and sonority will depend on the preceding fricatives, which in the above environments may sustain the structure of a weak syllable after the schwa or the weak vowel is elided.

Acoustically, each fricative's sonority seems to vary, in contrast to the classification assumed by phonologists (i.e., Table 1 and Figure 1). For example, Fletcher (1929: 70–76) measured and illustrated a relative phonetic power of the fundamental speech sounds. By measuring the average value of the power of sounds produced by a number of subjects, a relative phonetic intensity or power was gained, with /θ/ being the weakest sound. The ratio of the strongest sound /ɔ:/ and the weakest one /θ/ is 680:1 (p. 74, Table X).

According to Fletcher's illustration, the ratios of the relative powers of the voiceless fricatives /ʃ/, /s/, /f/, and /θ/ is 80:16:5:1. From the data, it is clear that /ʃ/ is the greatest—that is, if we take this relative phonetic power as sonority. However, it remains unexplained why /s/ is preferred over the more sonorant /ʃ/ as a sub-syllabic segment, though voiceless fricatives (/s/, /ʃ/, and possibly, /f/) seem to be good candidates for sub-syllabic segments.

Finally, Wells (2008: 52) reports that some speakers of British English may pronounce *strong* as [ʃtrɒŋ] and *student* as [ʃtʃu:dᵊnt], where a syllable-initial segment /s/ becomes a more sonorous [ʃ] sound before /tr/ and /tʃ/. Although the place of articulation of /s/ and /t/ is closer, the palato-alveolar fricative replaces the alveolar fricative in this environment. While Wells regards this as a case of assimilation, this phenomenon may also suggest that sub-syllabicity of fricatives can be fortified—through the replacement of /s/ by a more sonorous segment—for the purpose of highlighting the status of the sub-peak.

4. Concluding Remarks

Building on the insights of Giegerich (1992), this article proposes a refinement of his syllable template through reappraising some intrinsic phonological properties of the voiceless alveolar fricatives. More specifically, based on the fact that the voiceless alveolar fricative brings about additional acoustic peaks in the syllable, this article proposes to treat this segment more

positively than Giegerich did and regarded it as being sub-syllabic and semi-sonorant, thereby upgrading its status from a mere consonantal phoneme in the appendices to a more prominent segment that can stand as a peak on both sides of a core syllable and as a supporting element for the nuclear vowel inside the syllable core.

This is not an ad hoc stipulation but follows from the inherent properties of the segment as being [+continuant] and semi-sonorant. Through this treatment, what Giegerich has regarded as mere exceptions has turned out to be an indispensable element in the syllable theory. The voiceless alveolar fricatives, with their own additional peaks, can signal the initial word boundary and enhance the availability of possible words in the Onset, signal several grammatical functions in the Coda, and even assist the nuclear vowel just like the second element of a diphthong and a sonorant immediately following a short vowel.

This article has also discussed: (i) the existence of a word or syllable made solely of voiceless fricatives, (ii) the transfer of voiceless fricatives to the Nucleus, and (iii) the replacement of alveolar fricative /s/ by /ʃ/ for the purposes of fortification. These cases seem to indicate that the voiceless alveolar fricative /s/ as well as other voiceless fricatives, such as /ʃ/ and /f/, can become a sub-peak of a syllable because they share the feature [+continuant] and have a relatively high sonority. It is not clear, however, why /s/ is preferred in English as the most frequently used segment over the more sonorous segment /ʃ/.

Finally, it is important to highlight some further problems for future studies so as to strengthen the ideas developed in this article. First, this article has argued that the sub-syllabic segment in the Onset and the Coda have important linguistic functions that correspond to their status as phonological sub-peaks. To corroborate the argument that the voiceless alveolar fricative is an indispensable element and that its behavior is far from being exceptional, it is necessary to investigate the frequency of the segment in question at least in the syllable-initial position and provide numerical evidence for the utility of this segment. The analysis is now in progress and the results will be presented and discussed elsewhere. Second, it is necessary to have a much

finer characterization of sonority, from the viewpoint of acoustic phonetics, and to discuss whether or how we can incorporate into the present analysis the framework by Fujimura & Lovins (1978) and Fujimura (1979). This framework adopts a similar analysis in characterizing a syllable as being made up of a core and an affix but is quite different in several respects (Fujimura & Lovins, 1978: 111; Fujimura, 1979: 474). Third, it is necessary to tackle the following questions: Why is /s/, rather than /ʃ/ or /f/, preferred as a sub-peak of a syllable? A typological perspective will be necessary, such as the work on a numerous number of languages by Nartey (1979), who states that "[t]here is a highly significant tendency for languages to have at least one primary fricative" (p. 4). Nartey also mentions that if a language has only one fricative, "its primary allophone is most likely to be /s/" (ibid.), and that if a language has two primary fricatives, "the second one is most likely to be /f/" (ibid.), pointing to the cross-linguistic prevalence of the voiceless alveolar fricative /s/ in terms of its "articulatory ease, perceptual salience and acoustic superiority" (p. 6).

Notes

1 The space does not allow us to provide the exhaustive list of the possible consonant combinations in the Onset and the Coda. For example, in the consonant clusters in the Onset, /sl/, /dr/, and /fr/ (e.g., *slash*, *drink*, and *fry*) are possible, but */sr/, */dl/, and */fw/ are not permissible. Likewise, while /spl/ and /str/ (e.g., *splash* and *strict*) are possible, */spw/ and */stl/ are not permissible.

2 This example, together with /ts/, its voiceless counterpart, is considered as an affricate, and they can be analyzed as a single segment. Thus, they may be excluded from the present discussion.

3 Giegerich's (1992) analysis is not very clear as to the proper place of the voiceless alveolar fricative that can be in either X_3 or X_4. Since /s/ is [+consonantal] it may fill either the X_3 or X_4 position without violation of the sonority principle. The same applies to a case involving a diphthong, such as *face*, where the well-formedness condition is met by virtue of the two morae in the Nucleus. On the other hand, if the vowel is a monophthong such as *pass*, the final segment must be considered as a member of the syllable core, namely X_3.

4 Logically speaking, these phonemes should share the same or a similar role. For the

syllabicity of /f/ and /ʃ/, see 3.4. On the other hand, /θ/ may not be utilized because of its weak sonority. See also 3.4 for discussion.

5 The inflectional suffixes include other coronal segments such as /t/ (e.g., *hoped*, *kicked*, and *passed*) and [θ] (e.g., *fourth*, *sixth*, and *tenth*). Note that only /t/ is [−continuant]. Again, the formation of their voiced counterparts (e.g., *played*, *saved*, and *listened*) follow an independent factor, namely progressive assimilation.

6 The voiceless alveolar fricative embedded in words (e.g., *fax* and *tax*) does not accompany a significant linguistic function. The segment seems to be simply allocated to the appendix so as to avoid the sonority restriction.

7 English has the alveolar click spelled as *tsk*. Although this is a conventional spelling, it has only one segment.

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The Voiceless Alveolar Fricatives in English as Sub-Syllabic Segments

英語における無声歯茎摩擦音 /s/ を副次的成節子音として捉える

熊　谷　吉　治

英語の音節理論において、無声歯茎摩擦音 /s/ は大きな問題である。なぜなら、当該音素は子音であるにもかかわらず、音節内で音響的なピークを構成し得るからである（例：*speak*, *street*（頭子音）や *tax*, *fax*（尾子音））。この事実は、「音節は単一の聞こえ度のピーク」と見なす立場にとって重大な反例となるため、Giegerich (1992) は当該音素を音節の中心構造（syllable core）の外枠に位置づけ、「付加物」（appendices）と見なしている。Giegerich の枠組み自体は音節内部の音素分布を記述的に妥当な形で捉えているが、なぜ核母音以外に単音節内に聞こえ度のピークが存在し得るのか、なぜ /s/ だけがこの現象に関与するかを説明せず、単なる例外として処理している。さらに Giegerich は、*task* や *risk* のように、音素 /s/ が核母音の直後に現れて母音と共に音節の中心構造を占める現象も例外扱いしており、現象の背後にある一般性を捉えようとしていない。

音素 /s/ は副次的な聞こえ度のピークを持ち、音節の中心構造の前後で付加物として現れたり中心構造内で核母音の直後に現れたりするが、これは当該子音の継続音性や聞こえ度の高さといった内在的特徴によるものである。このため、副次的な成節要素として音節内で重要な役割を果たすのである。/s/ が選ばれるのは、比較的高い聞こえ度を持った継続音であることに加え、英語の子音結合では阻害音の有声／無声の対立が棚上げされること、/s/ が子音の中で一番種類の多い舌頂音であることが挙げられる。

加えて、/s/ は顕著な言語学的機能を有している。音節を中心構造と付加物に分離することで、接辞としての /s/ の役割が明確になる。/s/ は頭子音位置で語の冒頭を示したり語形成の可能性を拡大したりする一方、尾子音位置では屈折標識として文法的役割を果たす。/s/ の生み出す副次的な聞こえ度のピークは、当該音素が重要な言語単位であることを示している。これは単音節で核母音を中心とした構造が語としての意味領域を示すのに類似している。さらに、継続音性と比較的高い聞こえ度によって、/s/ は共鳴音のように音節の中心構造内で直前の短母音を支える役割も果たすのである。

したがって、/s/ は音節理論の例外ではなく、重要な音韻論的ステータスと言語学的機能を有する音素であると考えられる。