In Osamu Fujimura, Brian D. Joseph, and Bohumil Palek, eds., *Proceedings of LP '98: Item Order in Language and Speech*. Prague: The Karolinum Press, 1999, pp. 271-299.

Affricates as Noncontoured Stops

G. N. Clements, CNRS, Paris

clements@idf.ext.jussieu.fr

Abstract. This paper reviews evidence that affricates are simple stops bearing no feature [+continuant] and involving no subsegmental contouring at any level of the phonology. The fricative noise associated with the affricate release can usually be regarded as the phonetic implementation of the feature [+strident], as originally proposed by Jakobson, Fant, and Halle (1952). This analysis is strongly confirmed by the principle of Plosive-Affricate Complementarity, according to which the simple-stop analysis of affricates predicts just the attested set of plosive-affricate contrasts and no others, given a rather small set of widely-accepted features. The common process of affrication before high vowels and glides does not involve [+continuant] spreading but reanalysis of the intrusive fricative segment created by aerodynamic conditions at the stop-to-vowel transition.

1. Introduction

Affricates constitute a well-known case of phonology-phonetics "mismatch," in which one phonological segment (the affricate) is realized as two phonetic segments (a plosive interval released into a fricative interval). Though affricates superficially resemble plosive + fricative sequences, they are counted as single segments in the phonology for reasons such as the following:

1. *phonotactics*: affricates occur in positions where single stops are allowed but bisegmental stop + fricative sequences are prohibited;
2. *tautosyllabicity*: affricates syllabify as syllable onsets in contexts where bisegmental stop + fricative sequences usually syllabify as coda + onset sequences;
3. *noncompositionality*: the stop + fricative sequence cannot be plausibly decomposed into a sequence of two independently-occurring phonemes;
4. *noncommutivity*: the stop and/or fricative component does not commute with another phoneme;
5. *inalterability*: affricates fail to undergo rules of cluster reduction that apply to bisegmental consonant sequences;
6. *inseparability*: the stop + fricative sequence cannot be broken up by epenthesis, reduplication, speech errors, and so forth;
7. *contrastivity*: some languages (e.g. Czech, Polish) have lexical contrasts between affricates and the corresponding stop + fricative sequences.

Classic literature justifying a monosegmental analysis of affricates includes Trubetzkoy (1939) and Martinet (1939).

It is commonly believed, however, that while affricates present a genuine phonology-phonetics mismatch in terms of pure segmental count, the mismatch is absent at the level where segments are assigned feature structure. At this level, affricates are represented as internally sequenced or *contour* segments, whose first part has the features of a stop and whose second part those of a fricative. This bipartite analysis has been formalized in several ways, including the sequencing of single features, feature matrices, or feature clusters, or the skewing of segment-internal feature boundaries (representative proposals include Hoard 1967, 1978, Campbell 1974, Hockett 1975, Ewen 1982, Clements and Keyser 1983, Sagey 1986, Steriade 1993, 1994, and van de Weijer 1996). In a variant of this view, affricates are represented as *complex* segments bearing simultaneous, contradictory specifications for [stop] and [continuant] (Hualde 1988, 1991, Lombardi 1990); these features are sequenced only at the phonetic level (or postlexically, according to Lombardi 1995).

This paper reviews evidence showing that affricates should be represented as simple stops in the phonology, bearing no feature [+continuant], whether sequenced or simultaneous, at any level of analysis.[1] In this view, affricates are always distinguishable from nonaffricated stops in terms of independently-motivated features such as [strident], [distributed], [anterior], and the like. Any further representational distinction, such as one involving a feature [+continuant] (whether contoured or simultaneous), would make incorrect predictions concerning affricate behaviour, and massively overgenerate the number of potential contrasts predicted by the representational system. The fact that affricates consist of stop + fricative sequences phonetically is best accounted for at the phonetic level, where phonological feature combinations such as [-continuant,+strident] are spelled out sequentially as a succession of acoustic events.

This position is not an entirely new one. A similar view was proposed by Jakobson, Fant, and Halle (1952), who characterized affricates universally as strident stops, that is, as single noninterrupted (stop) segments bearing the feature [+strident]. This proposal has more recently been revived by Rubach (1994) on the basis of evidence from Polish. Lacharité (1992) and Kim (1997) have proposed an extension of this view in which affricates, though still viewed as simple stops, are not necessarily [+strident] sounds. Their approach has the advantage of accommodating the existence of nonstrident affricates in several languages, as will be further discussed below.

In spite of the considerable amount of evidence produced by Rubach, Lacharité, and Kim for a simple-stop analysis of affricates, the current literature largely continues to treat these sounds as contour or complex segments in one or another of the senses defined above, with little or no discussion of the alternative (and considerably more restrictive) view. This neglect is rather surprising when we consider the fact that affricates have often been taken as providing a particularly strong case for allowing contour segments in phonology in the first place. Evidence that affricates are not contour segments would go a long way toward undermining the case for contour segments in general, and require a closer look at other presumed candidates for this status, such as prenasalized stops, short diphthongs, and others.

This paper is organized as follows. Section 2 reviews earlier evidence for the simple-stop analysis of affricates. Section 3 introduces new evidence from a principle of *Plosive-Affricate Complementarity* according to which independently-motivated features are sufficient to account for all known phonological contrasts between plosives and affricates, with no gaps and no residue. Section 4 addresses the problem raised by a common process which creates affricates from simple plosives before high vowels, and argues that affrication in this context involves reanalysis driven by a mismatch between the phonological and phonetic levels of representation. Section 5 provides a summary and considers the consequences of the analysis for the Congruence Hypothesis (Clements and Hertz 1996). We conclude that whatever representational framework one adopts,[2] affricates must be characterized as simple stops bearing no feature [+continuant] or the equivalent at any level of description.

2. Some analyses of affricates

Several recent contour and complex segment analyses of affricates are summarized in (1). *Contour segment* analyses as shown in (1a) treat affricates as stop + fricative sequences linked to a single skeletal position (e.g. Clements & Keyser 1983). *Contour feature* analyses as shown in (1b) postulate segment-internal sequenced features [-cont] [+cont] or their equivalent (e.g. Sagey 1986). *Aperture node* analyses as shown in (1c) posit a sequence of phonological aperture nodes A_0, A_{fr} representing the stop and fricative components respectively (Steriade 1993, 1994). *Complex segment* analyses as shown in (1d) assign affricates the features [continuant] and [stop] on separate tiers (e.g. Lombardi 1989). These choices are illustrative, and other models assigning affricates a bipartite structure have been proposed as well, as indicated in the references given earlier.

(1)	a.	b.	c.	d.
	C / \\ t s	root / \\ [-cont] [+cont]	σ / \\ A_0 A_{fr}	[cont] | root | [stop]

While differing in detail, all these analyses predict that affricates should pattern with fricatives by virtue of their fricative or [+continuant] component. The first three representations predict that affricates should pattern with fricatives on their right side only, that is, with respect to following segments, while the fourth predicts such patterning on the left side as well. In contrast, the simple-stop theory of affricates predicts that affricates will never pattern with fricatives on either side, by virtue of the feature [+continuant]. In this view, genuine natural classes of affricates and fricatives will always be defined by some independently-motivated feature, such as [+strident].

In defending a complex-segment model of affricates, Hualde (1988, 1991) and Lombardi (1990) brought to light a certain amount of evidence appearing to show that affricates sometimes pattern as continuant segments to their left as well as to their right (giving rise to "anti-edge effects"). However, Lacharité (1992), Rubach (1994), and Kim (1997) note that in most of their examples, the fricatives and affricates that pattern together are all [+strident] sounds. Thus, most crucial examples of affricate-fricative solidarity can be reanalyzed by replacing reference to [+continuant] by reference to [+strident].

In Basque, for example, affricates and fricatives form a class with respect to Sibilant Harmony, a principle which requires all sibilants in a morpheme to agree in the features [±anterior, ±distributed] (Hualde 1991). Morphemes draw their affricates or fricatives exclusively from one of the three sets: apical *ts*, *s*, lamino-alveolar *z*, *tz* , or palato-alveolar *x*, *tx*. Thus, well-formed morphemes include *asots, zuzen, eltsuntse, urtxintx, samats, zimitz, sasoin, itseso, zapelatz*, but not hypothetical forms like **asotx*, **zutsen*, etc. As there are no nonsibilant coronal fricatives or affricates in Basque, however, the class of harmonizing segments can be adequately defined by the features [coronal] and [+strident].

Lacharité, Rubach, and Kim have also cited several cases in which affricates *fail* to pattern with fricatives on their left and/or right, as they should if affricates are analyzed as continuants. The problem here is a serious one, since under contour- and complex-segment analyses of affricates there is no straightforward way to define a natural class of fricatives that excludes affricates other than by such dubious formalisms as allowing reference to the *absence* of [-continuant] (or equivalently, [stop]) specifications.[3]

In the past, the simple-stop analysis of affricates ran afoul of the observation that not all affricates are strident sounds (McCawley (1967). For example, we find the following contrasts among coronal plosives and affricates in several Athabaskan languages, such as Chipewyan, Slave and Tahltan:

(2) Athabaskan affricate contrasts:

t	tθ	ts	tʃ	tɬ
t^h	$tθ^h$	ts^h	$tʃ^h$	$tɬ^h$
t’	tθ’	ts’	tʃ’	tɬ’

The problematical contrast is that among the members of the first three columns: if affricates are strident stops, how can we distinguish / tθ / from both / t / and / ts /?[4]

On the simple-stop analysis of affricates, phonemic contrasts such as / t tθ ts / cannot involve a difference in continuance alone, but must involve differences in further features. This view appears to be consistent with the Athabaskan facts. Nater (1989) describes the / tθ /-sounds of the Iskut Tahltan as “interdental predorsal-alveolar” and the / t /-sounds as “dental”, without specifying whether the latter are apical or laminal; if they are apical, of course, the two sounds can be distinguished by the apical vs. laminal (or [±distributed) contrast. Shaw (1989, 1991) regards the / tθ /-sounds of the Telegraph Creek variety of Tahltan as distinctively [+distributed], and assigns the / t /-sounds the value [-distributed] by default. Rice (1987) gives a similar analysis of Slave. She has independently informed me that the / t /-series “seems to be apico-dental” while the / tθ /-series is front dental or interdental, and “probably lamino-dental” (p.c. 1998). In the absence of instrumental studies these descriptions can only be taken as suggestive, but they do show that a distinction involving the feature [±distributed] cannot be excluded on a priori grounds. If such an analysis proves correct, the Athabaskan sounds /t tθ ts/ can be distinguished as shown in (3):

(3)

	t	tθ	ts
strident	-	-	+
distributed	-	+	

This analysis is consistent with other aspects of Athabaskan phonology. As is well known, most Athabaskan languages have a principle of Coronal Harmony similar to Basque Sibilant Harmony, except that it applies at the word level, and to a larger set of phonemes. In Tahltan, as described by Shaw (1991), all coronal obstruents in a word agree in their specifications for [±strident, ±distributed, ±anterior]; violations across morpheme boundaries are eliminated by assimilation to the rightmost member of the sequence. The / t /- and / tɬ /-series are fully neutral, neither triggering, blocking, nor undergoing the rule. Shaw, who assumes a simple-stop analysis of affricates similar to that proposed here, characterizes Strident Harmony in terms of the spreading of the coronal node with the dependent features [±strident, ±distributed, ±anterior]. She accounts for the exceptional status of the / t /-sounds and / tɬ /-sounds by assuming that their place features (all of which are unmarked, assuming that [+lateral] is a manner feature linking above the place node) are underspecified. In her analysis, the set of alternating sounds is coextensive with those bearing the feature [coronal], and does not require reference to [+continuant].[5]

The case to be made for the simple stop analysis of affricates, then, is that it is highly restrictive yet appears to be fully consistent with the behavior of affricates across languages. In particular:

1. it does not predict unattested natural classes; affricates pattern with other stops but not fricatives, except by virtue of features such as [+strident];
2. it does not predict unattested "edge effects": affricates behave exclusively as stops to their left and right;
3. it does not predict "affricate separability" under speech errors, epenthesis, reduplication, or metathesis; as no features or nodes are ordered, there is nothing to separate;
4. it requires no special features such as [±delayed release], nor special segment types such as contour segments, nor simultaneous specifications for contradictory features such as [stop] and [continuant], all of which lend unwanted potential power to the representational system

For these reasons, in the absence of empirical evidence to the contrary, we must prefer the simple-stop analysis of affricates to alternative, less restrictive theories of affricate structure.

3. Plosive/affricate complementarity

We now develop a further argument for the simple-stop analysis of affricates based on a principle which we term *Plosive-affricate Complementarity*. In the following discussion, the term "plosive" will be used to refer exclusively to nonaffricated stops, and "affricate" to affricated stops.

"Stop" will be employed as a cover term for plosives and affricates alike, in conformity with standard usage and with the phonological analysis proposed here.

In its strongest form, the principle of Plosive-affricate Complementarity states that given the simple-stop analysis of affricates, a small set of well-motivated features, not including [±continuant], is sufficient by itself to account for all known phonological contrasts between plosives and affricates, with no gaps and no residue. Given this principle, it follows that special analyses of the sort represented in (1) are not just superfluous, but predict the existence of many more speech sounds than are actually attested.[6]

We consider coronal, labial and dorsal stops in turn.

3.1. Coronal stops

The richest set of distinctions among plosives and affricates is found at coronal places of articulation, i.e. those involving the tip, blade, or front (i.e. the "crown") of the tongue as active articulator. To characterize the major coronal places of articulation, I propose the standard features [±anterior], [±distributed], and [±strident], following in most respects the feature framework of Chomsky and Halle (1968) as further elaborated by Clements (1976), Halle and Stevens (1989), Sagey (1986), Hume (1994), and Hall (1997). These three features generate eight coronal stop categories, four plosive and four affricate, as shown in (4).

(4) Feature characterization of coronal plosives (odd numbers) and affricates (even numbers), with common realizations in transcription:

	1	2	3	4	5	6	7	8
	ṭ, ḍ	ṭṣ, ḍẓ	t, d	ts, dz	ʈ, ɖ	ʈʂ, ɖʐ	c, ɟ, t̠, d̠	tʃ, dʒ
anterior	+	+	+	+	-	-	-	-
distributed	-	-	+	+	-	-	+	+
strident	-	+	-	+	-	+	-	+

KEY: plosives / affricates

plosives	affricates
1= apical dental/alveolar	2= strident apical dental/alveolar
3= laminal dental/alveolar	4= strident laminal dental/alveolar
5= retroflex	6= strident retroflex
7= laminal post-alveolar (e.g. palatal, palato-alveolar)	8= strident laminal post-alveolar (e.g. palato-alveolar, alveo(lo)palatal)

In this table, columns 1-4 present the anterior (dental/alveolar) stops, and columns 5-8 the posterior (post-alveolar) stops. Within each of these sets, the first two columns present the apical (tongue tip) sounds, and the second two the laminal (tongue blade or tongue-front) sounds. Odd columns present nonstrident stops and even columns, their strident, and hence affricated, counterparts. Each feature column is headed by symbols indicating the class of sounds it typically represents, as suggested by traditional phonetic labels listed in the key. Thus, column 1 presents the proposed feature description of any nonstrident apical-anterior stop, whether interdental, dental, alveolar, or denti-alveolar, and so forth.

Palatal stops, analyzed in column 7 as nonstrident, posterior, and distributed, were sometimes treated as noncoronal in the past (Chomsky and Halle 1968, Ladefoged and Maddieson 1996). However, a wide range of evidence has emerged over the past few decades to show that stops described as "palatal" typically pattern with coronal sounds in the phonology, and should therefore bear the feature [coronal] (Clements 1976, Halle and Stevens 1989, Hume 1994, Hall 1997). Palatal stops, as we use the term here, are phonetically distinct from front or palatalized velar stops, whose major place of articulation is dorsal (Keating and Lahiri 1993). They are distinguished from palato-alveolar and alveo-palatal affricates by their lack of stridency (Jakobson, Fant, and Halle 1952, Chomsky and Halle 1968).[7] Column 7 also includes the nonstrident palato-alveolar plosives [t̠, d̠] as found in some Australian languages (Butcher 1995); these sounds do not appear to contrast with palatal plosives [c ɟ] in any language.

Column 8 groups together all strident post-alveolar stops, typically represented by the palato-alveolars [tʃ dʒ]. As is well known, these stops contrast with alveo-palatal affricates [tɕ dʑ] in some languages, such as Polish. Following Rubach (1994) and Hume (1994), we analyze the latter as palatalized palato-alveolars, which can alternatively be transcribed as [tʃʲ dʒʲ]. Under this analysis, alveo-palatal sounds do not need to be separately listed in (4), which lists contrasts involving major articulations only.

Given the 8 different categories in (4), we predict exactly 28 possible contrasts among plosives and strident affricates at major coronal places of articulation. These contrasts are displayed in (5), together with languages that appear to exhibit them. Each cell in this table exemplifies a contrast between the categories of the intersecting row and column. For example, the entry "Ewe" at the intersection of row 1 and column 4 indicates that Ewe has a contrast between stops of category 1 (apical-anterior nonstrident) and category 4 (laminal-anterior strident).

(5) Contrasts between plosives and strident affricates (coronal places of articulation)

	2 ṭ ṣ, ḍ ẓ	3 t, d	4 t s, d z	5 ʈ, ɖ	6 ʈ ʂ , ɖʐ	7 t̠, d̠, c, ɟ	8 tʃ, dʒ
1	Tarascan	Toda	Ewe	Yanyuwa	Tacana?	Arrernte	English
2	-	Dahalo	Basque	Rukai?	Mazatec?	Basque	Polish
3		-	Russian	Arrernte	Acoma	Malayalam	Chipewyan
4			-	Pashto?	Acoma	Basque	Basque
5				-	Burushaski	Tamil	Burushaski
6					-	Ostyak	Mandarin
7						-	Hungarian

It will be noted that all cells in the table are filled. However, some of the entries are followed by a question mark. These represent cases in which available sources do not specify whether one or the other of the contrasting sounds is apical or nonapical. In these cases, following a strong but not exceptionless crosslinguistic trend (Ladefoged and Maddieson 1996, 20-21), I have considered a sound to be apical if it is alveolar, and laminal if it is dental. In most cases, if this analysis should prove wrong for a given language, other plausible candidates can be substituted in its place.

It appears, then, that the feature system in (4) does not overgenerate phoneme contrasts at major coronal places of articulation; all predicted contrasts are attested by plausible candidate languages. But does it undergenerate contrasts? That is, are there place contrasts that cannot be accounted for by this feature system? We examine a number of potential cases below.

First, lateral affricates as illustrated in Athabaskan languages (cf. (3)) are not at issue here, as the feature [lateral] is not a place feature but a manner feature, represented independently of the coronal node (Shaw 1991, Clements and Hume 1995). Table (4) lists major place contrasts only.

Second, I am unaware of any contrasts between dental and alveolar stops that do not also differ in terms of other features. Malayalam was earlier described by Ladefoged (1971: 38, 40, 102) as having phonemic contrasts between apical dental and apical alveolar stops, but this language has more recently been described by Maddieson and Ladefoged (1996, 21) as following the familiar pattern in which dental stops are laminal and alveolars are apical. This analysis is consistent with Mohanan and Mohanan's (1984) feature characterization of these sounds as [+distributed] and [-distributed], respectively. Other reported contrasts between dental and alveolar stops typically involve other features, such as [strident]. It seems that the distinction between dental and alveolar places of stop articulation is unnecessary in phonological description, as far as presently-known evidence is concerned.

Let us next consider possible further contrasts involving palatal sounds. One difficulty in assessing contrasts involving palatals is the latitude with which the term “palatal” is used in the literature. This term is used to describe sounds produced at a variety of places of articulation including prepalatal, mediopalatal and postpalatal (front velar). There is a genuine issue regarding how many of these distinctions are phonologically relevant, and how they should be characterized if relevant. It will be recalled, for example, that SPE feature theory did not distinguish between palatal sounds and front velars, assigning both to a single noncoronal category (Chomsky and Halle 1968, 308). In their phonetic study, Ladefoged and Maddieson (1996) follow this tradition. However, Keating and Lahiri (1993) cite articulatory and acoustic evidence showing that palatal and front velar sounds constitute distinct phonetic categories, and this distinction appears to function phonologically as well. Though phonemic contrasts are rare, a three-way contrast between palatal / ɲ /, front velar / ŋ’/ and velar / ŋ / is reported in Saami (Lappish) by Maddieson (1992), and indeed, surface contrasts between palatal and front velar stops can be widely expected in languages having fronted allophones of both / c / and / k / before front vowels. The feature system in (4) distinguishes palatals from front velars, treating the former as coronal sounds and the latter as palatalized dorsal sounds.

Before concluding that a reported contrast involving a palatal sound cannot be handled by the system in (4), then, we must establish exactly what type of “palatal” sound is involved. As a case in point, Ladefoged and Maddieson (1996) cite Malayalam as a language having a minimal distinction between palato-alveolar and palatal stops. They state (p. 33):

> Some dialects of Malayalam contrast laminal post-alveolar, palatal, and velar nasals. Although the more well-known dialects of this language contrast only six places of articulation, Mohanan and Mohanan (1984) note that there is a dialect that distinguishes seven places on the surface by having both **n̲** and **ɲ**.

Examples given by Mohanan and Mohanan include both nasal stops (palato-alveolar in man̲naḷ ‘turmeric’ vs. “palatal” in mat̲t̲aŋʼŋʼ pumpkin’) and oral stops (palato-alveolar in maraccu ‘covered’ vs. “palatal” in marakʼkʼu ‘cover-imp’). Neither Ladefoged and Maddieson nor the Mohanans give instrumental evidence establishing the place of articulation of the “palatal” sounds. However, the Mohanans transcribe the “palatals” with the conventional symbols for front velars [k’ ŋ’] and characterize these sounds as differing from ordinary velars in having the feature [-back] in place of [+back]. Furthermore, they describe a process which derives these sounds in the context of front vowels as one of “palatalization,” and refer to these sounds in n. 23 as “velar/palatal.” Textual evidence thus suggests that the “palatal” sounds in this dialect of Malayalam are more likely to be phonologically palatalized velars than true mediopalatals.[8]

The feature system in (4) incorporates the traditional view that all palatal sounds are nonstrident. A further type of potential contrast among coronal stops that cannot be accommodated in feature system (4), then, would be one between palatal plosives such as / c ɟ / and palatal affricates such as [cç ɟ ʝ]. I know of reported contrasts of this type in just two languages, Komi and Iate. The question is whether the release of the reported palatal affricates is nonstrident or strident; in the latter case they would belong to the palato-alveolar or alveo-palatal class (column 8 of (4)).

For Komi, a Finnic language spoken in Russia, Maddieson (1984) assigns the native coronal stops to three series: alveolar, palato-alveolar, and palatal, as shown in (6a). However, Bubrikh (1949) and Lytkin (1966), Maddieson's sources, transcribe the "palatal" affricates with symbols normally used to transcribe strident sounds, as shown in (6b) and (6c). (I have transliterated Bubrikh's symbols according to conventional equivalences between Russian and Western transcription practice.)

(6) a. Maddieson (1984) b. Bubrikh (1949) c. Lytkin (1966)

t		c	t		t'	t		t'
d		ɟ	d		d'	d		d'
	tʃ	cç		tʃ	ts'		č	č'
	dʒ	ɟ ʝ		dʒ	dz'		ǯ	ǯ'

In particular, Bubrikh uses the same symbols to transcribe the fricative release of the affricates as he uses to render the corresponding fricatives / s' z' /, namely, ɜ, c. Neither Bubrikh nor Lytkin provide instrumental evidence that would allow us to identify the phonetic nature of the "palatal" affricates with more precision. However, tapes of a female speaker of Komi kindly provided to me by Alexei Kochetov clearly show the "palatal" affricates to be palatalized sounds with a salient, high-frequency noise component resembling that of strident sounds in other languages, consistently with the transcriptions of Bubrikh and Lytkin. Available evidence suggests, then, that the sounds in question are most likely strident stops, distinguished from the palato-alveolar affricates by their palatalization, and thus not "palatal" in the sense assumed here.

The full set of coronal stops in Iate (Yate), a Macro-Ge language spoken in Brazil, is given by Maddieson as in (7a), following the description of Lapenda (1968).

(7) a. Maddieson (1992) b. da Costa (p.c.)

t	c	d	
th	ch	t	
ts	cç	ts	tʃ
tsh	ɟ ʝ	(ts^{h})	dʒ

I have so far been unable to obtain a copy of Lapenda's work. However, Januacela da Costa, who has carried out field work on Iate, reports a smaller stop system than that reported by Maddieson containing no plosive/affricate contrast at the palatal place of articulation, as shown in (7b). She states (personal communication to this author via Leo Wetzels): "sobre as africadas, a língua não tem uma oposição entre uma plosiva palatal, uma fricativa palatal e uma africada palatal, conforme encontrado no dito trabalho de Lapenda, nem, também, tem uma plosiva palatal como alofone de /t /."[9]

This brief discussion does not exhaust the possible counterexamples to be found in the literature and cannot be regarded as conclusive. A caveat is in order, however. There is a great deal of variability in the literature in the use of terms like "dental", "apical", "palatal", and "palato-alveolar," among others, due largely to the fact that these terms are more often used as impressionistic-auditory labels than as strict articulatory descriptions. Instrumental study often shows such impressionistic labels to be inaccurate (Kim 1997) or to mask considerable interspeaker variation (Dart 1998). Great caution must be exercised, then, in taking impressionistic descriptions of coronal places of articulation at face value.

3.2. Labial stops

Let us next consider labial sounds. The principle of Plosive-affricate Complementary is illustrated by the voiceless sounds shown in (8), which includes fricatives for comparison:

(8)		plosive	affricate	fricative
	bilabial	p	-	ɸ
	labiodental	-	pf, p̆f	f

Crosslinguistically, labial plosives are bilabial and labial affricates are labiodental, at least at their release. Thus the same feature that distinguishes bilabial and labiodental fricatives—whether the traditional feature [+strident] or an alternative—can be used to distinguish plosives from affricates. I know of no counterexamples.[10].

3.3. Dorsal stops

We finally consider dorsal sounds. Representative dorsals, including fricatives for comparison, are shown in (9).

(9)

	plosive	affricate	fricative
velar	k	kx	x
uvular	q	qχ	χ

At first sight, it appears that Plosive-Affricate Complementarity breaks down here, as several languages are reported to have plosive/affricate contrasts such as / k kx /. On closer examination of cases, it turns out that many such contrasts are not minimal after all, and can be analyzed in other ways. A classic case can be cited from Nama, after Trubetzkoy (1969). This language contrasts the simple plosive / k / with the aspirated affricate / kxh /. Its non-click consonants are shown in (10):

(10)

p	t	k	ʔ
	ts^h	kx^h	
	s	x	h
m	n		
	r		

As Trubetzkoy points out, the aspiration of the velar affricate can be plausibly explained as a phonetic consequence of its aspiration. He states: "... it would probably be advisable to consider Nama *kx* (or more precisely *kxh*) an aspirated fortis consonant, and the affrication an irrelevant phonetic phenomenon" (158). Following Stevens and Keyser 1989, we might alternatively say that affrication *enhances* the primary cue to the aspirated consonants, namely their noisy release, at least in some varieties of Nama.[11] Similar treatments can be plausibly extended to Athabaskan languages such as Chipewyan and Navajo, whose aspirated affricated velars occupy the same slot as aspirated stops at other places of articulation, as well as to the / q' / vs. / $q\chi^h$ / contrasts found in Nez Perce and Kabardian.

In certain other languages, the affrication of velars functions as a redundant expression of phonemic length. For example, Avar, a NE Caucasian language spoken in SW Russia and Azerbaijan, has a contrast between short [k'] and long [kk'x] (Charachidze 1981). Pairs such as / ts tts / and / χ χχ / show that length (or intensity, in Charachidze's analysis) is independently distinctive in Avar, and can be taken as the basis of the [k'] vs. [kk'x] contrast. Voiceless dorsal phonemes with their phonetic realizations are shown in (11) (the uvular affricates have alternative pharyngeal realizations).

(11)

	velar:			uvular:	
plosives	affricates	fricative		affricates	fricatives
k [k^h]	kk [kkx]	xx		qq [qqχ]	χ χχ
k’	kk’ [kk’x]	-		qq’ [qq’χ]	- -

This analysis of the long velar affricates follows that of Charachidze, who states: “les fortes, si elles sont physiquement des affriquées, ne le sont pas sur le plan phonologique: c’est là un trait concomitant sans valeur distinctive” (p. 21). Just as the phonetic aspiration of short / k / can be regarded as enhancing the difference between it and its glottalized counterpart / k’ / in Avar, the phonetic affrication of long / kk kk’/ can be seen as enhancing the difference between these sounds and their short counterparts.

In other languages, surface velar or uvular affricates can be viewed as reflecting a stop + fricative sequence. In !Xóõ, a Southern Khoisan language spoken in SW Botswana and Namibia (Traill 1985), we find the three-way contrast [q q’ qχ’]. At first sight, this appears to establish a minimal plosive/affricate contrast in the ejective series. However, an examination of other stem-initial consonants and clusters suggests a different analysis, as shown in (12):

(12)

	dental	postdental	velar	uvular
basic stop	t	ts	k	q
ejected stop		ts’		q’
fricative		s		χ
stop + uvular fricative	tχ	tsχ		
stop + ejected uvular affricate	tqχ’	tsqχ’		qχ’

As Traill points out (p. 207), sequences such as [t χ], [tsqχ’] would be highly unusual if treated as unit consonants; but since their component parts occur independently, they can unproblematically be regarded as consonant sequences such as / t + χ /. The same line of reasoning suggests a parallel analysis of [qχ’] as / q’ + χ /.[12]

A further case involves languages in which alleged velar affricates prove, upon closer examination, to be uvular stops produced with noncontrastive affrication. Though most descriptions of Southern Sotho (Sesotho) list a contrastive velar affricate / kx /, I have found this to be regularly produced as an affricated uvular sound by one native-speaker linguist. Creissels, whose treatment of affricates is much like the one proposed here, states on the basis of unpublished palatography that the supposedly velar affricates in the closely related Tswana language are actually uvular (Creissels 1994: 109 and p.c. 1999).

Varieties of Swiss German are also commonly reported to have a / k kx / contrast, though in at least some cases, this can again be analyzed as non-minimal. Paul Boersma, a phonetician and native speaker, has suggested to me that the dorsal affricate is widely pronounced as a uvular sound in Swiss German dialects (p.c. 1998). According to Astrid Kraehenmann, the dorsal affricate is velar, at least in NE Switzerland, but she analyzes the Thurgau dialect as having a geminate-singleton contrast / kk / vs. / k /, realized as [kk] vs. [kx], respectively (p.c. 1998). Marti (1985) analyzes the sequence / kx / in Bernese as bisegmental / k + x /. The Swiss German facts are complex and deserve more careful study than I have been able to give them so far; it seems, though, that apparent plosive-affricate contrasts among velars may be analyzed in other ways, at least in many cases.

A / k kx / contrast is reported for Nganasan (Tavgy) by Maddieson (1986), but I find no mention of / kx / in either of his sources, Castrén (1854) and Tereshchenko (1966). I have found no further plosive/affricate contrasts at dorsal places of articulation that cannot be treated in one of the ways suggested above.[13]

In this section, we have reviewed evidence suggesting that a rather conservative and highly constrained feature analysis, including the coronal features shown in (4), provides for most (and perhaps all) reliably reported contrasts between plosives and affricates across languages, on the assumption that affricates are simple stops, not characterized as [+continuant]. The introduction of a further representational contrast to characterize affricates (such as the use of contour or complex segments, or a feature [+delayed release]) would vastly overgenerate contrasts among stops, predicting, as simple calculation shows, 120 contrasts instead of the 28 attested ones listed in (5).

4. Affrication and affricate structure

We now turn to a potential objection to the simple-stop analysis of affricates arising from a common process of affrication before high vowels. A selection of some common (and less common) affrication processes is listed in (13).

(13)

process:	examples:
a. assibilation before high vowels and glides: t > ts, tʃ / __ i/j, t -> t^s/ __ u/w	Korean, Japanese, Danish, Bantu, Romance
b. assibilation of palatalized, laminal, or post-alveolar stops: t^j > tʃ	Russian, Polish, Acadian French
c. strident (sibilance) assimilation: t > ts / __ sibilants	Polish
d. strident (sibilance) dissimilation: s s > ts	Basque
e. post-nasal occlusion: n s > n ts	Basque, Bantu, English "intrusive stops"
f. post-stop occlusion: t s > t ts	Russian, Polish
g. phonetic enhancement of aspiration: k^h > kx^h	Nama, Navaho, Old Alemannic

Assibilation before high vowels and glides (13a), which is one of the commonest way of creating affricates cross-linguistically, can be illustrated by the following examples in Japanese, showing alternations of the stem /tat/ 'stand' (Shibatani 1990):

(14) ta[ts]-u (present)
ta[tʃ]-i-mas-u (polite present)
ta[t]-e (imperative)
ta[t]-oo (cohort)
ta[t]-a-nai (negative)

The plosive /t/ is realized as the affricate [ts] before [u] and as [tʃ] before [i]; elsewhere it is realized as [t]. (These alternations are purely allophonic; we take no position here as to whether they are best treated in the phonology or the phonetics.)

The potential objection arises from the analysis of pre-high-vowel assibilation (13a). It is often assumed that affricates are created in this context by [+continuant] spreading as shown in (15):

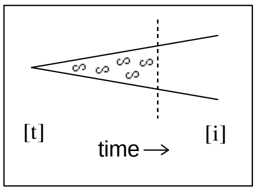
(15) A continuant-spreading analysis?

```
       t      i                    tʃ    i
       |      |         >         / \   /
  [-cont] [+cont]            [-cont] [+cont]
```

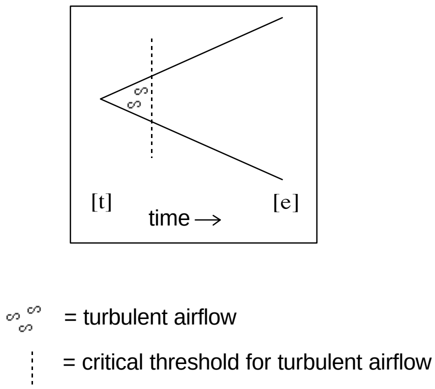
However, given the treatment of affricates as simple stops, this analysis cannot be correct. We have already seen very strong evidence that affricates are not characterized by the feature [+continuant] at any level of the phonology, and do not have the structure of contour segments, as the above analysis would require. Furthermore, this analysis does not explain the appearance of the feature [+strident], which cannot have its source in the vowel.

There is reason to believe that type (13a) affricates are created not by assimilation, but by feature insertion triggered by a phonology-phonetics mismatch. This view derives from the observation that the voiceless aspirated noise following the release of a simple stop consonant into a high vowel may be spectrally similar to the fricative noise of a strident fricative such as [ʃ], which, if sufficiently prominent, can be reinterpreted as the phonetic exponent of a strident affricate (Thomason 1986, Cedergren et al. 1991, Kim 1997, 1999). Such an analysis is schematized in (16):

(16) [t]-release into a high vowel:



[t]-release into a nonhigh vowel:



The first figure in (16) shows the release of a t-closure into a high vowel [i]. Just after the t-release, the stricture is sufficiently narrow to generate turbulent airflow. Such turbulence may have spectral properties similar to those of a palatalized coronal fricative, and if sufficiently prolonged can be interpreted as a feature of the consonant itself.

The second figure compares the release of a t-closure into a mid vowel [e]. In this case the articulators open more rapidly, and consequently the fricative-like turbulence is shorter in duration, and thus less prominent. According to this scenario, high vowels will normally provide a more favorable context for affrication (assibilation) than nonhigh vowels.

Acoustically, this scenario can be visualized in terms of an integrated representational system, or IRS, in which phonological and phonetic tiers are united in a single multi-tiered structure. (17) shows three tiers in the full representation of [ti] and [tʃi]. The root tier displays the root nodes of the phonological part of the representation, which are associated with appropriate phonological features on other tiers, not included here. Each duration node *d* is a variable over the duration of the acoustic values to which is is linked on phonetic tiers, which include tiers for frication noise (as shown here), voicing, aspiration, and so forth. Root nodes which are linked via the duration tier to intrinsic formant values constitute *phones*, and others represent transitional events, or *transitions*, between phones. (See Clements and Hertz 1996 for further discussion.)

In stage A, representing the sequence [ti], the fricative noise constituting the second phonetic event is analyzed as the first event of the inter-phone transition. In stage B, showing the sequence [t͡ʃi], this event is reassigned to the initial stop segment, where it forms the second member of a two-phone sequence characterizing the phonologically monosegmental stop [t͡ʃ]. In these figures, *fr* represents a value of frication noise greater than zero.

(17) Stage A: [ti]

```
t             i      (root tier)
|             |
d   d   d     d      (duration tier)
|   |   |     |
0   fr  0     0      (fricative noise)
```

Stage B: [t͡ʃi]

```
  t͡ʃ          i      (root tier)
 /  \          |
d   d   d     d      (duration tier)
|   |   |     |
0   fr  0     0      (fricative noise)
```

For this analysis to go through, it is not necessary for an intrusive fricative to appear between [t] and [i] on all occasions, in all contexts, or in all languages. It is just necessary that it appear with sufficient frequency in some contexts in a given language for it to come to the attention of speakers. In this case, it may come to be regarded as the exponent of a phonological feature [+strident], and (depending on its spectral characteristics) [-anterior], characterizing the stop. As this analysis gains ground, the language will acquire a phonological rule or constraint causing [t] to be realized as the sibilant affricate [tʃ] before [i]. In a rule-based framework, for example, the resulting analysis could be expressed as in (18):

(18) [coronal,-continuant] -> [+strident,-anterior] / __ i

Once the new analysis enters the grammar, the mismatch between the phonology and the phonetics is eliminated.[14]

I do not know of any strict experimental testing of the intrusive-fricative model of pre-high-vowel assibilation just outlined. Informally, I have found its predictions to be confirmed by my own realizations of [t] before [i] in words like *tea*, where a brief ʃ-like transitional fricative often appears just after the t-burst, preceding aspiration. However, study of spectrograms of the sequence [ti] in the speech of a Kikuyu speaker failed to show similar fricative noise after the burst; for this speaker, the burst was immediately followed by aspiration overlaying visible formant transitions. Further study is needed to show how widespread the intrusive fricative is across languages, what its spectral characteristics are, and how its spectral and temporal characteristics vary across language, context, and speaking style.

There is nevertheless considerable evidence supporting this model, which I summarize below, following the discussion in Kim (1997, 1999):

1. Type (a) affrication typically takes place before high vowels or glides, but rarely or never before nonhigh vowels. The explanation under the reanalysis scenario is that nonhigh vowels do not present a sufficient constriction to produce prolonged frication noise (cf. (16)).

2. Type (a) affrication typically takes place *before*, not after, high vowels. The explanation here is that transitional frication generally occurs at the release phase of a stop, not the arrest phase.

3. Type (a) affrication typically creates strident affricates (ts, tʃ, tɕ, etc.), but rarely nonstrident affricates (tθ, tç, etc.). The explanation here is that the transitional frication noise has a spectral profile characterized by high-frequency, high-amplitude spectral energy resembling that of strident fricatives.

4. Type (a) affrication commonly shifts the place of articulation of anterior [t] to a post-alveolar sound such as [tʃ] before [i], though not before [u]. The explanation is that the transitional frication noise tends to have a spectral profile resembling that of a post-alveolar fricative before [i], but does not have such a profile before [u].

In contrast, the continuant-spreading analysis shown in (15) predicts none of these effects.

The reanalysis scenario makes a number of rather surprising further predictions as well, involving other plosive + vowel sequences. We have so far considered the case of [ti], in which the stop and vowel are relatively homorganic to begin with. What effects might we expect when we consider a heterorganic sequence such as [pi]? In this sequence, the two sounds, being produced by different articulators (lips, tongue front) are easily coarticulated in normal speech, as the tongue front can freely move to the position of [i] before the [p] has been released. If it does this, the lips will open directly into a narrow palatal constriction, which can create an intrusive fricative resembling [s], [ʃ], or [ɕ]. Following a line of reasoning parallel to that developed above, we predict the possibility that "labio-coronal affricates" may arise from labial stops before [i]. Such an effect is well attested in many languages. Some Bantu examples are cited from Guthrie (1967-71) in (19).

(19) "Labio-coronal affricates" in Bantu languages:[15]

*p > ps / __ i	(Manyika S13a)
*p > ps, *b > bz / __ i	(Nyungwe N43)
*p > pɕ / __ i	(Tumbuka N21, Manganja N31c)
*p > ɸsʷ, *b > βzʷ / __ i	(Tswa S51)
*b > bʑ / __ i	(Fang A75)

Indeed, Meinhof (1932: 11) includes [ps pʃ pz pʒ ɸs ɸʃ βʒ] as among "the commonest Bantu sounds." Such sounds are almost always created before high front vowels in Bantu languages, and as noted by Meinhof (1932: 26), Hyman (1976), Ohala (1978), and Thomason (1986), they can be accounted for on an acoustic reanalysis scenario along the lines developed above.

The same reasoning, applied to plosives occurring before the high labial vowel [u], predicts the emergence of "corono-labial affricates" from coronal plosives and "velo-labial affricates" from velar plosives. In these cases, the plosive is released into a narrow labial-velar vowel which can give rise to an intrusive fricative resembling [f] or [v]. Further Bantu examples, also from Guthrie, are given in (20) and (21).

(20) "corono-labial affricates" in Bantu languages:

*t > tfʷ / __ u	(Boma B82)
*t > tʃfʷ / __ u	(Ngɔm B22b)
*d > dvʷ / __ u	(Fang A75)

(21) "velo-labial affricates" in Bantu languages:

*k > kfʷ / __ u	(Bali B75, Boma B82, Ngulu P33)
*g > kfʷ / __ u	(Ngɔm B22b)

In regard to such examples, Hyman states: "Those of us working on Comparative Bantu are used to diverse C_1 modifications which owe their existence to the 'noise' factor frequently surrounding and/or accompanying high vowels" (Hyman 1976, 412). He cites the following example of synchronic alternations between [k] and [f] from Ganda (Luganda):

(22)	<u>verb</u>	<u>adjective</u>
	-afika ‘be cracked’	-afifu ‘cracked’
	-ewuka ‘be light’	-ewufu ‘light-weighted’

and states: "the synchronic alternation between [k] and [f] in present-day Luganda is accounted for by the following historical derivation: kụ > kXu > kfu > pfu > fu" (where X designates "noisy release"). He notes that all intermediate stages in this long chain, including the crucial third step, are attested in various Bantu languages. Once again, this development takes place almost exclusively before high back vowels.

There is one further prediction of special interest. Given the above reasoning, we would expect velar stops such as [k] to be reanalyzed as velo-coronal stops such as [kʃ] before a high vowel [i]. In this case, however, confirming examples are surprisingly rare. A clue as to why this may be so is provided by Meinhof (1932), who suggests that "velo-palatal" affricates such as [gdʒ] may be transitional sounds on the way to "palatal" affricates such as [dʒ]. He hypothesizes the historical chain *ɣ*î* > *gji > dji from Ur-Bantu to Swahili to explain reflexes such as djina ‘name’ (*j* = I.P.A. [dʒ]), and lists the "velar-palatal" sounds he writes as *kj*, *gj* as among the "commonest Bantu sounds" (p. 11). Current phonetic theory regards such sounds as unusual (the I.P.A. provides no symbol for them), but one suspects they may be commoner that is generally thought. Thus, for example, Ladefoged and Maddieson (1996) discuss several examples of velo-palatal stops in Australian languages, and Keating and Lahiri (1993) argue that the palatal stops of Czech and Hungarian may contain both coronal and dorsal components. In the feature model developed here, the fricative corresponding to a front velar is [x’], which according to Hall (1997) is phonologically identical to the high-pitched palatal fricative [ç]. If this is correct, it would be sufficient for this fricative to acquire stridency for it to become reinterpreted as a strident coronal such as [ʃ]. Thus a shift from [k] to [kʃ] before [i] is not phonetically implausible, and a subsequent shift from [kʃ] to [tʃ] might be motivated by considerations of perceptual confusion.

In sum, the reanalysis model of pre-high-vowel affrication is in general quite plausible and its predictions are well-attested, at least in some language groups. It is not entirely problem-free, however. Perhaps most troublesome is the fact that while it readily accounts for the affrication of voiceless stops, it extends less readily to voiced stops, which are less likely to create the conditions favorable to intrusive fricative noise. Yet many languages (e.g. Bantu) create sibilants from voiced stops as readily as from voiceless stops before high vowels, and in some cases do so preferentially (thus the evolution **bu* > *bvu* is much commoner that **pu* > *pfu* in Bantu).[16]

5. Summary and Discussion

This paper has reviewed evidence for the view that affricates are phonological units: that is, simple stops bearing no feature [+continuant] and involving no subsegmental contouring. In this view, the fricative noise associated with the affricate release can most often be regarded as the phonetic implementation of the feature [+strident], as originally proposed by Jakobson, Fant, and Halle (1952). This analysis is strongly confirmed by the principle of Plosive-Affricate Complementarity, according to which the simple-stop analysis of affricates predicts just the attested set of plosive-affricate contrasts and no others, given a rather small set of widely-accepted features.

We have also seen evidence that pre-high-vowel affrication does not involve continuant spreading, but the reanalysis of intrusive fricative segments created by aerodynamic constraints at the stop-to-vowel transition. Once phonologized, this type of affrication is expressed as the insertion of features such as [+strident] and [-anterior]. Affrication thus involves regularization of a *mismatch* between the acoustic and phonological levels of representation (cf. (17)).

Nevertheless, the fact that affricates consist of single segments in the phonology and two segments in the phonetics constitutes a residual case of phonology-phonetics mismatch which cannot be resolved by any further reallocation of phonetic material to phonological segments. In this case, however, the mismatch is a principled one, motivated -- when the affricates are nonlateral sibilants -- by the fact that the features [-continuant,+strident] cannot be produced simultaneously, given their definitions:

- *noncontinuant* sounds are produced with no airflow through the center of the oral tract;
- *strident* sounds are produced with turbulent airflow

It is just this inherent conflict in feature definitions which -- as in the case of feature combinations like [-continuant,+spread glottis] -- requires the incompatible features to be phonetically sequenced. We do not take these cases, then, to be genuine counterexamples to the Congruence Hypothesis of Clements and Hertz (1996), according to which phonological and phonetic representations are (in the ideal case) maximally congruent. Rather, they are systematic exceptions, required by the principle that surface-phonological features must be phonetically expressed.

Notes

*This paper has benefitted from comments and suggestions received from the participants at several meetings, including the LSA Institute, Ithaca, N.Y. (July-August 1997), Current Trends in Phonology II, Royaumont (June 1998), LP 98, Columbus, Ohio (September 1998), and the Workshop on Phonetics and Phonology, Nijmegen (October 1998). Special thanks go to Paul Boersma, Januacela da Costa, Alexei Kochetov, Astrid Kraehenmann, and Keren Rice for their help in understanding languages with which I have no first-hand experience; any mistakes are my own.

[1] It is assumed here that phonological features are not present as such in phonetic representations.

[2] I will generally employ a familiar and somewhat conservative view of feature representation in order to ensure wide intelligibility. However, most of the discussion can be recast in terms of alternative theories of phonological primitives, to the extent that they describe the same natural classes of sounds. Similarly, the choice between "derivational" and "non-derivational" accounts of rule or constraint interaction does not bear directly on the issues discussed here.

[3] See Clements (1987), Mester and Itô (1989: 280) for discussion of theoretical problems raised by allowing direct reference to zero specifications.

[4] Jakobson and Waugh (1979, 141-2), in a defense of the strident-stop analysis of affricates, note that Chipewyan / t^h / is produced with strong velarization, and propose that it is this feature that distinguishes it from / $t\theta^h$ /; the latter can then be treated as a nonvelarized, nonstrident stop, contrasting with velarized / t^h / and strident / ts^h /. While this solution is possible for the aspirated series, it does not extend to the other two series, since / t t'/ are not velarized.

[5] See Halle (1995) for an alternative analysis of Tahltan which does not make use of coronal underspecification, and Kim (1997) for an simple-stop analysis of affricates in which [+strident] is not a coronal dependent.

[6] This remark does not hold of the aperture node system proposed by Steriade (1993, 1994), in which aperture nodes are absent in the underlying representation of stops, and so cannot create lexical contrasts between simple stops and affricates.

[7] It is less clear whether palatal stops are inherently palatalized. Hall (1997) notes that there are no well-attested contrasts between plain and palatalized palatal stops, and proposes that palatal stops are always redundantly palatalized (and thus alveopalatal, in our terms; see below), at least in the surface phonology. This analysis is compatible with the feature description in column 7.

[8] This interpretation has been confirmed to me by K.P. Mohanan, who states that these sounds are "roughly the same as the fronted velar in English 'cue'" (p.c. 1998).

[9] I venture to translate: "Concerning affricates, the language does not have an opposition between a palatal plosive, a palatal fricative and a palatal affricate, as found in the mentioned work by Lapenda, nor does it have a palatal plosive as allophone of /t/."

[10] Mbum, a Niger-Congo language spoken in Cameroon, is cited by Maddieson (1992) as having a voiced labiodental plosive. But this sound, represented as “V” by his source (Hagège 1971), is described there as a “labiodental occlusive,” and in later work by the same author as a “labiodental flap” (Hagège 1975). Labiodental flaps occur with some frequency in central African languages (Greenberg 1981, Cloarec-Heiss 1998). However these sounds are to be characterized phonologically, they pose no problem for the present analysis, since Mbum has no contrasting labiodental affricate.

[11] According to Ladefoged and Traill (1984: 2), in other varieties of Nama the aspirated velar stops “do not have the prominent fricative, scraping sound that can be heard in the variety described by Beach,” who was Trubetzkoy’s source.

[12] Traill transcribes [tχ], [qχ’], [χ] etc., as *tx*, *kx’*, *x*, and lists them as “velars” in his Table 5, p. 151. However, his discussion elsewhere (pp. 100, 142-3, 152-5) confirms that they are indeed uvular (or uvular-pharyngeal) sounds.

[13] Some languages allow heterorganic plosive + fricative sequences, of which the !Xóõ sound [tχ] shown in (12) is representative. Such sequences can usually be treated as involving either a phoneme sequence (as in !Xóõ), a nondistinctive feature of phonetic realization (as in Chipewyan, note 4), or in some cases a minor articulation realized with unusually narrow stricture (as in certain realizations of labialization in Caucasian languages, Comrie 1981, 202-3).

[14] A similar account can be given of the assibilation of [t] to [s] before [u]: here the fricative noise generated at the release may have spectral qualities similar to those of a nonpalatalized coronal fricative such as [s]. For the assibilation of [t] to [tʃ] before [u], see below.

[15] Languages are cited with their Guthrie classification. [^{W}] represents labiodentalized lip protrusion.

[16] Assibilation before high vowels in Bantu languages has sometimes been attributed to the presence of “super-high vowels” at an earlier historical stage. This hypothesis is seriously weakened by the fact that in the vast majority of present-day Bantu languages, including those with four distinctive vowel heights and those in which assibilation has taken place, the high vowels are not reported to be any higher than the typical values of [i u] in other languages. Furthermore, assibilation has taken place under similar conditions in many other languages families (e.g. Romance) for which “super-high vowels” have never been postulated. Nevertheless, high vowels are known to have a narrower stricture in some languages than in others, and the relation between degree of stricture and coarticulatory effect on preceding stops has not yet been fully explored.

References

Bubrikh, D.V. 1949. *Grammatika Literaturnogo Komi Jazyka*. Leningrad: Leningrad State University.

Butcher, A. 1995. “The Phonetics of Assimilation: the Case of Australian Coronals.” In J.W. Lewis, ed., *Studies in General and English Phonetics: Essays in Honour of Professor J.D. O’Connor.* London; Routledge, 10-38.

Campbell, L. 1974. “Phonological Features: Problems and Proposals,” *Lg* 50, 52-65.

Castrén, M.A. 1854. *Grammatik der Samojedischen Sprachen.* St. Petersburg.

Cedergren, H., D. Archambault, and G. Boulianne. 1991. “Stop Assibilation in Quebec French: an Analysis by Articulatory Synthesis,” *Proceedings of the 12th International Congress of Phonetic Sciences*, Aix-en-Provence.

Charachidze, G. 1981. *Grammaire de la langue avar.* Saint-Sulpice de Favières: Editions Jean-Favard.

Chomsky, N. and M. Halle. 1968. *The Sound Pattern of English*. New York: Harper and Row.

Clements, G.N. 1976. “Palatalization: Linking or Assimilation?” In S.S. Mufwene, C.A. Walker, and S.B. Steever, eds., *Papers from the 12th Annual Meeting of the Chicago Linguistic Society (CLS 12)*, Chicago: Chicago Linguistics Society, University of Chicago, 96-109.

Clements, G.N. 1987. “Toward a Substantive Theory of Feature Specification.” In J. Blevins and J. Carter, eds., *Proceedings of NELS 18*, Amherst: GSLA, 79-93.

Clements, G.N. and S.R. Hertz. 1996. “An Integrated Model of Phonetic Representation in Grammar,” *Working Papers of the Cornell Phonetics Laboratory* 11, 43-116.

Clements, G.N. and E. Hume. 1995. “The Internal Structure of Speech Sounds.” In John Goldsmith, ed., *Handbook of Phonological Theory*. Oxford and Cambridge, Ma.: Basil Blackwell, 245-306.

Clements, G.N. and S.J. Keyser. 1983. *CV Phonology: a Generative Theory of the Syllable*. Cambridge, Ma.: MIT Press.

Cloarec-Heiss, F. 1998. “Entre Oubangien et Soudan Central : les langues banda.” In I. Maddieson and T. J. Hinebusch, eds., *Language History and Linguistic Description in Africa.* Trenton: Africa World Press, Inc., 1-16.

Comrie, B. 1981. *The Languages of the Soviet Union*. Cambridge: University Press.

Creissels, D. 1994, *Aperçu sur les structures phonologiques des langues négro-africaines*, 2e édition. Grenoble: ELLUG, Université Stendhal.

Dart, S. N. 1998. “Comparing French and English coronal consonant articulation,” *J of Phonetics* 26, 71-94.

Ewen, C. 1982. “The Internal Structure of Complex Segments.” In H. van der Hulst and N. Smith, eds., *The Structure of Phonological Representations*, part 2, 27-67.

Greenberg, J.H. 1980. “Some areal characteristics of African languages.” In Ivan Dihoff, ed., *Current Approaches to African Linguistics* (vol. 1). Dordrecht: Foris, 3-21.

Guthrie, M. 1967-1971. *Comparative Bantu*, vols. 1-4. Farnborough, Hants: Gregg International Publishers.

Hagège, Claude. 1971. *La langue mbum de Nganha (Cameroun)*. Paris: SELAF 18-19.

Hagège, Claude. 1975. “Some contributions of Central African languages to African linguistics, linguistic theory, and language universals.” In R.K. Herbert (ed.), *Proceedings of the Sixth Conference on African Linguistics*. (Working Papers in Linguistics, 20). Columbus, Ohio: Dept. of Linguistics, The Ohio State University, 148-160.

Hall, T. Alan. 1997. *The Phonology of Coronals*. (Current Issues in Linguistic Theory, 149) Amsterdam: Benjamins.

Halle, M. 1995. “Feature Geometry and Feature Spreading,” *LI* 26.1, 1-46.

Halle, M. and K. Stevens. 1979. “Some reflexions on the theoretical bases of phonetics.” In B. Lindblom and S. Ohman (eds.), *Frontiers in Speech Communications Research.* London: Academic Press. pp. 335-349.

Hoard, J.E. 1967. “Complex phonological segments in distinctive feature theory,” paper presented at the annual meeting of the LSA, Chicago, Ill. Ms.

Hoard, J.E. 1978. “Syllabification in Northwest Indian Languages, with Remarks on the Nature of Syllabic Stops and Affricates.” In A. Bell and J.B. Hooper, eds., *Syllables and Segments*. North- Holland Linguistic Series, 59-72.

Hockett, C.F. 1975. “If you slice it thin enough it’s not baloney,” *American Speech* 47, 233-55.

Hualde, J. I. 1988. “Affricates are not Contour Segments,” *Proceedings of WCCFL* 7, 77-89

Hualde, J. I. 1991. *Basque Phonology.* London: Routledge.

Hume, E. 1994. *Front Vowels, Coronal Consonants and their Interaction in Nonlinear Phonology*. New York: Garland Publishing, Inc. (Published version of 1992 Cornell University thesis)

Hyman, L. 1976. “Phonologization.” In Alphonse Juilland, ed., *Linguistic Studies Offered to Joseph Greenberg on the Occasion of his Sixtieth Birthday.* Vol. 2: *Phonology*, pp. 407-418. Anma Libri.

Jakobson, R., G. Fant, and M. Halle. 1952. *Preliminaries to Speech Analysis: the Distinctive Features and their Correlates*, MIT Press, Cambridge, Ma.

Jakobson, R. and L. Waugh. 1979. *The Sound Shape of Language*. Bloomington: Indiana University Press.

Keating, P. and A. Lahiri. 1993. “Fronted velars, palatalized velars, and palatals,” *Phonetica* 50, 73-101.

Kim, H. 1997. The Phonological Representation of Affricates: Evidence from Korean and Other Languages. Unpublished PhD dissertation, Cornell University, Ithaca, N.Y.

Kim, H. 1999. "A Phonetically-based Account of Phonological Sibilantization," paper delivered at the GLOW Colloquium, Potsdam.

LaCharité, D. 1993. The Internal Structure of Affricates. Unpublished PhD dissertation, Un. of Ottawa.

Ladefoged, P. 1971. *Preliminaries to Linguistic Phonetics* (2nd edition, 1973). Chicago: Un. of Chicago Press.

Ladefoged, P. and I. Maddieson. 1996. *The Sounds of the World's Languages.* Oxford: Blackwell Publishers.

Ladefoged, P. and A. Traill. 1984. "Linguistic Phonetic Description of Clicks," *Lg* 60:1, 1-20.

Lapenda, G. 1968. *Estrutura da Lingua Iate: Falada pelos Indios Fulnios en Pernambuco*. Recife: Universidade Federal de Pernambuco.

Lombardi, L. 1990. "The Nonlinear Organisation of the Affricate," *NLLT* 8 (3). 375-426.

Lombardi, L. 1995. "Affricates, Level-Ordering, and the Feature [strident]," *University of Maryland Working Papers in Linguistics* 3, 89-115.

Lytkin, V.I. 1966. "Komi-Zyrjanski Jazyk" In V.V. Vinogradov, ed., *Jazyki Narodov SSSR*. Vol. 3. Moscow and Leningrad: Nauka, pp. 281-99.

McCawley, J. 1967. "Le rôle d'un système de traits phonologiques dans une théorie du langage," *Langages* 8, 112-123. (Reprinted in the original English as "The Role of a Phonological Feature System in a Theory of Language" in V.B. Makkai, ed., *Phonological Theory: Evolution and Current Practice*, Holt, Rinehart and Winston, 1972, 522-8.)

Maddieson, I. 1984. *Patterns of Sounds*, Cambridge University Press, Cambridge.

Maddieson, I. (with K. Precoda). 1992. UCLA Phonological Segment Inventory Database, version 1.1. Los Angeles: Dept. of Linguistics, UCLA.

Marti, W. 1985. *Berndeutsch-Grammatik*. Bern: Francke.

Martinet, A. 1939. "Un ou deux phonèmes?" *Acta Linguistica* 1, 94-103.

Meinhof, C. 1932. *Introduction to the Phonology of the Bantu Languages*. (Translated and edited by N.J. van Warmelo.) Berlin: Dietrich Reimer.

Mester, R.A. and J. Itô. 1989. "Feature Predictablility and Underspecification: Palatal Prosody in Japanese Mimetics," *Lg* 65.2, 258-93

Mohanan, K.P. and T. Mohanan. 1984. "Lexical Phonology of the Consonant System in Malayalam," *LI* 15.4, 575-602.

Nater, H.F. 1989. "Some comments on the phonology of Tahltan," *IJAL* 55.1, 25-42.

Ohala, J. 1978. "Southern Bantu vs. the World," *Proceedings of the Fourth Annual Meeting of the Berkeley Linguistics Society*, Berkeley: Linguistics Department, Un. of California, 370-386.

Ohala, J. 1983. "The Origin of Sound Patterns in Vocal Tract Constraints," in Peter F. MacNeilage, ed., *The Production of Speech*, N.Y.: Springer-Verlag, 189-216.

Paradis, C. and J.-F. Prunet, eds. 1991. *Phonetics and Phonology*, vol. 2: *The Special Status of Coronals: Internal and External Evidence*. San Diego: Academic Press.

Rice, K. 1987. “The Structure of Structure Preservation: Derived Environments.” In Joyce McDonough and B. Plunkett, eds., *Proceedings of NELS 17*. Amherst, Ma.: GSLA, Department of Linguistics, University of Massachusetts, 501-20.

Rubach, J. 1994. “Affricates as Strident Stops in Polish,” *LI* 25.1, 119-144.

Sagey, E. 1986. *The Representation of Features and Relations in Nonlinear Phonology*, Ph.D. dissertation, MIT, Cambridge, Ma. (Revised version published 1991 by Garland Publications, New York.)

Sasse, Hans-Jürgen. 1976. “Multikolumnale Segmente in der Phonologie,” Working Papers no. 6, Institüt für Phonetik, München.

Shaw, P. 1989. “On the phonological representation of laterals and affricates.” Paper delivered at the Annual Meeting of the LSA, December 1988. Ms., University of British Columbia.

Shaw, P. 1991. “Consonant Harmony Systems: the Special Status of Coronal Harmony.” In Paradis and Prunet, pp. 125-57

Shibatani, M. 1990. *The Languages of Japan*. Cambridge: Cambridge University Press.

Steriade, D. 1993. “Closure, Release, and Nasal Contours.” In M.K. Huffman and R.A. Krakow, eds. *Phonetics and Phonology* vol. 5: *Nasals, Nasalization, and the Velum*. New York: Academic Press. Pp. 401-470.

Steriade, D. 1994. “Complex Onsets as Single Segments: the Mazateco Pattern.” In J. Cole and C. Kisseberth, eds. *Perspectives in Phonology*. Stanford, CA: CSLI Publications, 203-291.

Stevens, K.N. 1999. *Acoustic Phonetics*. Cambridge, Ma.: MIT Press.

Stevens, K.N. and S.J. Keyser. 1989. “Primary Features and their Enhancement in Consonants,” *Lg* 65, 81-106.

Tereshchenko, N.M. 1966. “Nganasanskij Jazyk.” In V.V. Vinogradov, ed., *Jazyki Narodov SSSR.* Vol. 3, 416-37. Moscow: Nauka.

Thomason, Sarah G. 1986. “On changes from palatalized labials to apical affricates,” *IJAL* 52.2, 182-186.

Traill, A. 1985. *Phonetic and Phonological Studies of !Xóõ Bushman*. Hamburg: Helmut Buske.

Trubetzkoy, N.S. 1969. *Principles of Phonology*. (Translation of *Grundzüge der Phonology* 1939, by Christiane A.M. Baltaxe) Berkeley: University of California Press.

Weijer, J.M. van de. 1996. *Segmental Structure and Complex Segments.* Tübingen: Niemeyer.