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The Structure of Fricative-Stop Onsets

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1. Introduction

The well known generalization that segments in a syllable tend to be arranged in order of increasing sonority approaching the syllable nucleus faces a number of apparent counterexamples, among them English onsets consisting of *s* followed by a stop.[1] The anomalous distribution and patterning of fricative-stop onsets in English and numerous other languages have inspired various proposals concerning their structure. This paper reviews the behavior of these clusters in various languages and brings new evidence to bear on this issue from the domain of second language acquisition and loan phonology. Examination of the patterns of simplification of foreign language clusters among speakers of a wide range of native languages reveals that even speakers whose native language allows no onset clusters at all frequently treat onset sequences of rising sonority differently from fricative-stop clusters, in ways that are strikingly consistent across different native languages. I argue that the cross-linguistic patterning of fricative-stops onsets can be accounted for by assuming (1) that fricative-stop onsets are structurally distinct from obstruent-sonorant clusters in a way that renders them immune to sonority sequencing constraints and that accounts for their behavior with respect to various native language phonological processes; (2) that the treatment of fricative-stop onsets in foreign language borrowings and in second language acquisition also follows from the structure proposed for these onsets; and (3) that language learners are led to the proposed analysis of fricative-stop onsets by their knowledge of universal constraints on phonological structure. One aim of this paper is therefore to argue that the tendency to distinguish foreign language fricative-stop onsets from those that conform to sonority sequencing constraints--even where the native language permits neither type of onset cluster--suggests that the performance of adult language learners is constrained by the principles of universal grammar.

The second aim of the paper is to suggest an analysis of the structure of these sequences that accounts for their behavior, and to situate this analysis within a general theory of segment structure. The theory of feature geometry developed in Clements 1985, Sagey 1986, McCarthy 1988, and elsewhere makes possible a monosegmental representation of segments with multiple and sometimes contrasting articulations. Sagey's work distinguishes two types of segments, **contour segments**, such as affricates and prenasalized stops, which have distinct manner specifications, and **complex segments**, which may involve both the use of multiple articulators and the use of different manners. The latter class includes clicks and units with secondary (and/or tertiary) articulations such as *tsk, skw* in Kinyarwanda, Shona, and Kirundi. Both classes of segments consist of sets of features dominated by

a single root node, which defines the segment and serves as the domain for constraints on segment sequencing. I will argue that the class of segment types should be expanded to include what I call **adjunction segments**, which are derived by the coalesense of two independent segments. These adjunction structures contain two root nodes, one dominant and one subordinate, and therefore behave in some respects like single segments, in other respects like two independent but connected segments. I argue that the class of adjunction segments includes both fricative-stop onsets and certain of the multiply-articulated complex segments described by Sagey as monosegmental.

Before developing this analysis, I begin by reviewing the distribution and patterning of fricative-stop onsets (FSOs) in a number of languages, along with various proposals designed to render these onsets compatible with the hypothesis that sonority sequencing constraints are universal, in section 1. I argue that the behavior of FSOs is not fully explained either by analyzing these sequences as single segments (similar to affricates), or by analyzing the fricative as extrasyllabic and adjoined to the syllable or word node at some point late in the derivation. In section 2 I develop the proposal that FSOs are adjunction structures, originating as two segments but with the fricative ultimately incorporated into the syllable by virtue of its adjunction to the stop. Section 3 explores the implications of this proposal for additional sequence tyeps.

1. Fricative-Stop Onsets and Sonority Sequencing

As mentioned above, *s*-stop onset clusters in English violate the principle that segments within a syllable tend to be arranged according to sonority. One recent statement of this principle is that of Selkirk (1984):[2]

1. Sonority Sequencing Generalization (SSG):
   In any syllable, there is a segment constituting a sonority peak that is preceded and/or followed by a sequence of segments with progressively decreasing sonority values.

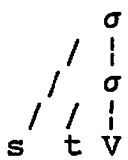
While there has by no means been universal agreement on the relative sonority ranking of various types of segments, a fairly widely accepted version of the sonority hierarchy is as in (2):

2. Sonority Hierarchy
   Obstruent - Nasal - Liquid - Glide - Vowel
   least sonorous.....most sonorous

The members of the various classes are often further subdivided, with factors such as continuancy, voicing, and place of articulation considered to play a role in sonority rankings. *S*-stop onsets violate the SSG, since as a cluster of two obstruents they constitute either a sonority plateau or, under the assumption that stops are less sonorous than fricatives, an onset of decreasing sonority.[3] Various solutions to the problem of reconciling FSOs with sonority sequencing constraints have been suggested. One approach is simply to loosen sonority sequencing constraints to allow obstruent sequences (Clements 1988). Another approach is to analyze these onsets as a single consonant, and

therefore immune to constraints on sequencing of segments (O'Connor and Trim 1953, Fudge 1969, Selkirk 1982, Fujimura and Lovins 1982, Ewen 1982, Church 1983, Steriade 1992), or to assign them a different constituent structure than other onset clusters (Cairns and Feinstein 1982). And a third approach assigns a constituency to FSOs that makes the fricative only distantly connected to other onset consonants, with *s* outside the syllable itself (Steriade 1982, 1988, Levin 1985, Borowsky 1986). Under the assumption that all segments not prosodically licensed (Ito 1986, 1989)--that is, incorporated into higher prosodic structure--are deleted by Stray Erasure (Steriade 1982), word-initial fricatives must receive some special provision, perhaps in the form of extrametricality followed by rules then attach the fricative to the syllable node or word node at some point in the derivation. Levin, for example, proposes the following structure for English *s*-stop onsets, where *s* has been Chomsky-adjoined to the core syllable:

3. Structure of s-stop onsets (Levin 1985)



These accounts give no explanation of why it is fricatives in particular that so often receive special dispensations.

In the following discussion, I will examine a wide range of differences in the patterning of FSOs vs. rising sonority onsets. I assume that this evidence is sufficient to establish the desirability of maintaining the sonority hierarchy and the SSG in a form that maintains a distinction between FSOs and rising sonority onsets in terms of markedness. I argue furthermore that a cross-linguistic survey of FSOs uncovers a paradox: FSOs behave in some respects like single segments, in other respects like segment sequences.

1.1. S-Stop Onsets as Single Segments

The analysis of *s*-stop onsets as single segments is consistent with the distribution and patterning of these onsets in a number of languages. As pointed out by Pike (1967), Fudge (1969), Selkirk (1982), this analysis provides a unified solution to two problems concerning the distribution of consonants in English onsets. All other biconsonantal onset clusters (with the exception of *sf* and *š*-stop, found in a few words of Greek, Yiddish, or German origin) consist of an obstruent followed by a sonorant (consistent with the SSG). Furthermore, the only three-consonant clusters in onset position consist of *s* followed by a stop-sonorant sequence, where all the stop-sonorant clusters which may follow *s* are also attested as independent onset clusters. If *s*-stop is analyzed as a single consonant, the description of English onsets is quite simple: all onsets consist of at most two consonants, the first of which is an obstruent and the second of which is a sonorant; furthermore, all English onsets obey the SSG, assuming that the segment is the relevant unit for this constraint. Similar arguments may be

complexity of syllable contact types, determined by the sonority of the adjacent margins of two consecutive syllables, the heterosyllabic sequence vowel-obstruent, as in *si-kii*, is the least complex, while obstruent-obstruent syllable contacts, as in *?is-kii*, are considerably more complex. The resistance of vowel insertion to breaking up the fricative-stop sequence therefore has no explanation in terms of complexity of derived syllable structure.

The Egyptian/Telugu pattern of prothesis before *s*-stop and epenthesis into other clusters is of course not universal. Languages that permit complex onsets have no need to simplify foreign onset clusters at all, while languages that do not permit obstruents in coda position simply do not have the option of prothesis before an unsyllabified consonant, since this would create a syllable with a consonantal coda. And some languages, such as Iraqi Arabic, choose the prothesis option regardless of cluster type, making no distinction between onsets of differing sonority sequencing. However, a number of other languages exhibit precisely the same pattern. Among them is Hindi, discussed by Singh (1985):

10. Hindi (Singh 1985)

a.	fIrut	'fruit'
	pIlIz	'please'
→	pʌfaizʌr	'pfizer'
	sIlIpʌr	'slipper'
b.	IspEliŋ	'spelling'
	Iskul	'school'
	Iskru	'screw'

Note that the onset *pf* patterns with onsets of rising sonority, as is to be expected if fricatives do indeed have a higher sonority value than stops.[6] The same pattern of prothesis before fricative-stop clusters and epenthesis into other clusters appears in other Indo-Aryan languages, including Bengali and Central Pahari (or Kumauni), spoken in Uttar Pradesh:[7]

11. Bengali (Mahato 1974)

a.	gelaš	'glass'
	šelet	'slate'
b.	iškul	'school'
	istæmp	'stamp'

Central Pahari (Sharma 1980)

c.	kilip	'clip'
	pileres	'press'
	silet	'slate'
	siliipðr	'slipper'
b.	istuul	'stool'
	ispiič	'speech'
	ispriŋ	'spring'

Thus this pattern occurs in several language families: Dravidian (Telugu), Indo-Aryan (Hindi, Bengali, Central Pahari), and Semitic (Egyptian Arabic; also Amharic: *sɨliper* 'slipper' but *ɨstadiyom* 'stadium' (Haile Araya, personal communication)). It has been also been reported for some dialects of Turkish (Swift 1963).

adduced for related languages, as Ewen (1982) points out.

Additional evidence for the single-segment analysis is provided by the patterning of *s*-stop onsets as a unit with respect to various processes. Thus in Gothic reduplication, which normally prefixes a copy of the initial stem consonant followed by *ai*, both the *s* and the stop are copied (Kiparsky 1979):

4. Gothic Reduplication
   a. *gai*grot 'wept'
   b. *stai*staut 'pushed'

Similarly, in Old Norse and Old English poetry, words beginning with *s*-stop may alliterate only with other words beginning in the same sequence, even though alliteration generally requires only that the initial consonant of an onset cluster be repeated (Davidsen-Nielsen 1973). This follows, of course, if *s*-stop is analyzed as a single segment. Furthermore, as Laeufer (1985) points out, obstruents in *s*-stop clusters failed to undergo various historical processes (such as Grimm's Law) that applied to obstruents not preceded by *s*. Additional evidence for a monosegmental analysis of *s*-stop comes from French where, as Clements (1990) points out, two word-initial consonants may not generally be followed by a palatal glide. Again, *s*-stop clusters constitute an exception to this generalization; thus the high front vowel alternates with a glide in (5b) but not (5a):

5. French vowel-glide alternation
   a. plie (*plye) 'to fold'
   b. skie ~ skye 'to ski'

1.2. S-Stop Onsets as Heterosyllabic

S-stop sequences do not always behave as a single unit with respect to phonological processes, as they should if they are lexically specified as single segments. Sanskrit reduplication provides an interesting contrast to the Gothic pattern illustrated above; in Sanskrit, reduplication copies only the stop in an *s*-stop cluster is copied (6a), while in clusters consisting of an obstruent followed by a sonorant (6b,c) the first consonant is copied:

6. Sanskrit Reduplication (Kiparsky 1979, Steriade 1982, 1988)
   a. *tan*stan 'thunder'
      kan-i-skand 'leap'
   b. *sa*smara 'remember'
      *saa*svap 'sleep'
   c. *kan*-i-krand 'cry out'
      *vaa*vyadh 'pierce'

A similar pattern is seen in Greek nominal reduplication (Steriade 1982, 1988). These facts appear to be incompatible with the single-segment analysis, since if *s*-stop clusters are single segments, they presumably should not serve as targets for the reduction to a single consonant imposed by the Sanskrit reduplicative template. A similar pattern is found in the treatment of borrowed words in the Dravidian language Telugu. Telugu forbids onsets containing more than a single consonant; biconsonantal onsets in borrowed words are reduced either by

deletion of a consonant, or by insertion of a vowel, which allows these onsets to be split among two syllables:

7. Telugu (Rao, 1986)

a.	situ	'sweet'
b.	d∂mmu	'drum'
c.	gasu (~galasu)	'glass'
d.	tešδnu (~istešδnu)	'station'

(Telugu adds *u* word-finally to both native and borrowed words). As in Sanskrit reduplication, the more sonorous member of the onset cluster is deleted. Again, if *s*-stop clusters were analyzed by Telugu speakers as monosegmental, they would presumably not trigger deletion.

One possible analysis of the facts of Sanskrit, Greek, and Telugu is to assume that the *s* in *s*-stop onsets is targeted for deletion because it is outside the core syllable (Steriade 1982, 1988). Given this analysis, the patterning of *s*-stop onsets across languages presents a paradox: with respect to certain processes, the members of an *s*-stop onset appear to share a closer relationship than other onset consonants, while for other processes, the *s* appears to be less closely integrated into the syllable than other onset consonants. In the following section I explore an additional example of anomalous patterning by FSOs, illustrated by the vowel insertion pattern in the Telugu examples (7c,d). I show that far from being an isolated example, this pattern is attested across a wide range of languages.

1.3. Fricative-Stop Onsets in Foreign Language Phonology

This section presents evidence that in both second language acquisition and borrowings from a foreign language, FSOs are often treated differently from rising sonority onsets in strikingly consistent ways across a number of languages and language families.[4] Furthermore, the pattern discussed below follows from neither the monosegmental nor the heterosyllabic analysis of FSOs.

The data in this section illustrate the restructuring process that foreign words generally undergo to bring them into conformity with the syllable structure constraints of the native language. I focus on the process of vowel insertion which is frequently used when the syllable structure constraints of the native language prevent the incorporation of all the consonants of the foreign language into well-formed syllables. Egyptian Arabic, for example, allows only a single consonant in onset position; codas are also restricted to single consonants except in absolute phrase-final position, where two consonants are permitted (Broselow 1976). In borrowed or foreign words, a vowel is therefore inserted in initial clusters of two consonants or medial clusters of three or more consonants (Abdul Hamid 1970, Broselow 1983):

8. Egyptian Arabic

a. bilastik	'plastic'
b. fired	'Fred'
c. čildiren	'children'
d. tiransilet	'translate'
e. siwetar	'sweater'
f. silaid	'slide'

These forms can be accounted for by assuming that all segments must be prosodically licensed (Ito 1989, among others) by their incorporation into higher prosodic units. Since Egyptian allows only a single consonant in onset and coda positions, even the creation of maximal syllables in the English forms above will leave a residue of unsyllabifiable consonants (*t-ran-s-let*). Vowel insertion creates new syllables to license the unsyllabified consonants; in Egyptian, this vowel is inserted to the right of the unsyllabified consonant (Selkirk 1982, Broselow 1983, Ito 1989, Broselow 1992). However, this analysis is contradicted by one class of forms, those beginning in *s*-stop:

9. Egyptian Arabic

a. ʔiskii	'ski'
b. ʔistadi	'study'
c. ʔispiriŋ	'spring'
d. ʔistiriit	'street'

In these forms, rather than inserting a vowel to the right of the unsyllabified consonant--producing *sikii* 'ski', for example--speakers typically place the inserted vowel before the *s*. This pattern exactly parallels the one found in the Telugu renderings of 'glass' as *galasu* but 'station' as *isteš∂nu*. This cannot be ascribed to any special property of *s* itself: as seen above, clusters of *s* plus sonorant consonant pattern with other obstruent-sonorant clusters.[5] Nor is there anything in the grammar of Egyptian Arabic to rule out forms with initial *siC* (cf. *sikitt* 'I became quiet'). More generally, since this dialect allows no onset clusters of any kind, there is nothing in the native language grammar that would cause speakers to distinguish the *s*-stop onsets from the rising sonority onsets. Furthermore, this pattern represents a relatively inefficient strategy, necessitating changes beyond the insertion of the vowel: a glottal stop must be inserted before the *i* to prevent the occurrence of a vowel-initial syllable (prohibited in this language), and an additional epenthetic vowel is required in triconsonantal clusters (*istiriit* 'street' rather than the expected *sitriit*). Nor is the prothesis before *s*-stop/epenthesis into obstruent-liquid pattern supported by any theories of syllable markedness; in fact, this strategy is chosen in direct defiance of markedness considerations. Insertion of a vowel **after** a stray consonant--creating, for example, *si-kii*, rather than *ʔis-kii*,--appears to be by far the preferred means of simplification cross-linguistically, creating the maximally unmarked CV syllable structure. And in the explicit complexity rankings of syllable types provided in Clements 1988, obstruent-vowel, as in *si*, is the least complex onset-nucleus combination, while vowel-obstruent, as in *is*, is the most complex nucleus-coda combination. In terms of

Furthermore, this pattern is not restricted to borrowings from English. Sinhalese, for example, treats loans from Sanskrit in precisely the same fashion:

12. Sinhalese (Samarajiwa and Abeysekera 1964)

	Sinhalese	Sanskrit	
a.	tiyage	tyage	'gift'
	tirividə	trividə	'triple'
	siriyavə	sriyavə	'grace'
b.	istiri	stri	'woman'

The prothesis-epenthesis pattern is also found in borrowings from French into Wolof, a Niger-Congo language (here the inserted vowel is a copy of the following vowel):

13. Wolof (Ka 1985, personal communication)

	Wolof	French	
a.	kalaas	klas	'class'
	giri	gri	'gray'
	silip	slip	'undergarment'
	sonob	snob	'snob'
b.	estati	statü	'statue'
	espoor	spoR	'sport'

The same pattern of prothesis before *s*-stop onsets is reported for French-derived words of Haitian Creole (Tinelli 1981), and English-derived words of Hawaiian Creole (Ito, personal communication).

What is of crucial importance is that in all these cases, non-native speakers distinguish the two sorts of onsets even where neither type occurs in the native language--that is, where the native language allows either no onset clusters at all, or only a subset of the clusters permitted in the source language. Therefore, the behavior of the non-native speakers cannot be attributed to any properties of their native language grammars. Nor do the various foreign languages provide any obvious indication that these two onset types should be distinguished, and in any case it seems implausible that this pattern should arise from the speaker's analysis of the foreign language grammar, since it is manifested most clearly in the pronunciation of beginning language learners or in borrowed words. I therefore conclude that non-native speakers are led to distinguish FSOs from rising sonority onsets by their knowledge of universal principles of sonority sequencing and segment structure, and that these principles lead speakers to an analysis of the structure of FSOs that makes the prothesis/epenthesis pattern a natural one. If this is correct, one might expect the prothesis/epenthesis pattern not only to emerge in the simplification of foreign language onsets, but also to be manifested in the grammar of some native language. In fact, Modern Western Armenian displays a pattern very much like the second language prothesis/epenthesis pattern. On the surface, Armenian onsets may consist of no more than one consonant, though initial clusters are common in the orthography. In pronunciation, these clusters are broken up by insertion of a schwa, which is not represented in the orthography, is generally not recognized as a 'real' vowel by native speakers, and is generally agreed by Armenian grammarians to be excrescent (Bardakjian and Thompson

1977, Andonian 1974, Gulian 1955, Kogian 1949). In most cases, the schwa occurs after the first of two onset consonants (data from Bardakhian and Thompson 1977; thanks to Mher Hedeshian for confirmation):

14. Western Armenian
    a. grag -> gərag 'fire'
    b. vnas -> vənas 'harm'
    c. srel -> sə… 'sharpen'
    d. hnar -> hənar 'resource'
    e. sxal -> səxal 'mistake'
    f. nman -> nəman 'similar'
    g. mgrdel -> məgərdel 'baptise'

However, there is a set of exceptions to this generalization: if the initial cluster consists of *s*, *z*, *š*, or *ž* followed by a stop, the inserted schwa appears before the initial consonant:

15. a. stapil -> əstapil 'come to one's senses'
    b. spopel -> əspopel 'console'
    c. skančeli -> əskančeli 'wonderful'
    d. stapel -> əstapel 'hurry'
    e. zpaγil -> əzpaγil 'be occupied'
    f. sbannel -> əsbannel 'kill'
    g. sgsil -> əsgəsil 'begin'

The Armenian data argue against an analysis of the second language onset simplification as a matter of simply comparing the sonority of the onset consonants (an analysis of the Hindi data along these lines is suggested by Singh 1985). Under this analysis, one would simply insert a vowel before the more sonorous consonant, or between two consonants of equal sonority (as (14e,f)). Comparison of (14g) and (15g) reveals, however, that fricative-stop onsets pattern differently from other falling sonority onsets; if the position of the inserted vowel depended solely on relative sonority of onset consonants, we would expect (14g) to emerge as **əmgərdel*, parallel to (15g) *əsgəsil*.

The resistance to being split by vowel insertion extends to word-internal fricative-stop clusters in Armenian. The following forms contain initial clusters of five consonants. In (16a), a vowel is inserted between the second and third consonants, while the third and fourth consonants remain adjacent. In (16b), where the second and third position corresponds to a fricative-stop sequence, the inserted vowel appears between the third and fourth consonants, while the fricative-stop sequence remains adjacent:[8]

16. a. lmnt^{s}nel -> lə -mən-t^{s}ə-nel 'finish'
       CCCC C Cv -CvC-C v-C...
    b. jškrdowtiwn -> jəš-kər-dow-tiwn 'zeal'
       CskCCC Cvs-kvC-C...

1.4. Analyses of Fricative-Stop Onsets

To summarize the facts of fricative-stop onsets discussed so far:

1. Exceptional distribution: FSOs violate the Sonority Sequencing Generalization.

2. Unitary behavior: FSOs may pattern with single consonants with respect to reduplication and alliteration.

3. Susceptibility to simplification: FSOs may, like clearly bisegmental onsets, be subject to simplification with respect to reduplication and vowel insertion or deletion.

4. Greater deletability of the fricative: where simplification is accomplished through deletion, it is the fricative that is normally deleted.

5. Preference for adjacency: if a language positions an inserted vowel differently in different sequence types, the vowel appears before the fricative-stop sequence, with the result that the fricative and stop remain adjacent (the prothesis/epenthesis pattern).

Though some of these facts are consistent with either the monosegmental or the heterosyllabic analysis of FSOs, neither analysis explains the entire range of facts. Nor does the prothesis/epenthesis pattern follow straightforwardly from either analysis.

The argument against the monosegmental analysis of the prothesis/epenthesis analysis of FSOs is straightforward: the function of vowel insertion is to reduce onsets to single segments; therefore, if FSOs are single segments, even complex ones, they should not require reduction. Indeed, the FSOs frequently contrast in this respect with affricates, which are fairly uncontroversially analyzed as single segments, albeit ones with a temporal ordering of contrasting continuancy articulations. For example, although *č* does not occur in Egyptian Arabic, the affricate is maintained intact in English words (thus *children* is never pronounced as either *tišildiren* or *itšildiren*).[9]

The analysis in which the fricative in an FSO is extrasyllabic appears to provide a more promising approach to the prothesis/epenthesis problem, since it analyzes FSOs as biconsonantal and therefore in need of simplification in languages that allow only monoconsonantal onsets. For this analysis, we need to make the following assumptions:

17. Assumptions:

    i. Sonority sequencing principles rule out syllable onsets of falling sonority; therefore, a fricative-stop sequence cannot constitute the onset of a core syllable.

ii. The principle of prosodic licensing (Ito 1986) requires that all segments be prosodically licensed (incorporated into higher prosodic structure). Segments that cannot be incorporated into syllables at some point in the derivation are deleted (Steriade 1982, Ito 1986); therefore both the fricative and stop in an FSO must be prosodically licensed.

iii. Principles of segment structure rule out single segments with the order continuant-stop (Lombardi 1991); therefore, a fricative-stop sequence cannot constitute an affricate (where affricates are analyzed as a segment with contrasting articulations attached to a single root node).

iv. All speakers, even those whose native language admits no onset clusters, have access to universal principles (i-iii). These principles force the analysis of foreign-language fricative-stop onsets as something different from either true sequences of rising sonority or from true single-segment consonant onsets.

Assumptions (i-iv) provide a rationale for treating FSOs differently from rising sonority onsets in terms of vowel insertion (the prothesis/epenthesis pattern). I will argue in section 2 that the structure assigned to FSOs, even by non-native speakers, is an adjunction structure, and that this structure is consistent with the prothesis/epenthesis pattern, as well as the other aspects of FSO behavior. First, however, I will consider three alternative accounts, assuming an extrasyllabic analysis of the fricative. None of these, I argue, is satisfactory.

One possible analysis of the prothesis/epenthesis facts, consistent with the assumption that fricatives in FSOs are extrasyllabic, is to assume that speakers who use the prothesis/epenthesis pattern to simplify foreign language clusters employ different vowel insertion rules on different domains. A form like *Fred* or *snow*, for example, is recognized as a core syllable, and a rule of vowel insertion which applies only on the domain of the core syllable inserts a vowel between the two onset consonants. (This rule might be conceived of as a phonetic retiming of consonant and vowel gestures, similar to the analysis of Dorsey's Law in Winnebago proposed by Steriade (1990).) In contrast, a form like *ski* is analyzed as containing the core syllable *ki* plus an extrasyllabic fricative, which is subject to a second rule of vowel insertion which places a vowel before an extrasyllabic consonant. Cluster simplification therefore involves the use of different vowel insertion rules on different domains.[10]

There are two obvious objections to this account. First, the position of the inserted vowel does not follow from any aspect of the analysis: if the fricative in an FSO is actually a peripheral element, it is difficult to see why vowel insertion should resist positioning a vowel **between** the fricative and the stop. Second, though this analysis might account for the second language pattern, it leaves unexplained the Armenian facts. Since no clusters of any

type are allowed in Armenian onsets, the prothesis/epenthesis pattern cannot be accounted for by an appeal to a difference between tautosyllabic and heterosyllabic clusters. To maintain the parallel with the second language case, we would have to say that initially, Armenian exhaustively syllabifies all initial two-consonant clusters except those consisting of coronal fricatives or affricates before stops unsyllabified (*nman* vs. *s-ta-pil*). Then forms with onset clusters undergo an epenthesis rule that inserts a vowel after the first of two onset consonants *nman* -> *nəman*). Finally, a distinct rule applies to insert a vowel before a consonant which has not been incorporated into a syllable (*s-ta-pil* -> *əs-ta-pil*). But, since many of the cluster types undergoing the first type of vowel insertion constitute SSG violations, the SSG cannot provide a motivation for an initial difference in syllable structure assignment in the FSO vs. other cluster cases, as it does for the foreign language data. In Armenian, syllabification would have to apply in defiance of the SSG on forms containing sonority violations at least as serious as those posed by FSOs. Therefore, the tautosyllabic vs. extrasyllabic distinction used to account for the prothesis/epenthesis pattern in second language environments does not generalize in any natural way to the strikingly similar prothesis/epenthesis pattern exhibited by native speakers of Armenian.

A similar objection adheres to an alternative account of the prothesis/epenthesis pattern. We might assume, following Zec (1989) and Bagemihl (1991), that the mora, as well as the syllable, is a valid unit for prosodic licensing; that is, segments which are extrasyllabic but dominated by a mora are protected by deletion. This account also provides a distinction between onsets like *fr, sn* on one hand (contained within a syllable) and onsets like *sk*, which would have the structure in (nnb):

18. Moraic Licensing Analysis

Again, two different vowel insertion rules can be posited, one targeting consonants dominated by syllable and the other targetting consonants dominated only by mora. The use of prothesis rather than epenthesis for these moraic segments could in turn be argued to follow from the structure proposed by McCarthy and Prince (1986) and Hayes (1988), in which onset segments are directly dominated by a syllable node, but rime segments are dominated by a mora node. Prothesis before FSOs would then follow from an attempt to maintain the moraic status of the fricative by assigning it to a position in the rime, rather than the onset, of a derived syllable. But again, this approach fails to generalize to the Armenian data. To account for the prothesis/epenthesis pattern in Armenian, it would be necessary to stipulate that only *s* could be moraically licensed, and then only when followed by a stop: neither *s* in forms like *sxal* -> *səxal*, nor more sonorous segments in other clusters of falling sonority *(mgrdel* -> *məgərdel*) could be moraic, since these segments trigger epenthesis rather than prothesis.

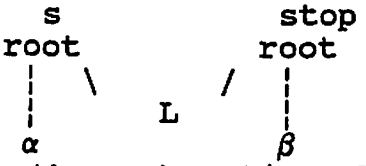
The prothesis/epenthesis pattern suggests yet a third analysis of FSOs. If FSOs were indeed single segments, they should not be split by vowel insertion, but neither should they condition vowel insertion. But in fact, in the pattern described above, these sequences do condition vowel insertion, which operates so as to maintain the adjacency of the fricative and the stop. This pattern is reminiscent of the behavior of geminates or partial geminates (such as homorganic nasal-stop sequences). As is well known, sequences of this type generally resist separation by otherwise productive rules of epenthesis (Guerssel 1977, Hayes 1986, Schein and Steriade 1986), and sometimes displace an inserted vowel to one side of the geminate cluster, as in Palestinian Arabic (Abu-Salim 1980):

19. a. akl + na -> akilna 'our food'
    b. imm + na -> immina 'our mother'

Thus, an analysis by language learners of fricative-stop onsets as two root nodes sharing certain melodic features would be consistent with the prothesis/epenthesis pattern. If these onsets contain two root nodes, they should be subject to simplification, but because the root nodes dominate shared features, the two segments cannot be separated by epenthesis.

The question then becomes what features are shared by the members of a cluster such as, for example, *sk*. If, as McCarthy (1988) argues, the root node is itself composed of the major class features, the assumption that these clusters contain two separate root nodes rules out the possibility of shared specifications for features [sonorant, consonantal]; segments in these clusters may but need not share neither place features; and stricture features differ, by definition, in FSOs. This leaves laryngeal features as the shared element. In fact, an analysis of *s*-stop clusters as sharing their laryngeal specifications has quite convincing justification in English phonetics. Browman and Goldstein (1986) argue that these onsets are associated with a single glottal gesture, citing as evidence both the lack of a voicing contrast and the lack of aspiration in stops following *s*. Since English *s* is characterized by the a spread glottis (in contrast to, for example, the aspirated @u[s] of Korean; Halle and Stevens 1971), spread of the laryngeal features of *s* to a following stop would derive a voiceless, unaspirated stop. Browman and Goldstein's proposal can be formalized in an autosegmental representation as follows, where L indicates the laryngeal node and Greek letter variables the place and stricture features:

20.



Thus the phonetic facts of English provide strong justification for the analysis of FSOs in English as two segments sharing a single set of laryngeal feature specifications. The Armenian data appear at first glance to contradict this generalization, since they show FSOs in which the fricative and

stop disagree in voicing, for example (15e) *ðzpaγil*. However, in pronunciation the fricative does in fact appear to agree in voicing with the following stop, as illustrated in Figure 1, which shows the pronunciation of (15e) by Mher Hedeshian, a native speaker of Western Armenian. This analysis was done on a Kay Elemetrics Computerized Speech Lab, which marks voicing by means of vertical ticks beneath voiced portions of the waveform; the waveform of (15e), transcribed by Bardakjian and Thompson (1977) as *ðzpaγil*, shows no voicing for the fricative portion.[11]

It seems reasonable, then, to conclude that FSOs are partial geminates. This does not itself account for their violation of sonority sequencing constraints, however, since if the root node is the locus of sonority restrictions, they still involve two root nodes of decreasing sonority in onset position. We need a further assumption to allow both members of FSOs to be licensed (that is, linked to a syllable node) in onset position. A reasonable candidate is to assume that segments may be licensed by virtue not only of direct linking to a syllable node, but parasitically by virtue of linking of some portion of the segment to another segment that is itself prosodically licensed:

21. Parasitic Licensing: A segment S@-[i] which is linked to a segment S@-[j] is prosodically licensed if S@-[j] is itself prosodically licensed.

Thus a segment which is not itself a member of a syllable, and is prevented by sonority constraints from linking to an existing syllable node may itself escape deletion so long as it shares melodic material with a segment that is itself prosodically licensed.[12] If all speakers of a language, even those whose native language allows no tautosyllabic consonant clusters, are aware of the universal constraints on sonority sequencing, and the necessity for prosodic licensing, they will presumably be led to analyze fricative-stop onsets as linked structures, and will resist breaking them up by epenthesis.

Once again, this account is vulnerable to two objections. First, the parasitic licensing condition is probably too strong. It leads us to expect, for example, that English should allow nasal-stop sequences in syllable-initial position; sonority restrictions prevent the nasal from being licensed directly by the syllable containing the stop, but since nasals generally share place features with a following stop, the nasal could presumably be parasitically licensed. Second, this analysis requires a laryngeal node to be shared by fricatives and voiceless stops in English. But, as argued by Lombardi (1991), Cho (1991), there is strong evidence that laryngeal features are privative, and that a voiceless unaspirated segment has no laryngeal features and therefore no laryngeal node. If this argument is correct, there is nothing for the fricative and the stop in English FSOs to share.

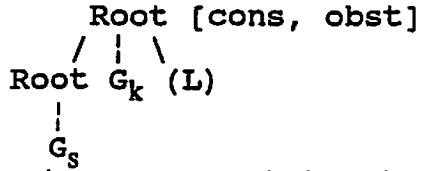
I conclude then, that the full range of behavior of FSOs, including the prothesis/epenthesis pattern, is not fully explained by any of the analyses considered so far: that these sequences as single segments (analogous to affricates), segments distributed among two prosodic units, or partial geminates. The following

section outlines the analysis of FSOs as a derived segment type that is at one level monosegmental, at another level bisegmental. I argue that this analysis is consistent both with the foreign language cluster simplification facts and with the behavior of these onsets in native languages.

2. Adjunction Analysis of FSOs

In this section I argue for the following representation of fricative-stop onsets:[13]

22. Adjunction Structures



G (gesture) indicates specifications for stricture and place (I ignore for the moment the question of the precise geometry of these features), while L indicates laryngeal features (which I assume, following Lombardi 1991, are absent in voiceless, unaspirated segments). This structure is derived by language-specific rules of adjunction, which may target particular segment types as undergoing adjunction rules. Since, as discussed above, both fricative-stop onsets involve a single set of laryngeal specifications, I assume that adjunction structures are universally restricted to a single L node. In this representation, fricative-stop onsets are seen as in some sense single segments, since a single root node dominates the entire complex of features in the sequence. In another sense, these segments are bisegmental, since the structure contains not just the dominant root node but also a subordinate root node. In section 2.1 I consider the fit between this representation and the characteristics of FSOs discussed above. Section 2.2 places this structure within a more general theory of segment structure, presenting arguments that complex segments of the Bantu type *tkw, skw* should also be considered a adjunction structures. Section 2.3. considers arguments for extending this representation to other sequences of obstruent articulations.

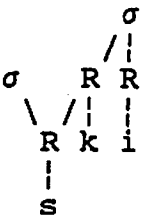
2.1. Adjunction Structures and FSOs

Examination of FSOs in various first language grammars as well as their simplification in foreign languages has revealed the following characteristics:

1. Sonority sequencing violations.
2. Unitary behavior in (some) reduplication, alliteration.
3. Susceptibility to simplification.
4. Greater deletability of the fricative.
5. Preference for adjacency of fricative and stop (prothesis/epenthesis pattern).

The structure in (22) is consistent both with the ability of these sequences to violate sonority sequencing and to pattern with single segments in some--but not all--languages. Languages may differ in whether they permit the adjunction of one root to another

root node; those that do not will require that each root node be independently incorporated in some prosodic unit, and will therefore not allow FSOs. The prothesis/epenthesis pattern is consistent with the assumption that speakers recognize that the only structure that makes a FSO possible is an adjunction structure; for example, an Egyptian hearing English *ski* recognizes that English *sk* must have the structure in (22). Egyptian Arabic does not, however, allow two root nodes, even in a relation of dominance/subordination, to attach to a single syllable in onset position. The solution that permits an Egyptian speaker to syllabify a word like *ski* while both preserving the recognized connection between the fricative and stop and conforming to Egyptian constraints on onset content is prothesis:

23. a.  => b. 

A syllable node is interpolated to license the *s* root, but the connection of this root to the root node dominating the *k* prevents insertion of a vowel between *s* and *k*. Language that do not permit *s* in coda position do not, of course, have this option, and simply split off the subordinate root node.

The difference between Egyptian Arabic and English that allows the latter but not the former to tolerate FSOs, then, is a difference in licensing restrictions. This difference may be represented in terms of the following parameter:

24. Licensing (preliminary): Each root node must be directly dominated by a prosodic constituent (that is, parasitic licensing of root nodes is not permitted): (yes/no)

A language that does not permit parasitic licensing requires that each root node, even one dominated by another root node which is itself licensed, must itself be part of a syllable. Armenian provides the case of a language that apparently permits fricative-stop adjunction but still requires independent licensing of each root node; the derivation of the prothesis cases in Armenian parallels the derivation in (23).

A language that allows surface FSOs (and thus presumably allows parasitic licensing) may still require simplification of the onsets in certain environments, as shown in the case of Sanskrit reduplication (*tan-stan*). Since onset sequences of all types are simplified to a single onset consonant under reduplication, we may assume, following McCarthy and Prince (1986), that the reduplicative prefix in this language consists of a 'core syllable', one in which the onset dominates no more than a single root. However, the requirement that core syllables dominate a single root node which itself dominates only melodic material (that is, no parasitically licensed roots) cannot be universal. The contrast between Sanskrit *tan-stan/kan-i-krand* and Gothic *stai-staut/gai-graut* discussed in section 1 shows that even languages

that simplify rising sonority clusters need not simplify FSOs. We can ascribe the contrast between Sanskrit and Gothic to a difference in the licensing restrictions on core syllables in the two languages.[14] While both languages presumably permit parasitic licensing in syllables, Sanskrit restricts the onset position of core syllables to a single root node. A revised version of (24) reflects the possibilities:

24. Licensing Parameter (revised):
Each root node must be directly dominated by a prosodic constituent:
  a. in all syllables: Egyptian Arabic, Armenian, Telugu, etc.
  b. in core syllables only: Sanskrit
  c. in no syllables: English, Gothic, etc.

The simplification pattern seen in Telugu borrowings results from the choice of the (a) setting of this parameter; Telugu, unlike Arabic, chooses deletion of the subordinate constituent rather than vowel insertion, to fulfill licensing requirements.

The availability of the adjunction analysis suggests a solution to another puzzle concerning fricative-stop sequences. Padgett (1991) analyzes the complex articulations of Kabardian, often called 'harmonic clusters' as single segments; again, these sequences behave like single segments with respect to syllabification. However, one class of harmonic clusters is problematic: those consisting of or containing a coronal fricative-stop sequences. Where the phonetic ordering of place articulations in all other harmonic clusters is predictable, with articulations proceeding from the front to the back of the vocal tract, only fricative-stop sequences may violate this generalization (for example, *št*). These sequences can be distinguished from the other multiply articulated segments in Kabardian, those with predictable ordering of articulations, if they are analyzed as adjunction structures rather than true single complex segments.

2.2. FSOs and Other Segment Types

One of Sagey's (1986) major for the monosegmental status of complex segments involves their occurrence in syllable onset position in languages where less highly marked onset sequences (such as stop followed by liquid) do not occur, and are modified by vowel insertion when introduced via borrowings:

25. Kinyarwanda
  a. tkwaaŋga 'we hate'
  b. perezida 'president'

The stop-(labialized) stop onset, if a single segment, is immune to constraints on sonority sequencing. A similar argument can be made for a monosegmental analysis of fricative-stop onsets. However, I have argued that FSOs cannot universally be analyzed as purely monosegmental; correspondingly, Maddieson (1983, 1989) argues that sequences such as Shona *tkw, skw* exhibit various phonetic properties of segment sequences. This suggests that complex segments of this type should be analyzed as well as adjunction structures, consisting of a dominant, host articulation and an adjoined, parasitic articulation. This account has several

advantages over a simple monosegmental account. First, segments of the *tkw, skw* type are in fact derived from the coalescence of two segments (consonant plus vowel), rather than basic. Second, as Sagey (1986, 1988) shows convincingly, all the articulator nodes in such segments are not equal; phonological evidence reveals major vs. minor articulations, a relationship that is difficult to represent in Sagey's geometry in which all articulator nodes are dominated by a single place node. Furthermore, as Padgett (1991) demonstrates, articulator nodes in multiply articulated segments may require non-redundant independent specifications for stricture. The representation in (22) (or its mirror image) overcomes these problems: it distinguishes a dominant root node (equivalent to Sagey's major articulator) from subordinate root nodes (minor articulators), and each root node receives its own set of place and stricture features.[15] Yet, since the structure allows attachment of the laryngeal node only to the dominant root node, it allows only one set of laryngeal specifications, a restriction that appears appropriate for the Bantu complex segments. The presence of two root nodes permits, for example, a vocalic articulation subordinate to a consonantal articulation, as seems appropriate for the representation of labialization, for example.

It seems likely, then, that the adjunction analysis should be extended to include sequences of obstruent articulations which pattern, with respect to syllabification, with single segments. Possible adjunction structures would then include stop-stop as well as fricative-stop articulations. In the next section I examine potential arguments for additional adjunction structures.

2.3. Further Consequences of the Adjunction Analysis

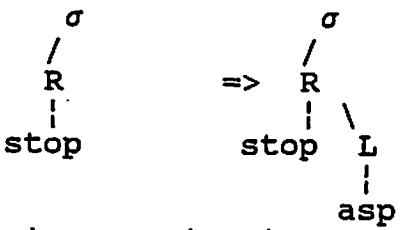
2.3.1. English Syllable Structure

A longstanding problem in English phonology has been to account for the distribution of aspiration. While medial voiceless stops tend to be aspirated before a stressed vowel, stops following *s* are never aspirated, even in environments where they should normally be aspirated (compare *t* in *distress/detest; astor/alter*. Perhaps the most thorough recent account of aspiration in English, Kahn 1976, treats aspiration as a rule conditioned by syllable structure: voiceless stops are aspirated when syllable-initial. Kahn assumes that syllabification proceeds according to the principle that onsets are maximized, and because *s*-stop is a possible initial cluster, a stop following *s* will never be syllable-initial. Hence the contrast between *astor*, with an unaspirated *t*, and *alter*, with aspirated *t*: the syllable boundary falls before the stop in the *alter*, because *lt* is not a possible onset. Thus this analysis predicts that in medial clusters of consonant followed by voiceless stop, the stop should be aspirated if and only if the cluster is not a possible onset.

However, the correlation between aspiration and word-initial occurrence in consonant-stop clusters is not perfect. If we compare *alter, astor* and *after*, we find that the *t* in *after*, like the one in *astor*, is also unaspirated. Kahn notes this fact, and is compelled to modify his syllabification rules to handle it:

instead of allowing as complex onsets only those sequences that are possible word-initially in the language, he posits an additional rule that creates complex onsets just when these are of a type that is "universally less marked" (where this is left undefined; this rule joins *f* in *after* to the second syllable. The prediction of this analysis--that the set of possible word-initial clusters is a subset of the set of possible word-medial onset clusters--runs directly counter to most recent work in phonology. We can get rid remove the need for this ad hoc syllabification, however, by assuming that while fricative-stop adjunction is restricted in the lexical phonology to *s*-stop clusters, it may apply post-lexically to any fricative-stop sequence. The constraint that association lines must be interpreted as exhaustive (Hayes 1986) would then prevent aspiration from applying to *ft*, as well as to *st*, assuming the following statement of aspiration (ignoring the position of place features):

25. Aspiration



This rule assigns aspiration to a segment specified as a stop but with no laryngeal specifications. A stop that had undergone adjunction would not meet the structural description of this rule:

26.

A further generalization of adjunction may also be motivated by additional aspiration facts. Kahn notes some additional problems for his analysis of aspiration as a syllable-initial phenomenon: the contrast between, for example, *napkin* with unaspirated *k*, and *bodkin*, with aspirated *k*. Here neither medial cluster is an unmarked word-initial cluster; instead, the relevant correlation is between agreement of voicing in the stop-stop cluster and aspiration of the second member of the cluster. Kahn is forced to motivate another ad hoc rule adjusting syllable boundaries to account for these facts, but again, the assumption that the stops share their larygeal features in the first word will block the application of aspiration to the laryngeal tier of only the second consonant. If, however, post-lexical adjunction may apply to two voiceless stops, aspiration would be prevented from applying to the adjoined structure in *napkin*.

The possibility of the adjunction of any sequence of obstruents, along with the requirement that adjunction sequences may contain only one laryngeal specification, suggests an analysis

of voicing assimilation in English obstruent clusters which at this point I merely offer as speculation. It is well-known that tautosyllabic obstruent clusters must agree in voicing in English. The apparent assimilation of obstruent suffixes such as the plural and past tense to stem-final consonants in English is a problem for a theory in which voicing is a privative feature, since both voiced and voiceless obstruents appear to spread their voicing specification to a following obstruent suffix. Mester and Ito (1989) have argued that voicing assimilation should be viewed as the product of a constraint requiring voicing in obstruent clusters, rather than a rule spreading laryngeal features. We might take this further by viewing the constraint as prohibiting sequences of obstruents at surface level in English--all obstruent sequences must be merged into adjoined structures. We would then expect to find that those cases in which epenthesis takes place between stem and suffix correspond to cases in which adjunction is universally ruled out; for example, since English requires epenthesis rather than adjunction in the sequence *č+s* (*e.g. matches*), we would expect not to find evidence for an adjoined structure of the form *čs* in any language. Exploration of this topic is beyond the scope of this paper.

2.3.2. Attic Greek

Another area in which fricatives and stops may appear in violation of otherwise regular syllable structure constraints is the coda of Attic Greek syllables. As Steriade (1982) demonstrates, stops are normally not permitted in Attic codas; thus the vocative of 'milk', which has no suffix, is realized with deletion of the final lexical stops, which, because unsyllabifiable, are deleted by Stray Erasure:

27. a. galakt -> gala 'milk (VOC)'
    b. t^{h}oraks 'thorax'

However, a final stop is retained just in case it is followed by *s*, as in (27b). Steriade shows that stops in final stop-*s* clusters invariably have the same laryngeal specifications as the following *s*. She therefore describes the coda facts as follows:

28. Steriade 1982: a stop can be linked to the coda only if it is linked to a following segment which is in the word template (= final *s*)

In our terms, the stop may be adjoined to the *s*; since the specification of the dominant root node with then be [continuant], the adjunction segment can escape the prohibition on coda stops.[16]

2.3.2. Other Peculiarities of *S*-Stop Clusters

S-stop clusters also differ from other clusters in being particularly subject to metathesis. Fromkin (1971) found that cases of consonant transposition involve two consonants that occupy the same position in a syllable: for example, *mazagine* 'magazine', where two onset consonants have been transposed, but not *atler* 'alter', where a coda and an onset have been transposed. The only two exceptions to this generalization in her corpus involved *s*-stop sequences: *whipser* for 'whisper' and *aks* for 'ask'. The latter is

also of course a common pronunciation in various dialects, and the history of English reveals much dialect variation in the order of *s*-stop sequences; Campbell (1959) gives alternants *waps/wasp*, and so forth. Under the adjunction analysis, the two root components, because they appear on separate tiers, are not directly ordered, so some variability in their ordering is not surprising.

3. Summary

The Sonority Sequencing Generalization receives support not only from the tendency of most tautosyllabic clusters to obey it, but also from the widespread aberrant behavior patterns of the clusters that violate it. This paper has presented evidence from various sources, most notably second language syllable simplification, that aberrant sonority onsets tend to pattern differently from onsets of rising sonority. I have suggested that onsets that violate sonority restrictions do so by virtue of their structure as adjoined segments--that these onsets are in fact monosegmental, though of a segment type more complex than true single segments. I have also argued that language learners, guided by universal principles of language, recognize the structure of FSOs and in many cases tailor their simplification strategies to this structure.

Notes

1. This work was supported by NSF grant BNS-8617876 to the author and Daniel Finer. Earlier versions have been presented at the University of Delaware, The New York Academy of Sciences, Middlebury College, the University of Texas at Austin, and at the Conference on the Organization of Phonological Features at the University of California at Santa Cruz, July 1991. I gratefully acknowledge the comments and suggestions of the audiences of those presentations as well as those of the many others with whom I have discussed the ideas contained herein, most notably Daniel Finer and Lisa Selkirk.

2. For earliest references, see Sievers (1881), Jespersen (1904), de Saussure (1916). Ewen (1982) and Clements (1988) provide comprehensive and illuminating discussions of various proposals concerning sonority.

3. Below we will see evidence that stop-fricative onsets pattern with obstruent-sonorant onsets, while fricative-fricative onsets pattern with *s*-stop onsets, supporting the assignment of different sonority values to stops and fricatives. See also Broselow and Finer (to appear) for experimental data supporting the subdivision of obstruents by voicing and continuancy.

4. I found identical patterns in all cases in which data was available both from the errors of language learners and from the pronunciation of nativized loanwords.

5. Karimi (1987) argues that in Farsi, any *s*-initial cluster, regardless of relative sonority, undergoes prothesis, while clusters beginning in consonants other than *s* undergo epenthesis. A similar pattern may hold for Spanish as well, though since Spanish does permit a wide range of clusters other than *s*-initial ones, it is difficult to find conclusive evidence that does not simply prothesize before all illegal cluster types. Assuming that both Spanish and Farsi do distinguish *s*-initial from other clusters, the evidence to follow establishes that this is clearly the minority pattern.

6. Note that although *pf* is a (monosegmental) affricate in German, the bisegmental analysis apparently assumed by the Hindi speakers is consistent with the SSG, given the relative sonority values of its two elements; in contrast, Egyptian speakers apparently maintain the monosegmental analysis of the initial affricate in *children*, even though this affricate is not a phoneme of Egyptian arabic. It should also be noted that Singh gives one fricative-fricative onset (*sphere*), which undergoes prothesis rather than epenthesis. Under the adjunction analysis presented in section 2, we can assume that Hindi speakers assume that English allows adjunction of *s* to certain fricatives as well as to stops,

rendering the fricative-stop and the fricative-fricative onset structurally similar.

7.I am grateful to Jong-Seong Lim for bringing the Central Pahari facts to my attention.

8. This cannot be ascribed to any restrictions on possible syllable onsets or codas; see *sðxal* 'mistake' for onset *s* and *tark-ma-nič* 'interpreter' for coda *k*.

9. Note however that since an onset sequence stop-fricative is consistent with general sonority sequencing restrictions, we might expect a bisegmental analysis of such a sequence in onset position to be available to language learners; the Hindi speakers' rendering of *Pfizer* as *pðfaizðr* suggests such an analysis.

10. This would be consistent with the difference in the quality of the prothetic vs. the epenthetic vowels in some (but by no means all) of the languages discussed.

11. Armenian does differ from English in that voiceless stops are always aspirated--even, apparently, after fricatives. Presumably the glottal gesture characteristic to the stops is compatible with the articulation of Armenian *s*.

12. Another way to interpret this restriction of the province of Stray Erasure is simply to conceive of Stray Erasure as blocked by the Geminate Constraint (Hayes 1986).

13. Van der Hulst (1991) also proposes an adjunction structure of these onsets, though his account differs from the one proposed here in certain respects.

14. Steriade (1988) offers an alternative analysis of the Sanskrit/Gothic dichotomy in terms of the constituent to which the reduplicative affix is prefixed. Since adjunction may apply on different domains in different languages, such an account might also be compatible with an adjunction analysis; in Sanskrit, attachment of the reduplicative template to the stem would precede the word-level adjunction rule. I have tried here, however, to relate the reduplication patterns to the range of FSO facts.

15. I ignore the question of the relationship among place and stricture features; see Padgett (1991) for arguments that place dominates stricture, and see Chen (1991) for arguments for the reverse relationship.

16. One question still unanswered in this investigation is why *s* so often has a privileged status; in the terms presented here, if only one fricative is singled out to undergo adjunction to a stop, it is the coronal fricative. Unfortunately, I do not have an answer to this question, though it seems likely that it is connected to the

status of anterior coronals as the least marked articulation.

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