On the representation of the affricate

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Part One. The representation of the affricate

0. Introduction

Affricates are segments which consist, on the surface, of a sequence of a stop and a fricative. However, they exhibit the phonological behavior of single segments, rather than of consonant clusters. Thus, their representation and their behavior in phonological processes has long been a matter of interest.

Previous analyses have included the ordering of the stop and fricative portions of the affricate as part of the underlying representation. Campbell(1974) proposes to treat the affricate as a single segment consisting of an ordered sequence of two complete distinctive feature matrices. In an autosegmental framework, Sagey (1986) represents the affricate as a segment with two ordered values of the feature [continuant].

However, if the underlying order is stipulated in this way, one would expect that ordering of [continuant] in single segments would be contrastive. Underlying representations need to contain only what is not

predictable. If affricates always consist of the equivalent of two segments in the order [-cont][+cont], then that ordering is predictable, and need not be specified in underlying representation. If the ordering is contrastive - that is, if there are also single segments of the type [+cont][-cont], then order will of course need to be underlyingly specified, since it is not predictable. It follows that the ordered representation, which I will refer to as the contour segment analysis, predicts that "backwards" affricates, segments with the order [+cont] [-cont], should exist. This is an incorrect prediction, as no language has a single segment [st], for example, the reverse of the affricate [c].[1]

In this paper I will attempt to show that there is no need to stipulate the order of the values of [continuant] in the underlying representation of the affricate. This hypothesis will eliminate the incorrect prediction made by the contour segment analysis that backwards affricates should exist. This representation will also allow an account of the phonological processes that affricates are known to participate in.

To begin I will review the facts about the status of the affricate as a single segment, and I will discuss previous attempts to represent it and the problems with these representations. I will examine the data which has been used to argue for an underlying ordering of two values of [cont], and show that it does not really support such an ordering. I will also examine the data which is a problem for the ordered representation and show that it is handled much more easily by the proposed unordered representation.

I. The Affricate is One Segment

Superficially, affricates look like a cluster of a stop and a fricative. However, closer examination reveals that they must be single segments.

1. Affricates contrast with stops and with fricatives in many languages. For example, many languages have a coronal stop, fricative and affricate [t,s,c]. However, this is not an argument for segmenthood in itself, since a cluster of a stop and fricative would also contrast with the stop and the fricative; for example, English ton, sun, stun. More important, then, is the

fact that in some languages affricates also contrast with clusters. For example, in Polish, the cluster [tš] contrasts with the affricate [č] (Campbell 1974):

(1) trzy [tšɨ] "three"
czy [čɨ] "whether"

2. Affricates pattern with single segments in syllabification. For example, in Chipewyan (discussed in greater detail below), syllables can have only one consonant in the onset; that consonant can be an affricate. If the affricate were a cluster, it would not be able to appear as the onset of a syllable, since intial consonant clusters are impossible.

3. Affricates spread as units. In Hebrew templatic morphology, for example, in the root /kc/, "cut", the affricate /c/ must spread to fill two consonant positions in some morphemes. It spreads as a unit, and does not break up into its component stop and fricative.

(2) [kicec] "he cut"
*[kites]

Thus /kc/ acts like a two-consonant root, like /hl/, rather than a three-consonant root like /šbr/:

(3) [šiber] "he broke"
[hilel] "he praised"

4. Affricates are treated as single segments by processes of reduplication. For instance, reduplication in Ewe (Ansre (1963)) copies only the first C if there is a consonant cluster in the root:

(4)	fo	fofo	"beat"
	si	sisi	"escape"
	fle	fefle	"buy"

Affricates are treated as single consonants:

(5)	ci	cici	"grow"
		*tici	
	dzra	dzadzra	"sell"
		*dadzra	

In Arabic, there are roots which consist of a reduplicated two-consonant sequences. The reduplicated root usually has an onomatopoeic iterative or

intensified meaning, and is sometimes related to a non-reduplicated root. Examples are given in (6). This reduplication is possible if one of the consonants is an affricate, as in the examples in (7). A three-consonant root can never have this reduplicated form: *ktbktb, for instance, would be impossible. Thus the affricate is behaving like a single segment; if it were two segments, the examples in (7) would not be possible.

(6)	ʈnʈn	
	ʈn	"ring"
	dndn	
	dn	"buzz"
	kƀkƀ	
	kƀ	"cough"
	kbkb	
	kb	"topple"
	zqzq	
	zq	"feed young (bird)"
(7)	jrjr	"to gargle, drag"
	jr	"drag, pull"
	rjrj	"tremble"
	rj	"shake"
	9j9j	"bellow, roar"
	9j	"yell"
	ljlj	"repeat words in speaking"
	j9j9	"to roar; a hubbub"
	jljl	"reverberate"
	jmjm	"stammer"

5. Epenthesis and metathesis do not break up affricates. For example, in Hebrew (Bolozky (1980)), there is a distinction between the cluster [ts] and the affricate [c]. Hebrew consonant clusters can be broken up by schwa in very careful speech:

(8)	/qraav/	[qəraav]	"battle"
	/ktiiv/	[kətiiv]	"spelling"
	/tsumet lev/	[təsumet lev]	"attention"

However, the affricates can never be broken up in this way.

(9)	/cilum/	*[təsilum]	"photograph"
	/carix/	*[təsarix]	"need (m. sg)"

Bolozky also discusses a process of metathesis in Hebrew which affects prefix-final /t/ and a stem-

initial coronal. This process treats affricates as single segments also. The /t/ and the entire affricate metathesize, not /t/ and the first part of the affricate.

(10) /hit+sarek/ [histarek] "he combed his hair"

/hit+calem/ [hictalem] "he had his picture taken"

*[hittsalem]

6. There are phonological processes which derive affricates from single segments. For example, palatalization before front vowels in Asanti (Campbell (1974); Schachter and Fromkin (1968)) turns velar stops into affricates:

(11) k -> tç I
g j / ____ E

(12) /kɛ/ -> [tçɛ] "divide"
/ge/ -> [je] "receive"

This is additional evidence for the segmenthood of the affricate, because phonological processes do not usually turn single segments into clusters. Single segments can spread to form geminate consonants or long vowels, but this is a different sort of process. Rules do not turn a consonant into a cluster of two different consonants.

7. Geminate affricates are not realized as two stop-fricative sequences, *[tsts], but as a long affricate: [ttss], [tts], or [tss]. Thus they are behaving like any single consonant which is geminated.

8. Language games treat affricates as single segments. For instance, there is a language game in Hebrew which inserts an infix into each syllable consisting of [b] and a copy of the vowel.

(13) tirgem -> tibir gebem "he translated"

Consonant clusters are broken up into separate syllables in one dialect of this game, inserting [ə] as the vowel:

(14) a. šmuel -> šəbə mubu ebel
(proper name)
b. tsumet lev -> təbə subu mebet lebev
"attention"
c. tsaper -> təbə saba peber

However, though the cluster [ts] is broken up, the affricate [c] is not:

(15) a. cilum -> cibi lubum "photograph"
b. kicec -> kibi cebec "he cut"

9. The two parts of an affricate must share place. This distinguishes them from clusters. If anything, tautosyllabic clusters have a bias against sharing place. For example, English allows stop-liquid clusters [kl, kr, gr, gl, bl, pl]. However, it prohibits some homorganic stop-liquid clusters: *[tl, dl]. ([dr, tr] are possible, however, so the prohibition is not absolute.)

10. Affricates have a coronal bias. This can be demonstrated by an examination of the lists of phoneme inventories in Maddieson (1984). There are 551 instances of coronal affricates in the languages analyzed, excluding sounds which are listed as rare or obscure in a given language. There are only 7 instances of velar affricates, which occur in only 5 languages.[2] Consonant clusters probably have no such bias, aside from the fact that all languages have coronal consonants and thus are likely to have coronal clusters if clusters are allowed.

Additional evidence for the segmenthood of the affricate comes from examination of the properties of affricates compared to clusters within a language. For example, Chipewyan, an Athapaskan language with a unusual number of affricates, exemplifies several of the points outlined above.

(16)

	voiceless stops and affricates			fricatives	
	unasp.	asp.	glottalized	-voice	+voice
labial	b				
dental	d	t	t'		
velar	g	k	k'	x	ɣ
labiovelar	gw	kw	k'w	xw	ɣw
interdental	dδ	tθ	t'θ	θ	δ
dental	dz	ts	t's	s	z
palatoalv.	dj	tc	t'c	c	y
lateral	dl	tl	t'l	l	l
glottal	?				h

The affricates all look like combinations of consonants that occur in the language as single segments. However, there are a number of reasons why they cannot be considered to be consonant clusters.

1. There are no other tautosyllabic consonant clusters in the language. If the affricates are single segments, this language can be described as having only two possible syllable types, CV and CVC. Note that if these are clusters, they are all clusters made up of a coronal stop and a fricative. Thus, if the hypothesis of Minimal Sonority Distance (Selkirk 1984) is correct, the language should also have all the clusters which are farther apart on the scale than stop-fricative. So for example, we should find stop-nasal clusters. But these do not occur.

2. The affricates are all composed of two elements which are at the same point of articulation. If they were clusters, we would have to stipulate that consonant clusters in this language can only be made up of two elements which have the same point of articulation. This would be a very unusual (possibly unknown) restriction on tautosyllabic clusters; on the other hand, this is a requirement for affricates.

3. There is an affricate corresponding to every coronal fricative. This is reasonable whether they are clusters or single segments. If the language has stop-fricative clusters, one would expect such clusters with all of the fricatives. If the affricates are single segments, then it is reasonable for the language to have all the types of articulation that it has at all the points of articulation that it has. But note that Chipewyan has velar fricatives as well, but no

velar affricates. If the language has stop-fricative clusters but does not have velar clusters, this is just an odd stipulation. But as for affricates, coronal affricates are vastly more common than velar affricates in the world's languages. So if affricates are single segments in Chipewyan, it would be unsurprising that we have no velar affricates, whereas if they were consonant clusters, the absence of velar clusters would be unusual.

II. Previous Analyses

i. Jakobson, Fant and Halle (1951) treat affricates as basically stops with the addition of the feature [+strident]. However, there are affricates which are not strident, such as Chipewyan [tθ], as Chomsky and Halle (1968) point out.

ii. Chomsky and Halle (1968) analyze the affricate as basically a stop with an additional feature of [delayed release]. Thus, stops and affricates are [-cont], and fricatives are [+cont]. The problem with this analysis is that affricates do undergo processes which apply to [+cont] segments: that is, there are processes which apply to both fricatives and affricates. Since affricates have no [+cont] feature in this system, it cannot explain the fact that affricates sometimes pattern with fricatives, as well as sometimes patterning with stops.

For example, consider English pluralization, a process in which affricates pattern with fricatives. Words which end in stops take the ending [s] or [z], depending on the voicing of the stop. Words which end in fricatives take [əz] as the ending. Affricates pattern with the fricatives in this case, in that they take the ending [əz]. If the affricate is analyzed as basically a stop with an additional feature of [del rel], this will not explain the fact that it patterns with the fricatives, since they do not share any features (fricatives are unspecified for [del rel].)

As mentioned in section I, affricates have a coronal bias. Fricatives also have a coronal bias. For example, Maddieson (1984) states that 261 out of 317 languages in the UPSID database have some kind of /s/, and that the three most common places of articulation for fricatives are dental/alveolar, labio-dental and palatoalveolar. Thus, this is another way in which affricates pattern with fricatives. If affricates were

represented as specified [+cont], one could simply say that [+cont] segments have a coronal bias.

Affricates also sometimes pattern with stops. For example, consider the process known as the Gorgia Toscana which occurs in some Italian dialects. This rule occurs intervocalically and affects stops and affricates. (Izzo 1972, Lepschy 1977). The stop [k] becomes [h], and affricates become the homorganic fricative.

(17)

Italian	Tuscan dialect	
amiko	amiho	"friend"
fwoko	foho	"fire"
paǰe	paǰe	"peace"
noči	noǰi	"nuts"

A similar process occurs in Yucatec Maya (Straight (1976)): Stops become [h] before homorganic stops and affricates; affricates become fricatives before homorganic stops and affricates. In other words, stops appear to lose everything but their laryngeal node, and affricates lose their entire stop portion.

(18)

a. taaŋ k pak'ik k kool -> taaŋ k pak'ik h kool
"we're planting our clearing"

b. le? iŋ w otǰo -> le? iŋ w ohǰo
"that house of mine/my house there"

c. tun kolik k'aaš -> tun kolih k'aaš
"he's clearing bush"

d. ?uc t iŋ w iǰ -> ?us t iŋ w iǰ
"I like it (lit., "goodness is at my eye.")

e. c'u ho?oǰ tik -> c'u ho?oš tik
"he scratched it"

("Homorganic" in this rule refers only to the major articulator features. Two coronal sounds are homorganic, regardless of whether one of them is also anterior.)

A similar process also occurs in Basque; I will discuss the Basque case and propose an analysis for these phenomena in Section IV.

Another type of process that gives evidence that affricates have both values of [cont] is that of merger

to form affricates. An example of this is the process traditionally called the D-Effect in Chipewyan.

The verbs of Chipewyan are divided into four classes according to whether they possess a zero, d, l, or ɬ, immediately before the stem. Since there are no syllable-initial consonant clusters in this language, something must happen when d comes before a stem beginning with a consonant. Generally the d or the initial consonant drops out, but d and the initial remain when the initial is θ, z, j, ɬ. These are the combinations which are the affricates of Chipewyan.

(19) na-hɛ-s-d-zus -> na.hɛs.dzus
"I slide down customarily, one time after another"

In this case, the [d] remains because it can fuse with [z] to form an affricate.

(20) cɛ-ɾe-s-d-ti -> cɛ.yes.ti
"I have eaten" (medio-passive, meaning 'to handle food to one's self')

In this example the [d] drops. Since consonant clusters are impossible, and the combination [dt] does NOT make an affricate, it cannot be syllabified.

The same process of fusion occurs when [d] is prefixed to a stem beginning in [?]. The features of the two segments can merge to form a glottalized consonant, which is a possible segment of the language.

(21) a. na-na-s-d-?a -> nas.t'a
"I own it again (a round solid object)"

b. nɛ-ɾɛ-d-?a -> nɛ.ɾe.t'a
"One is fooled"

Fusion can form a glottalized consonant or an affricate. In both cases, it appears that if the combination of all of the features of the two sounds form a possible segment of the language, the fusion is possible. The combination of the features for glottal stop and for a consonant yields a glottalized consonant. The combination of the features of a stop, which is [-cont], and a fricative, which is [+cont], forms an affricate, which has both values of [cont].

It is clear, then, that it is not possible to treat the

affricate as a stop with some special feature, or as a fricative with some special feature. It acts in various ways like a combination of the two.

iii. Clements and Keyser (1983) represent affricates in an autosegemental theory as a stop and a fricative linked to one skeletal position.

(22)

```
affricate c:  C          cluster ts:  C C
             /\                       | |
            t  s                      t s
```

This representation makes the affricate a single unit skeletally, but not a single element melodically, since both parts of the affricate are separate feature bundles. This representation solves some of the problems of the SPE-type analysis. The affricate will have both values of [cont], as I have shown is necesary.

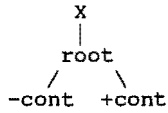
However, in this representation there is no connection between the melodic material of the two segments. This makes the incorrect prediction that there will be affricates which consist of a stop and a fricative at different places of articulation; such segments do not exist. In fact, the two parts of the affricate could differ in any feature at all, but this does not occur. Furthermore, affricates behave as single units melodically in many ways as shown above - for example, the fact that they spread as units in languages with templatic morphology (McCarthy and Prince 1986), such as Hebrew.

Campbell (1974) proposes a similar representation in a non-autosegmental framework. He proposes that the affricate is a single segment which consists of two ordered columns of distinctive feature matrices. Again, in this representation there is no necessary connection between the features of the two parts of the affricate; the fact that the two parts must share all features aside from the value of [cont] is unexplained, and impossible segments are predicted.[3]

III.1 <u>The underlying representation of Affricates</u>

Sagey (1986) represents the affricate as a single segment with two ordered values of [cont]:

(23)



This representation is proposed in order to account for rules which show "edge effects:" that is, rules in which affricates behave as stops with regard to rules sensitive to their left edges, and as fricatives with regard to rules sensitive to their right edges. For example, the English plural rule adds /z/ to the end of a word. If the word ends in a strident [+cont] segment, schwa must be inserted. Because the rule sees the [+cont] edge of the affricate, it will insert schwa after fricatives and after affricates.

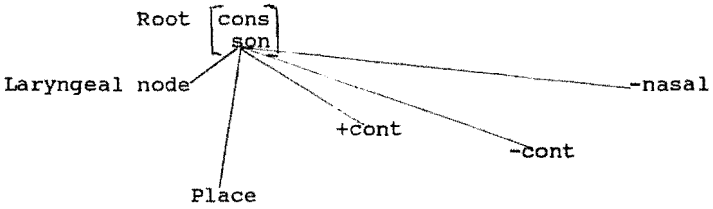
The values of [cont] are ordered, and such a representation is referred to as a contour segment. This is distinguished from a complex segment, such as [kp], which has two places of articulation which have no underlying ordering.

If the values of [cont] are ordered, it is easy to explain edge effects. However, there are also many processes applying to affricates which show the opposite of edge effects: for example, a rule which has its context on the right treats an affricate like a stop, although the [-cont] value is presumed to be on the left (Archangeli and Pulleyblank (1987)).

In addition, this representation makes an incorrect prediction about the type of consonant that can exist. Lexical entries should not contain predictable specifications (Kiparsky (1982); see also McCarthy (in press)). If ordering is stipulated underlyingly, then this means that the ordering should be contrastive. For example, in languages which have contour tones, the values of H and L must be ordered, because the contour tones HL and LH are distinct. This is not the case with affricates; the ordering is never contrastive.

My proposal is that in the underlying representation of the affricate, the values of continuant are not ordered. I will assume that the representation of the affricate is as shown in (24). The values of [cont] are on separate tiers and <u>unordered</u> in underlying representation.

(24)



An alternative possibility is that the two values of [cont] are dominated by an abstract node. This would predict that affricatehood would sometimes assimilate separately from all other features in a segment. This does not seem to happen. However, it is also very difficult to find cases where either value of [cont] spreads, so it is not clear what the absence of spreading of affricatehood means. The case of morpheme structure constraints in Yucatec, which I discuss in section IV.1, suggests that the two values of [cont] are on separate tiers, but the arguments I will give for the values being unordered are independent of whether the values are on separate tiers or dominated by an abstract node.

With this underlying representation, as I will show in more detail in section IV, rules involving affricates which do not show edge effects will be quite simple to analyze. They will be stated as requiring a particular value of [cont]; since the value will be present in the affricate, the rule will apply to it. Since the values of [cont] are not ordered, both values are adjacent to the contexts on either side of the affricate.

Of course the values are ordered eventually, since they are phonetically ordered. Phonetic processes, then, will still be expected to show edge effects.

It should be noted that this paper mainly deals with the behavior of affricates in languages where the affricate is contrastive with both stops and fricatives. In many languages an affricate is found in some places of articulation where you would expect a stop in the consonant system. For example, English does not have an alveopalatal stop, but rather an alveopalatal affricate. In such languages, it is

possible that the affricate is underlyingly underspecified for [+cont], since it does not need the [+cont] feature to make it distinctive from any other [-cont] segment at that place of articulation. More research would be needed in order to determine the status of affricates in such languages.

III.2 Remarks on the feature [continuant]

The existence of affricates shows that the feature [continuant] is different from most other features in that it cannot be privative. If only stops and fricatives existed, a fricative could be a segment which is specified [cont], and a stop could be a segment which lacks a value for [cont]. This is how other features, such as the place features are currently understood. A coronal segment is specified [cor]; a labial is specified [lab], and has no specification for [cor].

However, [cont] cannot work this way. The phonological processes discussed above show that affricates must have the same value of [cont] that stops have, and also the same value of [cont] that fricatives have. If [cont] were a privative feature, we could not represent affricates, because [cont] and the absence of [cont] will be a fricative, and cannot be the representation of an affricate.

Thus, it would seem that we cannot make the feature [cont] consistent with the rest of the feature system by making it privative. However, we could have privative features for these properties, by proposing that there are two privative features, which could be called [stop] and [fricative]. This will make the correct predictions about what types of segments exist; segments which are [stop], which are [fric], and which are [fric] and [stop]. Segments which are not specified for either [stop] or [fric] are also a logical possibility. These will be segments with no place features, since it will be impossible to have articulation at a particular place unless the manner of articulation is specified.

The implication of an equipollent feature is that the two values are opposed, and cannot coexist, but the values of [cont] can coexist. Again, the place features, which are privative, can coexist in complex segments. In this view, then, affricates are a type of complex segment, with respect to manner rather than place.

Privative features are generally presumed to be on separate tiers, and there is no temporal ordering between features on separate tiers. The proposed representation of the affricate, then, is what is predicted if there are two privative features for the values of [cont].

However, none of the arguments I will make depend on the distinction between a equipollent feature and two privative features. I will continue to refer to the feature [cont] in the following discussion.

IV. Phonological processes involving affricates

Two types of phonological rules involving affricates have been distinguished in the literature: rules showing edge effects, and rules showing anti-edge-effects.

Rules showing edge effects are rules which appear to be sensitive to whether the context for the rule is on the [-cont] or [+cont] edge of the affricate. Thus this includes two types of rules:

1. Rules which have their context on the right edge of the affricate, which is the [+cont] edge, and affect [+cont] segments. These rules apply to fricatives and affricates.

2. Rules which have their context on the left edge of the affricate, which is the [-cont] edge, and affect [-cont] segments. These rules apply to stops and affricates. "Affect" and "apply to" can be replaced by "conditioned by," for rules which have affricates in their context.

Rules showing anti-edge-effects are rules which are not sensitive to the edge of the affricate that the context is on. These are rules which see the value of [cont] which is <u>not</u> adjacent to the context of the rule (under the assumption that the values are ordered). So this includes two type of rules, opposite to the edge effect rules:

1. Rules which have their context on the right edge of the affricate, but which are rules that affect [-cont] segments, and apply to both stops and affricates.

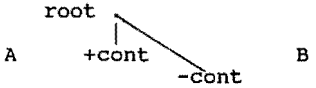
2. Rules which have their context on the left

edge of the affricate, but which are rules that affect [+cont] segments, and apply to both fricatives and affricates.

Processes involving affricates which do not show edge effects are a problem for a theory in which the values of [continuant] are underlyingly ordered. In an attempt to solve this, as well as to address other problems of phonological locality that will not be discussed here, Archangeli and Pulleyblank (1987) introduce the idea that phonological rules can involve either maximal or minimal scansion, which is a parameter set for each rule. Rules involving maximal scansion scan the segment from the level of the skeleton. This means that the rule can see all features of the segment which are below the skeletal level. Thus, such rules will have access to both values of [cont] in an affricate. Rules involving minimal scansion can only see the immediately adjacent value of [cont]. Rules involving minimal scansion will show edge effects; they are only able to see the value of [cont] which is immediately adjacent to the context.

However, processes which show anti-edge effects are quite simple to state if the values of [cont] in the affricate are underlyingly unordered.

(25)



A rule with the context A which applies to [+cont] segments will apply to the affricate, since in this representation, A is adjacent to [+cont]. Likewise, a rule with context B which applies to [-cont] segments will also apply to the affricates.

Some cases of edge effects in the literature are really only apparent edge effects. A rule which has its context on the right side of the affricate and which applies to [+cont] segments may appear to be sensitive to the ordering of the values of [cont]. But like the anti-edge effects, they are rules that can be stated as applying to a segment with a particular value of [cont], which the affricate will have; ordering is not necessary for their analysis. In (25), a rule with context A can also apply to [-cont] segments, and a rule with context B can apply to [+cont] segments.

For example, Sagey (1986) mentions the English plural rule as an example of an edge effect. Assume that the English plural rule inserts schwa between the plural ending and a word-final fricative or affricate. The plural ending, and thus the context of the rule, is on the right edge of the affricate. This is the [+cont] edge of the affricate on the surface, and the rule treats affricates and fricatives in the same way. Thus this appears to be a rule which is sensitive to the right edge of the affricate.

However, if the rule inserting schwa is stated as applying to a [+cont] segment, it will apply to affricates and fricatives, which are both [+cont]. It will not apply to stops, which are not [+cont]. It is irrelevant which edge the context of the rule is on, and ordering of the values of [cont] is not necessary for the statement of the rule.

Thus, in many cases the difference between edge effects and anti-edge-effects is illusory. Rules which operate on underlying representations should never show true edge effects. Phonological rules which apply to [-cont] segments should always apply to both stops and affricates; phonological rules which apply to [+cont] segments should always apply to both fricatives and affricates, always regardless of which side the context for the rule is on.

However, obviously the values of [cont] must be ordered at some point, since they are ordered phonetically. Since the values are ordered phonetically, phonetic processes will be expected to show true edge effects. Some of the edge effects discussed in the literature do not actually seem to be rules of phonology at all, but rules of phonetics, as I will show in section IV.2. Thus they are not counterexamples to the theory I am proposing. My theory predicts that there will never be a distinction between edge effects and anti-edge-effect in <u>phonological</u> processes. Phonetic processes, on the other hand, are predicted to show edge efects.

IV.1 <u>Rules showing anti-edge-effects</u>

a. Yucatec, Basque and Tuscan

The processes in Yucatec Maya and Tuscan Italian discussed above in section II are examples of a rule involving affricates which does not show an edge effect. Although the context for the rule is on the

right-hand side of the affricate - that is, the fricative edge - nevertheless the rule applies to affricates. Basque, as discussed by Archangeli and Pulleyblank (1987) and Hualde (1987), has a rule which deletes stops which immediately precede another stop. This process is basically identical to the rule in Yucatec. They state the Basque rule as:

(26) [-cont, -son] -> ∅ / ___ [-cont]

But in fact when the rule applies to an affricate, the affricate does not delete but rather becomes a fricative.

(27) Basque (from Archangeli and Pulleyblank (1987))
z = [s], s = [ś], x = [š], tz = [c],
ts = [ć], tx = [č]

a. Stop + stop:

/bait naiz/	[bai naiz]	"since I am"
/oroit+men/	[oroimen]	"remembrance"
/guk pitzu/	[gu piztu]	"we light"
/ardiek nituen/	[ardie nituen]	"we had sheep"

b. Affricate + stop:

/hitz+tegi/	[hiztegi]	"dictionary"
/hitz+keta/	[hizketa]	"conversation"
/haritz+mendi/	[harizmendi]	"oak mountain"

c. Contexts where deletion does not occur:

/ipin+tzen/	[ipintzen]	"put (imperfective)"
/eska+tzen/	[eskatzen]	"ask (imp.)"
/ikas+tzen/	[ikasten]	"learn (imp.)"
/az+tzen/	[azten]	"grow (imp.)"

Assuming a representation of affricates with unordered values of [cont], this rule will basically consist of the deletion of the feature [-cont]. This rule will apply to both stops and affricates, because it is a rule which applies to a segment with a [-cont] feature.

Assume that this rule consists of "Delete [-cont]" in the appropriate context. This will turn affricates into fricatives, since an affricate from which only [-cont] is deleted has all of the features of the corresponding fricative, and is a well-formed segment of the language.

Then, what effect does this rule have on stops? When stops lose their [-cont] feature, the segment will have place of articulation features, but no specification

for manner of articulation. This will result in an ill-formed segment. It seems reasonable to assume that it will be impossible to have articulation at a certain point if there is no specification for the manner in which the articulation is carried out. Thus, when the stop loses its manner feature, it will delete, since the remaining features do not constitute a possible segment of the language.

More precisely, the Place (or Supralaryngeal) features are what deletes, as the Mayan case shows. Note that the result of this process in Yucatec and Tuscan differs from Basque:

Basque: stops delete, affricates -> fricatives
Yucatec: stops -> [h], affricates -> fricatives
Italian: velar stops -> [h], affricates -> fricatives[4]

I assume that in all cases, the rule deletes the feature [-cont]. This will cause an affricate to become a fricative, but what will happen to the stops? If [-cont] is deleted from a stop, there is no specification for type of closure, and so it will be articulatorily impossible to realize the place features. However, the remaining laryngeal features are the features of [h]. This [h] will appear on the surface in Yucatec, where syllable-final [h] is possible, and in Tuscan, where the affected segments are syllable-initial. In a language without [h] or without syllable-final [h], however, the result will be deletion of the stop, as in Basque.

b. Turkish

Archangeli and Pulleyblank also discuss Final Devoicing in Turkish, as described in Clements and Keyser (1983). This is a rule which devoices stops and affricates, but not fricatives, in syllable-final position.

(29)

nom.	plural	possessed	
sebep	sebepler	sebebi	"reason"
pabuč	pabučlar	pabuju	"slipper"
*pabuj,	*pabujlar		
deniz	denizler	denizi	"see"
*denis,	*denisler		

Again, this presents a problem for a theory where the values are ordered, because the context is on the right-hand (fricative) side of the affricate, and yet

the affricate acts like the stops. This is another case which Archangeli and Pulleyblank analyze as maximal scansion. However, if the values of [cont] are underlyingly unordered, this rule is simply:

(30) [-cont] -> [-voice] /___#

Since affricates are [-cont], they will undergo this rule.

c. Yucatec Maya Morpheme Structure Constraints

The native Yucatec Maya (Straight (1976)) vocabulary consists mainly of monosyllabic CVC roots. There are several constraints on the cooccurence of consonants in a root. One of these is stated in (31):

(31) If both consonants in a root are [+cont], they must be identical.

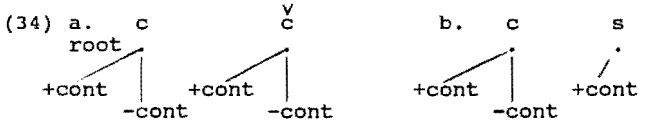
This applies to both affricates and fricatives, which are both [+cont]. (This is a slight oversimplification: glottalized affricates do not obey this constraint. However, I will leave aside this issue, which does not affect the main argument of this section.) Thus, the only possible CVC roots are those given in (32); the roots in (33) do not occur.

(32)	cVc	čVč	sVs	šVš
(33)	cVč	čVc	sVc	šVc
	cVc	čVs	sVč	šVč
	cVš	čVš	sVš	šVs

Vowels and consonants are transparent with respect to one another in these roots, and it can be shown (McCarthy, in press) that they are represented on separate planes. Therefore, the consonants are effectively adjacent in underlying representation. The cooccurence restrictions hold regardless of the order of the consonants in the root; both the order /cs/, where the [+cont] part of the affricate is adjacent to the fricative, and the order /sc/, where the [-cont] part of the affricate is next to the fricative, are ruled out. Thus, this constraint is an example of a condition on affricates which does not show edge effects.

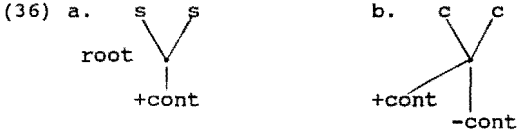
This constraint can be analyzed as the result of two principles (McCarthy (1985); Mester (1986)):

1. The OCP prohibits adjacent specifications of [+cont] in these roots. Thus the representations in (34) are ruled out:

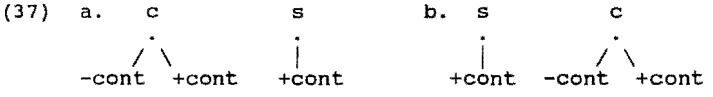


2. The language has a prohibition against a branching [+cont]. Thus the following alternative representations for the roots in (35) are also ruled out:

The only possible roots which have two [+cont] segments, then, are those which have a branching root node, and thus are two identical consonants:



Since this constraint holds regardless of the ordering of the two consonants, the values of [cont] in the affricates must not be ordered. If the values were underlyingly ordered, then only certain orderings of affricates and fricatives would violate the constraints. /cs/ would be ruled out, because the [+cont] part of the affricate is adjacent to the fricative (37a). But /sc/ would not be ruled out, as the values of [+cont] would not be adjacent (37b). This is the incorrect result, since both roots are impossible.



Because this constraint is independent of the order of the consonants in the root, it is likely that any analysis would have a similar problem if the values of [cont] were ordered.

It should also be mentioned that in Yucatec, the alveolar affricate contrasts with an alveolar stop, but there is only an affricate at the palatoalveolar place of articulation - there is no palatoalveolar stop. As mentioned earlier, it is possible that affricates are not specified for [+cont] in languages where they do not contrast with stops, like English. However, the two affricates in Yucatec behave the same in participating in these morpheme structure constraints, and so it appears that the palatoalveolar affricate in this language must be specified for both values of [cont], despite the fact that [+cont] is not strictly needed for distinctiveness in the palatoalveolar affricate. This does not necessarily make any prediction about languages like English where there are no contrastive affricates at any point of articulation, however; it is still possible that such languages may behave differently.

Thus far, I have shown that all examples of non-edge-effects, which Archangeli and Pulleyblank analyze as involving maximal scansion, can be accounted for as well under my hypothesis. This morpheme structure constraint is one case which cannot also be analyzed as involving maximal scansion of affricates with ordered values of [cont], and thus constitutes strong support for the present theory.

As McCarthy (in press) demonstrates, because of the rigid CVC shape of native Yucatec roots, both this shape and the relative ordering of vowels with respect to consonants are predictable; thus these are not part of lexical representations. The contrast among the roots /tka/, /tak/, and /atk/, for example, is impossible; of these, only /tak/ is a possible root of Yucatec. The only possible lexical entry for the root, then, is /a/,/tk/, with separate representation of vowels and consonants, if redundancy is to be eliminated from the lexicon. The consonants are adjacent in underlying representation, as is required to explain their behavior with respect to the morpheme structure constraints[5]. The vowel is not ordered with respect to the consonants, because the rigid CVC shape insures that ordering; but more important to the present point, this CVC skeleton is also not part of

the underlying representation, since it is completely predictable.

Since these morpheme structure constraints hold at the level of underlying representation, then, they are operative at a level where there is no CVC skeleton. In Archangeli and Pulleyblank's theory, maximal rules are rules which scan from the level of the skeleton. These are the rules which show anti-edge effects: from the skeleton, the rule can see both values of [cont]. Since there is no skeleton in the underlying representation of the Yucatec morphemes, however, the constraints cannot involve maximal scansion. Thus the constraint can only involve minimal scansion. Rules involving minimal scansion can see only the immediately adjacent value of [cont] in an ordered representation of the affricate. This yields the incorrect result that the cooccurence restrictions depend on the order of the consonants; (37a) would be ruled out, but not (37b).

Thus, in order to analyze these morpheme structure constraints, the affricate must have unordered values of [cont]. Maximal scansion is the only way that anti-edge-effects are possible with an ordered representation of the affricate. These constraints cannot be accounted for by invoking maximal scansion, since there is no skeleton to scan from at the necessary level of representation.

d. Classical Yucatec

Classical Yucatec also has a variety of morpheme structure constraints, some of which involve affricates, which differ from the constraints in the variety of Modern Yucatec discussed by Straight. These constraints also provide support for an unordered representation of the affricate. However, as their analysis is quite complex, I will postpone discussion of them to part II of the paper. First I will discuss the remaining cases which are discussed in the literature on the affricate, those cases which are presented as evidence for edge effects.

IV.2 <u>Edge effects and apparent edge effects</u>

a. Zoque

A rule in Zoque voices a non-continuant after a nasal, and it applies to affricates as well as stops. This is an edge effect because the context is on the [-cont]

edge of the affricate, and the rule treats the affricate as [-cont]. Fricatives after a nasal are not affected by this rule; they either remain voiceless, or delete.

(38)

a. Stops and affricates:

/min+pa/	[minba]	"he comes"
/min+tam/	[mindam]	"come! (pl.)"
/pʌn+čʌki/	[pʌnjʌki]	"figure of a man"
/N+pama/	[mbama]	"my clothing"
/N+čo?ngoya/	[ñjo?ngoya]	"my rabbit"

b. Fricatives:

[winsa?u]	"he received"
/N+sʌk/ -> [sʌk]	"my beans"

Again, since the rule applies to a segment specified [-cont], it will apply to affricates, since they are [-cont]. It will not apply to fricatives, since they are not [-cont].

b. Kutep

Labialization in Kutep is presented by Sagey (1986) as another example of an edge effect. Labialization results in a labiodental [f] or [v] after fricatives and affricates, and a bilabial [w] after stops. The following data from Ladefoged (1968) is presented:

(39)

a. Fricatives:

basfa	"they kneel"
nsazvakkwa	"the water is hot"
baʒve	"they washed"
baʒvam	"they begged"
açfapan	"groundnuts"

b. Affricates:

baćfap	"they chose"
batçfak	"they sleep"

c. Stops:

bapwa	"they grind"
bampbwa	"they tasted"
bandwap	"they wove"
nsazvakkwa	"the water is hot"
baŋgwa	"they drink"
baskwap	"they are foolish"

There is clearly a difference between the stops and the affricates. However, there is no evidence that this is a phonological process or a rule of any kind. This data comes from a list of the phonemic contrasts in this language. For example, /basfa/ contrasts with /basa/, "they took." This appears to be merely how this language realizes the feature [round]. Rounding the lips when a fricative is being produced will give the effect of [f] or [v] depending on the voicing of the fricative. Rounding of the lips during a stop will give the effect of [w] when the stop is released. Since affricates end in a fricative phonetically, the effect of rounding on a fricative will be heard, not the effect of rounding on the release of a stop.

For example, compare this to labialization in Higi, a Nigerian language. Mohrlang (1972) discusses the differences in phonetic implementation of labialization with different classes of consonants. Preceding stops and affricates, "the lips tend to completely close, and the effect...is that of a rounded bilabial preceding the consonant." Preceding fricatives, "the lips do not completely close. The effect...is that of a rounded bilabial fricative preceding the consonant." Some examples are given in (40).

(40)

a. Stops:
/^{w}p/ [p^{w}ɛ] "bubble"
/^{w}b/ [b^{w}a] "bigness"
/^{w}k/ [k^{w}a] "inside"
/^{w}g/ [g^{w}a] "body"
/^{w}t/ [p^{w}tá] "skin"
/^{w}d/ [b^{w}d̪i] "to pour"

b. Affricates:
/^{w}ts/ [p^{w}tsi] "grass"
/^{w}dz/ [b^{w}dzi] "strand"

c. Fricatives:
/^{w}s/ [^{w}sí] "thing"
/^{w}z/ [^{w}za] "farming"

This looks like a case of an edge effect: the labialization seems to occur on the left-hand side of the affricate, which is the [-cont] side, and the affricates are patterning with the stops. But once again, there is no reason to consider this a phonological rule which is sensitive to edges. Effects like this one and the one in Kutep are the result of

the phonetic realization of certain combinations of features, and have no bearing on the ordering of features in underlying representation. In both cases, what is at issue is the difference in implementation of a phonological contrast (a distinctive feature) in the two languages. Since the values of [cont] are ordered phonetically, the implementation of labialization will be sensitive to this ordering.

c. Sierra Popoluca

The distribution of aspiration in voiceless stops in Sierra Popoluca is presented in Sagey (1986) as an example of an edge effect. Stops are aspirated at the end of a syllable, but affricates and fricatives are not:

(41)

a. stops

/həp/	[həp^h]	"mouth"
/?ampat/	[?ampath]	"I met"
/mək/	[mək^h]	"fog"

b. affricates

/mac/	[mac]	"grasp"
/?apič/	[?apič]	"thorn"

c. fricatives

/wəsten/	[wəsten]	"two"
/pištək/	[pistək]	"flea"

Sagey analyzes this as a rule applying to a [-cont] at the end of a syllable. In an analysis where the affricate has underlying values of [cont], this rule will fail to apply to an affricate because the [+cont] value is on the right edge, at the end of the syllable. Thus the structural description for the rule is not met.

How could these facts be accounted for in a theory where the values of [cont] are unordered? To begin, note that the facts about aspiration in Sierra Popoluca are somewhat more complex than stated above, where only examples of word-final stops and affricates are given. The complete description is as follows, taken from Elson (1947):

1. Voiceless stops are unaspirated when followed by a vowel, or by a consonant at the same point of articulation.

(42) /kɛk.gak.pa/ [kɛk.gak^{h}.pa] "it flies again"

2. Voiceless stops are aspirated when followed by a nasal, or when syllable-final, except when there is a following syllable which begins with a consonant at the same point of articulation.

(43) /kɛk.pa/ [kɛk^{h}.pa] "it flies"

3. If the first member of a non-homorganic consonant cluster is a nasal, schwa is inserted between the members of the cluster.

(44) a. /ʔi.pɛʔn.pa/ [ʔi.pɛʔnə.paʔ] "he builds a nest"
b. /min.pa/ [minə.pa] "he comes"

A possible analysis for the facts of syllabification in Sierra Popoluca, following Ito (1986), would involve the following rules:

1. A rule merging sequences of identical place nodes, as suggested by Clements (1985). (Presumably this merger occurs in order to avoid a violation of the OCP, which prohibits adjacent identical elements on a tier.)

2. A condition that the coda of a syllable cannot have a place specification:

(45) Sierra Popoluca coda condition:

If the place nodes merge in homorganic clusters, the coda condition will not be violated, due to the Linking Condition (Hayes (1986), which states that association lines in the structural description of a rule must be interpreted exhaustively. In other words, the representation in (46) is not what the above coda condition is looking for; so it is not violated. Thus, homorganic consonant clusters will be successfully syllabified as in (46).

(46)

```
        σ       σ
      / |\      |\
    k  ϵ k      g a
         \  /
          place
```

What happens when the place nodes cannot merge, in non-homorganic clusters? In (47), /k/ cannot be syllabified as the coda of the first syllable, since it has a place specification and so would violate the coda condition.

(47)

```
        σ       σ
      / |      /  \
    k  ϵ  k   p   a
```

The only alternative is that it must be made an onset. Then, the syllable of which it is an onset must have a nucleus. In the case of a voiceless stop, the nucleus will be implemented as aspiration; in the case of a nasal, which is voiced, the result will be schwa.

Aspiration may seem like an unlikely syllable nucleus, but there are languages where this is routinely the case. For example, Bella Coola (Hoard 1978) has many vowelless syllables. In the case of stops, the syllable nucleus is aspiration of the stop; fricatives can be syllabic. Affricates have aspiration as the syllable peak.

(48) a. /sc'q/ -> [s.c'.q^h] "animal fat"
b. /sc'qctx/ -> [s.c'.q^h.c^h.tx]]
"that's my fat over there"

If frication is possible as a syllable nucleus, this may explain why affricates are not aspirated in the Sierra Popluca cases. These do not need aspiration, since they already have something which can function as the syllable nucleus. The affricates are then behaving differently than in Bella Coola, where they are aspirated. However, as previously stated, one would need more precise data from Sierra Popoluca to ascertain whether the affricates are actually aspirated.

Archangeli and Pulleyblank (1987) present data from Nahuatl which give evidence of the exact same phenomenon as in Sierra Popoluca: stops are aspirated

syllable-finally, and not affricates or fricatives. I was unable to obtain any more data on this phenomenon, but it seems probable that the explanation is similar to that for Sierra Popoluca.

V. Conclusion

Underlying ordering of the values of [cont] in the affricate, as assumed by previous autosegmental analyses, presents a number of problems. One is the fact that stipulating such ordering underlyingly predict that ordering will be contrastive. However, this is an incorrect prediction; there are no backwards affricates. A second problem is the fact that ordering explains edge effects, but cannot explain those rules which do not show edge effects, but which seem to see the non-adjacent value of [cont]. Both of these problems are solved by assuming that the values of [cont] are underlyingly unordered. Rules which do not show edge effects are then quite simple to state. The values are ordered phonetically, of course, and phonetic processes will be expected to show edge effects with affricates.

Part Two. Underspecification in the lexical representation of morphemes, with particular reference to the affricate.

I. Morpheme Structure Constraints in Classical Yucatec

Root morphemes in Classical Yucatec are of the form CVC. Table 1 gives all of the possible combinations of the stop, fricative and affricate consonants of Yucatec (glides and sonorants are omitted).[6] If there were no restrictions on the cooccurence of consonants, each box in the table could contain one or more possible roots of Yucatec in which the two consonants in the box appeared with one of the vowels of the language. However, there are systematic gaps in the table. It appears that certain of the logically possible consonant combinations are not possible in Yucatec roots, since roots with these combinations do not occur. I will attempt to account for these gaps by considering the underlying representation of these roots in the lexicon.

The constraints can be briefly stated as follows:

1. Roots are subject to a requirement of anterior harmony: two coronals in a root must agree in the value

of [anterior]. For example, sVc' is a possible root, but not *ʂVc', *sVɕ'.

2. There is a restriction on the order of affricates with respect to stops and fricatives in a root which is made up of only nonglottalized coronal consonants. If such a root contains a stop and an affricate, or a fricative and an affricate, the affricate always occupies the second C position. tVc and ʂVɕ are possible roots, but cVt and ɕVʂ do not occur. This constraint does not apply to glottalized affricates; tVc' and c'Vt are both possible, as are sVc' and c'Vs. It does not apply if the consonants differ in Place.

3. If both Cs in a root are glottalized, they must be identical. There are roots of the form $C'_1VC'_1$, but roots of the form $C'_1VC'_2$ are impossible. For example, p'Vp' is a possible root of Yucatec, but /p'/ and any other glottalized consonant cannot cooccur: *p'Vt', *p'Vk', etc., are impossible.

4. In Modern Yucatec, the plain and glottalized version of a C cannot cooccur in a root. Classical Yucatec appears to have a restriction on ordering rather than an absolute prohibition in cases like this. Where $C_1=C_2$, CVC' is impossible, but there are a few examples of the form C'VC. Although the latter sort of example is rare, there are absolutely no examples of the former type.

1. Anterior harmony

If there are two coronal consonants in a root, they must agree in the value of [anterior]. Adjacent identical place nodes constitute an OCP violation in these roots. "Identical" in this case means that both place nodes are [coronal]; they are still identical for the purposes of the OCP even if one is also specified [anterior]. Since two adjacent [coronal] specifications are prohibited, if both consonants are coronals, they must share a branching Place node. Since [anterior] is dependant on the Place node, two consonants which have the same place node will necessarily have the same value of [anterior].

A requirement that coronals share the same value of anterior is fairly common cross-linguistically. For example, rules of assimilation can assimilate the feature [anterior]. Navaho has such a rule affecting fricatives, affricates and glottalized affricates.

Prefixes with the consonants s, z and j become ʃ, ʒ and ʃ before prefixes or stems containing ʃ, ʒ, ʃ, ʧ, or ʧ'. Prefixes with the consonants ʃ, ʒ, and ʃ become s, z and j before prefixes or stems containing s,z,j,c, or c'. (Sapir and Hoijer 1967). Chumash (Poser 1982) has a system of anterior harmony, which makes all sibilants in a word agree in [anterior]. In Ngiyambaa, the distributed coronals in a root must agree in [anterior]. (McCarthy (to appear)).

This constraint has the effect of requiring that if a root consists of two fricatives, they must be identical. This is because the two fricatives in Classical Yucatec, /ʃ/ and /s/, do not agree in [anterior]. Thus, the only possible roots with two fricatives are sVs and ʃVʃ; prohibited are sVʃ and ʃVs. This constraint also rules out many of the possible combinations of affricates and fricatives which appear as gaps in the table. However, there are additional restrictions on the cooccurence of affricates and fricatives; these are dealt with in the following section.

2. Constraint on ordering of affricates

2.1 The values of [cont] in these roots

2.1.1. The lexical entries of roots

Considering only nonglottalized coronal consonants, the following constraints hold on the ordering of an affricate with respect to a stop or a fricative in a root: A stop and an affricate can cooccur in a Yucatec root, but only in that order. This means that roots such as tVc are possible, but roots such as *cVt are not. Fricatives and affricates can cooccur as well, but again, only in that order; sVc is possible, but not *cVs.

Thus, the ordering of the stop or fricative with respect to the affricate is never contrastive in these roots. If we are to eliminate redundancy in the lexical entries, the representation of these roots should not permit a constrast between, for example, the order stop-affricate and the order affricate-stop, since the latter order is impossible.

Affricates have two values of [cont]; stops and fricatives each have only one. In a root which contains a stop and an affricate, both Cs are [-cont]; in

addition, the affricate is specified [+cont]. Thus the lexical entry must contain the feature [+cont], which distinguishes the stop and the affricate. This [+cont] appears on the second C in all cases, since the order affricate-stop never occurs.

Although the feature [+cont] is linked to the second C on the surface, if [+cont] is linked to the second C in the lexical entry, such a representation predicts that the linking of this feature is contrastive, since it is specified in the lexicon. It predicts that the feature could be linked to the first C as well. This prediction is incorrect, since such a linking never occurs; the first consonant is never an affricate.

Thus, under the assumption that the lexicon should not contain information which is predictable, but only information which is contrastive, in the underlying representation of these roots [+cont] should <u>not</u> be linked to a root node of a consonant. The linking of the feature is predictable, so it should not be specified in the lexical entry; the feature can associate to the rightmost C by a later rule.

2.1.2 Derivations

For example, take a root of the form <u>tVc</u>, which consists of a stop and an affricate. As discussed (previously), vowels and consonants are represented separately in the lexical entries of these roots, since their ordering is predictable. So we can consider only the representation of the consonants. In a root such as /tVt/, the underlying representation will consist of only one consonant; association to the root template will result in a root wth two identical consonants. The lexical entry will be just /t/, or roughly as in (49) (details omitted):

(49)

```
              .root node
             /  \
        place    -cont     etc.
```

When this entry is associated to the CVC template, the single root node will spread to fill both positions.

```
(50)        C  V   C
             \ · /
              / \
      coronal    -cont        =   tVt
```

A stop-affricate root such as <u>tVc</u> will also be represented as a single consonant. It will consist of one root node with features; however, the entry also contains the feature [+cont], unassociated to the root node:

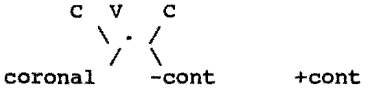
```
(51)
          root     .
                 /     \
           coronal     -cont       +cont
                                (unassociated)
```

Again, the root node will spread to fill both C positions in the template. Alone, this process would yield the same root as the entry above: /tVt/. But this entry contains additional material which distinguishes it from that entry: the unassociated [+cont]. Since it is unassociated, it must be linked by a rule. In this case, it is a rule which links it to the rightmost C.

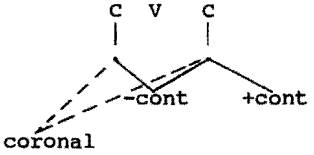
In order to link the unassociated feature to the rightmost C, some structure will have to change. One possible solution is that when the association required by the rule takes place, the structure of the root will change minimally to allow association to the C, as in step 2 of the following derivation. Thus, in the output of the rule which associates the unassociated feature, the two consonants of the root will have their own separate root nodes.

(52)

a. Root node spreads to fulfill template:



b. Associate unlinked feature to the right, changing structure minimally as necessary:



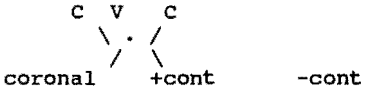
This will yield the root /tVc/. It is correctly predicted that the root */cVt/ will never occur, since the rule will never link the floating value to the first consonant position.

In Step 2 of the derivation, the consonants have two root nodes, since this is the minimal change in structure that will make it possible to link the unassociated feature to the second consonant. If the feature were to link to the single root node of Step 1, it would yield a root with two identical affricates. Such roots are possible, but they are represented underlyingly with two features of [cont] linked to a single root node; there is no reason to represent them with an unassociated feature.

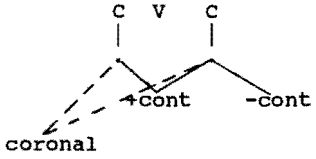
Fricative-affricate roots such as <u>sVc</u> will have exactly the same kind of representation except that the unassociated feature is [-cont]. The underlying representation consists of one root node specified [+cont], and an unassociated feature [-cont]. The association of the [-cont] feature is not contrastive, so it is not specified in the lexical entry; it attaches by rule to the rightmost C. As above, roots with the affricate in the first C slot, such as <u>cVs</u>, are correctly predicted to never occur, since the unassociated feature links by rule to the second C.

(53)

a. Root node spreads to fulfill template:

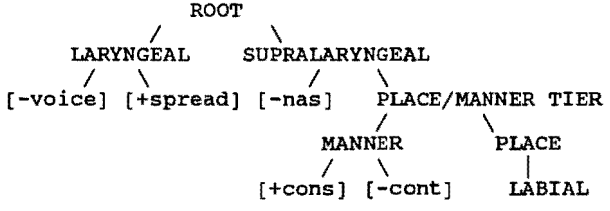


b. Associate unlinked feature to the right:



Another possibility for the linking of unassociated features is to adopt a theory which allows for the linking of features directly to the prosodic tier, such as the theory described in Hayes (1988). In this theory, association lines are eliminated in favor of coindexing to represent association of features to skeletal positions, and the grouping of features accomplished by feature geometry trees is achieved by representing the features grouped in the form of an outline. Thus, for Hayes, the tree in (54a) is represented as in (54b). (The particular form of feature geometry that Hayes assumes is irrelevant.)

(54)a.



b.

```
R: L: [-voice]                    = p
      [+spread]
   S: N: [-nas]
      PM: M: [+cons]
             [-cont]
          P: LB
```

A segment such as that in (54b) is linked to a skeletal position by means of coindexing. A Percolation Convention, stated in (55), has the effect that all features are both grouped in their tiers and linked directly to the skeleton:

(55) Percolation Convention:
When indices are assigned to or removed from a node N, the same indices are automatically assigned to all nodes dominated by N.

Thus, when the root node in (54b) is linked to a skeletal position with the index $\underline{i}$ the resulting structure is as in (56):

(56)
$$\begin{array}{l} C_i \\ R_i\text{: } L_i\text{: } [-\text{voice}]_i \\ \qquad\qquad [+\text{spread}]_i \\ \qquad S_i\text{: } N_i\text{: } [-\text{nas}]_i \\ \qquad\qquad PM_i\text{: } M_i\text{: } [+\text{cons}]_i \\ \qquad\qquad\qquad\qquad [-\text{cont}]_i \\ \qquad\qquad\qquad P_i\text{: } LB_i \end{array} \quad = \quad \begin{array}{c} C \\ | \\ P \end{array}$$

Then, to represent a segment linked to two C positions, all of the features would bear the indices of both positions:

(57)
$$\begin{array}{l} C_i \quad C_j \\ R_{ij}\text{: } L_{ij}\text{: } [-\text{voice}]_{ij} \\ \qquad\qquad [+\text{spread}]_{ij} \\ \qquad S_{ij}\text{: } N_{ij}\text{: } [-\text{nas}]_{ij} \\ \qquad\qquad PM_{ij}\text{: } M_{ij}\text{: } [+\text{cons}]_{ij} \\ \qquad\qquad\qquad\qquad [-\text{cont}]_{ij} \\ \qquad\qquad\qquad P_{ij}\text{: } LB_{ij} \end{array} \quad = \quad \begin{array}{c} C \quad C \\ \backslash\ / \\ P \end{array}$$

In this theory, it is very simple to allow the linking of the unassociated features in Mayan roots to link only to the second consonant position. (58) is a partial representation of the root discussed in (51-52), adapting Hayes' system to the feature geometry I have been assuming, at the point where the single root node is filling both skeletal positions, but the [+cont] is still unassociated:

(58)

$$\begin{array}{ll} C_i \quad C_j & \\ R_{ij}: [-\text{cont}]_{ij} & [+\text{cont} \\ \quad P_{ij}: \text{COR}_{ij} & \end{array} \quad = \quad \begin{array}{c} C \quad C \\ \backslash \quad / \\ t \quad [+\text{cont}] \end{array}$$

The rule which links the unassociated feature to the rightmost consonant will simply give that feature the index of that consonant, as in (59):

(59)

$$\begin{array}{ll} C_i \quad C_j & \\ R_{ij}: [-\text{cont}]_{ij} & [+\text{cont}]_j \\ \quad P_{ij}: \text{COR}_{ij} & \end{array} \quad = \quad \begin{array}{c} C \quad C \\ | \quad\ \ | \\ t \quad\ \ c \end{array}$$

2.2 The Place and Laryngeal node in these roots

This constraint on ordering only applies to coronals; also, it does not apply when the affricate is glottalized. If the place of articulation is not the same, affricate/stop and affricate/fricative roots can occur in either order: for example, all of the following are possible:

(60) k V c c V k s V k k V s

If the affricate is glottalized, again, both orders are possible:

(61) t V c' c' V t s V c' c' V s

I have analyzed the constraint on ordering in section 2.1 as resulting from the form of the underlying representation of these roots, combined with the directionality of the linking of unassociated features. The Cs in coronal-only, non-glottalized roots share all features except for the feature that I am proposing is unassociated. The latter feature must be unassociated because of the fact that its association is predictable and not constrastive. When this feature is not associated, the two consonants in the root share all remaining features. Because of the OCP, the only option for representing them, then, is as a single root node; this node will fill both Cs in the template. Whatever value of [cont] is linked to this root node will of course appear on the C in both positions; the unassociated value of [cont] will be linked by a rule.

Roots containing Cs which differ in place are predicted by this analysis to have no constraint on ordering. The coronal-only roots discussed above must be represented as single Root nodes in order to explain the constraint on ordering. But if the consonants in a root do not share place of articulation, the two Cs in the root must have separate Root nodes, since they need to have different Place nodes. Each Root node can have its own value or values of [cont] attached to it, so any order of stops, fricatives and affricates will be possible if the consonants differ in Place.

Affricates which are glottalized will not participate in the constraint on ordering for the same reason. The glottalized affricate does not share all features with the other C in the root, because it has the feature [cg]. Thus the root cannot be represented as a single Root node. The lexical entry will contain two separate Root nodes, and each Root node can have its own value or values of [cont], and there will be no constraint on ordering.

This analysis predicts that glottalized affricates might have a constraint on ordering with respect to glottalized stops (or glottalized fricatives, but these do not occur in this language.) The two consonants in such a root would share all features except for [+cont] on the affricate, and could be represented as a single root node and a floating [+cont]. However, due to another constraint, Constraint 3, two non-identical glottalized consonants cannot cooccur in a root. Thus, this prediction is impossible to test.

It is also possible that glottalized affricates in this language are not underlyingly specified for [-cont]. Since there are no glottalized fricatives, glottalized affricates could be the realization of any segment which is specified for both [cg] and [+cont]. However, this does not have any effect on the statement of the morpheme structure constraints. The fact that the glottalized affricates need to have separate root nodes will be sufficient for them not to be affected by the ordering constraint.

2.3 Relevance to representation of the affricate

In a theory where the values of [cont] were ordered underlyingly, it would be simple to capture half of the constraint on ordering of affricates. Given the representation in (62) and an unassociated [+cont]

associating to the right, the resulting root will be a stop followed by an affricate.

```
(62)   C V C                          C  V  C
        \ /                           |     |
        root              ->          .     .
         |                            |     |     \
       -cont   +cont              -cont  -cont  +cont
```

A root with an affricate preceding a stop would be impossible; if the unassociated feature associated to the first C, it would produce an impossible segment in which [+cont] precedes [-cont]. The association which would yield an affricate in the first position is impossible, because lines would cross.

```
(63)     C  V  C              *  C  V  C              *C
          \   /                 |     |               |
         root      ->           .     .      or       .
         |                      |     |              / \
+cont   -cont                   |     |
                          +cont -cont  -cont     +cont -cont
```

The ordering of stops and affricates, then, is possible to explain in a contour-segment theory. However, that theory makes the wrong prediction about the ordering constraint on fricatives and affricates. In the representation in (64), the only place the feature can associate is to the first C, because that is the only possible well-formed segment. This will yield an affricate followed by a fricative, which is the order which is actually prohibited in this language.

```
(64)   C V C                          C  V  C
        \ /                           |     |
        root          ->              .     |
         |                            |     |
-cont   +cont                     -cont +cont  +cont
```

It would be impossible to produce a representation of the order which is actually possible - that is, fricative followed by affricate - because that would result in line-crossing.

```
(65)  C V C                          * C  V  C
       \ /                             |     |
       root              ->            .     .
        |                             |     |
       +cont   -cont                  |     |
                              +cont   +cont  -cont
```

Thus, in the contour segment theory, we would expect the constraint to be:

possible: stop-affricate, affricate-fricative
prohibited: *affricate-stop, *fricative-affricate

This is incorrect, as the actual situation is:

possible: stop-affricate, fricative-affricate
prohibited: *affricate-stop, *affricate-fricative

If the two values of [cont] were on separate tiers, the representation in (65) would not cross association lines. However, it is generally presumed that features on separate tiers cannot be ordered (Sagey 1986). The only way to salvage the contour-segment theory of the affricate would be to say that at some point in the derivation, these roots can contain segments with unordered values of [cont], and the values are ordered later by a rule. This would be the exact rule that is needed to derive the surface phonetic form of affricates if we assume the unordered representation of the affricate. Thus, the contour segment theory has no advantage in this situation; the only variant of it that can account for these constraint is basically identical to the theory that the values of [cont] are underlyingly unordered. These constraints, then, constitute additional support for the hypothesis that the values of [cont] are unordered in the underlying representation of the affricate.

3. Constraints on laryngeal features

3.1 Contraint 3

In Classical Yucatec, if both Cs in a root are glottalized, they must be identical. There are roots of the form $C'_1VC'_1$, but roots of the form $C'_1VC'_2$ are impossible. For example, p'Vp' is a possible root of Yucatec, but p' and any other glottalized consonant cannot cooccur: *p'Vt', *p'Vk', etc.

This constraint can be expressed as a prohibition on a branching laryngeal node or feature [cg] in this language (McCarthy, in press). If this feature is not permitted to branch, then the only possible root with two glottalized Cs will be one in which the root node, which is specified [cg], branches; thus the two Cs will share all other features as well.

(66)a.

```
* C  V  C
  |     |
  .     .
   \   /
    cg
 lab    cor

*p'Vt'
```

b.

```
C  V  C
 \   /
   .  root
  / |
cg  |
    lab

p'Vp'
```

3.2 Constraint 4: More on Underspecification in Roots

3.2.1 Constraint 4

This constraint, like constraint 2 on affricates, is a constraint on ordering. If two consonants in a root are identical except that one of them is glottalized, the only possible order is that the glottalized consonant is first:

possible:	t'Vt	p'Vp	c'Vc	c'Vc	k'Vk
prohibited:	tVt'	pVp'	cVc'	cVc'	kVk'

The cases relevant to constraint 4 are very rare, as can be seen from the table. While the cases that I claim are prohibited never occur, there is only one example each of the cases that I list as possible. However, assuming that this constraint is correct, and that the scarcity of roots is an accident, what would be the analysis? Since order is not contrastive, as in the case of constraint 2, order of glottalized/nonglottalized identical Cs should not be specified in the lexical entry, and the form of the representation should not allow the nonoccuring order to be expressed. Thus, a representation like the one suggested for constraint 2 seems to be appropriate. The roots in question consist of a single root node and an unassociated [cg]. Unlike unassociated [cont], this feature attaches to the leftmost C.

(67)

a. Underlying representation of root <u>t'Vt</u>:

```
root   .
       |  \
     cor  -cont    +cg (unassociated)
```

b. Root node spreads to fill CVC template:

```
  C  V  C
   \    /
root  .        +cg (still unassociated)
      |
      t
```

c. Unassociated feature associates to leftmost C:

```
  C  V  C
  |     |
  .     .        -> t'Vt
 /
+cg
```

Key to Table 1:

Vertical columns - first C of CVC morpheme

Horizontal rows - second C

Each box contains a number which is the number of roots of that form. Some boxes also contain another number above that number. These numbers correspond to the morpheme structure constraints; unless otherwise indicated below, they indicate the constraint which rules out that form.

1. Anterior harmony.

2. Constraint on ordering of affricates.

3. If both Cs are glottalized, they must be identical.

4. If there are two glottalized Cs in a root, the glottalized C must be first. In the table, both orders - both occuring and nonoccuring - are marked.

Table 1: Root morphemes of Classical Yucatec

	p	t	c	č	k	p'	t'	c'	č'	k'	s	š
p	5	6	2	6	6	40	0	4	3	3	5	4
t	5	5	1	5	7	5	40	5	2	2	4	4
c	2	20	4	10	4	0	20	40	10	2	20	10
č	1	20	10	4	6	1	20	10	40	5	10	20
k	5	6	6	6	7	2	0	1	2	40	4	4
p'	41	4	0	2	6	1	30	30	30	30	6	3
t'	1	40	1	3	2	30	5	30	30	30	1	1
c'	2	3	40	10	5	30	30	3	30	30	2	10
č'	3	2	10	41	6	30	30	30	5	30	10	2
k'	6	4	1	7	41	30	30	30	30	4	6	6
s	5	6	0	10	5	4	1	6	10	3	10	10
š	4	3	10	2	7	3	4	10	3	5	10	2

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FOOTNOTES

1. Clusters such as [st, sp, sk] in English cannot be analyzed as single segments. They do not pass the tests for segmenthood, and do not agree in place, as affricates must.

2. One of those languages is Chipewyan, which Maddieson lists as having velar affricates. Chipewyan does not have velar affricates phonemically. Maddieson apparently lists them on the basis of Li's statement that "g is often produced with a *r*-glide (Li 1946)."

3. Anderson (1976) discusses prenasalized segments, which are generally grouped with affricates as contour segments. He proposes that prenasalized and postnasalized segments contain two ordered values of the feature [nasal]. This type of representation could be extended to affricates, but Anderson tentatively rejects this proposal. He discusses the nasalization of vowels in the environment of these segments, and concludes that nasalization is more like a suprasegmental feature, which can extend over, for example, a vowel and the beginning of a stop. Since [continuant] does not behave in this way, the details of his proposal do not extend to affricates.

4. The Gorgia Toscana is actually somewhat more complicated than this. The situation I describe is the more widespread dialect, but in a more limited area, /p,t/ also become fricatives intervocalically. Also, for some speakers the velar also becomes a fricative. The analysis in the body of the paper (Section IV) works for the dialect described there. In the other dialects, it appears that the Gorgia is actually a process of spirantization, where [-cont] -> [+cont]. Such a process would also apply to affricates, which are [-cont]; having lost their [-cont], they would also become fricatives.

5. See Myers (1987) for a useful discussion of those

configurations which count as structurally adjacent in phonological representations.

6. Classical Yucatec was spoken in the Yucatan peninsula of Mexico from the mid-15th to the mid-17th century. McQuown (1967) contains tables of all the roots from the Motul dictionary, which was compiled in the last quarter of the 16th century. These charts were my source for the morphemes of the language, checked against the other sources listed in the bibliography: the Motul dictionary itself, Swadesh et.al. (1970) and the Diccionario Maya Cordemex. The Yucatec Maya described in Part One of this paper is a modern form of this language. Not all dialects of Modern Yucatec have the constraints described by Straight and discussed in Part One - in some of the dialects, the constraints appear to more closely resemble the constraints of Classical Yucatec.

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