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On affricates*

Péter Szigetvári

The representation of affricates (and other "two-phase" segments) is far from being undisputed in phonological theory. Some researchers have even questioned whether affricates are monosegmental or rather consonant clusters. Though at present there seems to be consensus on the monosegmental analysis, how this segment should be thought of is a debated issue. This paper collects evidence for and against various views on affricates and it will offer a solution in a unary-element framework which dispenses with any meaningful distinction between contour and non-contour segments. As this paper is planned to be the outset of a larger scale work on segmental representations, I will leave a large number of problems open for further research.

A typical definition of an affricate runs as "a stop released into the homorganic fricative within one and the same syllable and one and the same morpheme" (Catford 1988 : 112). The first part of this definition belongs to the domain of phonetics, while the second part is phonological: syllables are theoretical constructs, the location of a syllable boundary is very often theory-dependent, and morpheme boundaries are even more remote from the physical properties of the speech signal.

A stop followed by a homorganic fricative may phonetically be treated as an affricate, such is often the case with sequences like *ca*[ts], [tr]*ue*. This, however, has little bearing on the issue whether this physical event is one phonological unit or two, that is, whether in an autosegmental representation it should occupy one slot on the timing tier or it should spread out holding on to two. Although the postvocalic parts of *cats* and *catch* sound similar (apart, of course, from the place of articulation), and the initial parts of *true* and *chew* are even closer to each other physically, the relevant portions of the first members of these pairs are almost unanimously considered two units by phonologists, those of the second members are treated as monosegmental: affricates. In this paper I am primarily concerned with the phonological representation of affricates, and will, therefore, disregard such phonetic similarities.

1 Affricates as consonant clusters

Looking for reasons for considering English [ʧ] and [ʤ] consonant clusters one may come up with the fact that these two sound (sequence)s do not pattern with some other, doubtlessly monosegmental sounds, like [t k p f], in branching onsets: beside the possible word-initial onset clusters [tr kw pl fj], *[ʧl], *[ʤw] and the like are ungrammatical. This fact would be neatly explained by supposing that affricates are bisegmental, thus a binary branching onset is saturated by an affricate. In this case *[ʧl] is just as impossible as *[plj].[1]

Another piece of argument for not treating affricates as monosegmental is that they are excluded from "genuine", i.e. word-medial, coda positions, at least in English.[2] The affricates [ʧ] and [ʤ] are either followed by a vowel or by a word- (strong morpheme-) boundary, #. It is not only the two affricates, however, that cannot occupy non-word-final

* I am grateful to Péter Siptár for pointing out a number of typos, stylistic and grammar mistakes and especially for the idea of ranking constraints on head-deletion.

1 Interestingly, *#[sʧ] is also unprecedented. This fact, however, does not corroborate the bisegmental view, since *s*-initial clusters can contain up to three consonants in English (cf. [str spl]), so even if the affricate were a consonant cluster like [tr] this would not immediately exclude it from this position. Instead, we may suspect an accidental gap here: even word-medially [sʧ] occurs only in a handful of words.

2 The codahood of word-final consonants has been seriously threatened (cf. Kaye 1990); in many languages word-final consonants share at least as many properties with onsets as with codas.

coda position in English but also two stops, [t] and [d].[3] This means that the restriction on codas is more general: there is a ban on any [+cor, −cont, −son] segment, i.e. [t d ʧ ʤ], in this position, which then has nothing to do with the mono- or bisegmental status of the consonants in question.

The branching-onset argument exposed above can also be partly explained away. A weak universal restriction on branching onsets is that the segments occupying the two positions cannot be homorganic.[4] Thus *[pw], *[tl], *[ʃj] are ruled out, and this also excludes *[ʧr] and *[ʧj].[5] *Cw* clusters are rather rare in English anyway; for the non-occurrence of *[ʧl] and *[ʤl] one may blame a historical conspiracy: there was no input in earlier stages of the language that any change could have turned into these clusters.[6] Besides these alternative reasons for affricates not turning up in branching onsets in English, it is not even true that an affricate cannot be the first segment in an onset. German provides examples like *Pflanze* 'plant', *Pfriem* 'awl', *zwanzig* [t͡sv] 'twenty'.[7]

Japanese and Hungarian also provide evidence that the consonant cluster view is untenable. Both languages "dislike" branching onsets: Japanese does not have word-initial consonant clusters at all, while Hungarian has them only in words that are usually felt to be foreign by native speakers (Törkenczy 1989). Despite these facts both languages have word-initial affricates: J [t͡suki] 'moon', H *cica* [t͡sit͡sɒ] 'kitty'. Even in languages that do have branching onsets without any restrictions affricates would exemplify the only stop+fricative clusters in this position. English does not feature branching onsets word-finally, hence *cycle* *[-kl] → [-kəl], affricates, however, are not affected by this restriction, they freely turn up at the end of words. Polish definitely forces the analyst to distinguish affricates and stop+fricative clusters, since it makes phonological use of this distinction in pairs like *czy* [ʧɯ] 'whether' vs. *trzy* [tʃɯ] 'three' or *czech* [ʧex] 'Czech' vs. *trzech* [tʃex] 'three GEN' (Jakobson *et al.* 1952). To add a last argument against the cluster view one might mention English stress assignment which treats both parts of an affricate as extrametrical: *mána⟨ge⟩*, for example, patterns like *édi⟨t⟩* and unlike *tormén⟨t⟩* (cf. Harris 1994 : 40).

We have seen that the overwhelming majority of arguments support the monosegmental analysis of affricates. What the representation of this one segment should be is a much less settled issue. This is what we are going to turn to presently.

2 Data and views on affricates

The different views on the status of affricates may be classified into two groups: for the better part of this century they were thought of — if monosegmental — as some (special) kind of plosives (e.g. Jones 1972 : 158; Jakobson *et al.* 1952; Laziczius 1963 : 61; SPE : 177 and 319), while from the 1970s a set of alternative analyses has evolved, which all share the idea of assigning two contradictory values to the feature [continuant] (Hoard 1971; Halle & Clements 1983; Sagey 1986; Hualde 1988; Lombardi 1990). Some researchers have lately returned to the affricates-are-plosives line of research (Steriade 1992, 1993, 1994; Rubach 1994; Schafer 1995), which this paper is also going to argue for.

[3] Word-internal *t/d+C* clusters in English either contain a word boundary (see last note), or are the result of syncope, in which case the stop may be assumed to be in onset position followed by an unpronounced nucleus.

[4] The constraint is violated in, for example, Polish: *błoto* [bw-] 'mud', *pług* [pw-] 'plough'.

[5] For gauging onset homorganicity, [r] must be treated as palatal to allow for [tr]. The cluster [ʃr] seems to contradict the restriction, but there is reason to suppose that it does not constitute a branching onset: its status is similar to *sC* clusters, whatever their status may be (cf. Kaye 1992).

[6] Alternatively, [ʧ ʤ] (as well as [ʃ ʒ]) may be classified as both coronal and palatal, which renders *[ʧl] ungrammatical, but one would still need the "conspiracy" escape hatch for *[ʧw].

[7] Here again the ban on homorganicity is respected, hence *[p͡fv], *[t͡sr], *[t͡sl].

2.1 Pre-autosegmental proposals

The Jakobsonian idea of affricates being strident plosives (Jakobson *et al.* 1952) has been put aside by Chomsky & Halle in their revised feature theory on the grounds that there exist non-strident affricates which do in certain languages (e.g. Chipewyan) contrast with strident ones (SPE : 321–322). What the SPE proposes is the distinction instantaneous release vs. delayed release, where the former characterizes "normal" plosives and the latter affricates. This renders the specification of stridency rather redundant: it now distinguishes affricates in, say, Chipewyan and also certain pairs of fricatives, but these latter also differ in their place of articulation usually. What's more, in this new framework [+strident] is incompatible with [−continuant, −delayed release]. Also, the very natural change $t{+}s \rightarrow \widehat{ts}$*(ː)* becomes very unnatural to express, as shown in (1):

(1) **$t{+}s \rightarrow \widehat{ts}$ as a feature-matrix changing rule**
(place and laryngeal specifications omitted)

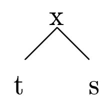
$$\begin{bmatrix} -\text{son} \\ -\text{cont} \\ -\text{del rel} \\ -\text{strid} \\ \vdots \end{bmatrix} + \begin{bmatrix} -\text{son} \\ +\text{cont} \\ -\text{del rel}^{8} \\ +\text{strid} \\ \vdots \end{bmatrix} \longrightarrow \begin{bmatrix} -\text{son} \\ -\text{cont} \\ +\text{del rel} \\ +\text{strid} \\ \vdots \end{bmatrix}$$

Its narrow range of applicability called for alternative models to replace the feature [del rel] very soon after its introduction. Hoard (1971) in his review of the SPE points to two other phenomena that disfavour the [del rel] representation of affricates: (i) the rule $s{+}t \rightarrow \widehat{ts}$*(ː)* is just as marked as its oposite (above), although its occurrence Hoard claims to be very unlikely[9] and (ii) Quileute (an Amerindian language spoken in British Columbia) features the rule *ʧ→ʃ / k__*, which again needs arbitrary feature value changing rules instead of the intuitively obvious deletion of the stop phase of the affricate. What Hoard proposes in order to dispense with this feature is a feature matrix that contains two, sequentially fixed, instances of the feature [continuant], the first with a −, the second with a + value. This, however, goes totally against the type of feature matrices Chomsky & Halle propose.

2.2 The orthodox contour segment analysis

Hoard's idea was revived in autosegmental frameworks, which let the analyst posit one-to-many relationships between features and time segments they are associated with. A typical representation thus looks like the one in (2):

(2) **The representation of [$\widehat{\text{ts}}$] in traditional autosegmental phonology**

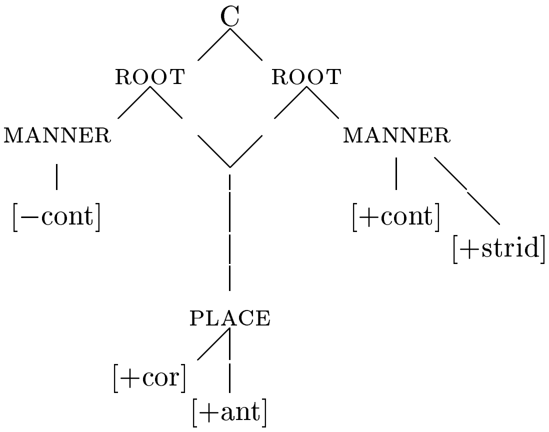


There are several problems with this representation. If the letters are taken, as is usual, to stand for abbreviations of feature matrices, several features (the place, source and major class features) are given twice, which is redundant. It is arbitrary then that there should not exist affricates whose two phases had different place of articulation or differed in voicing. Invoking some type of feature geometry, the model may be simplified having independent features hanging only from the Manner node (Polgárdi 1991 : 13):

[8] Some phonologists characterize fricatives and also some liquids as [+del rel] (cf. Siptár 1994 : 214). This unique move makes the change more natural.

[9] My own observations of child language do not support Hoard's claim: $s{+}t \rightarrow \widehat{ts}$*(ː)* does occur.

(3) **Modified representation of [t͡s]**



(Due to representational difficulties, the laryngeal specifications, which are also shared by the two root nodes, are omitted from the diagram.) The fact that it is the Manner node which holds the features that may be distinct in the two phases is felicitous: in the two usual types of contour segments, affricates and prenasalized stops, the difference between the first and the second half is in the values of [continuant] and [strident] in affricates and in that of [nasal] in prenasalized stops, all of which are dependent on the Manner node.

The underlyingly fixed order of the two halves of an affricate is supported by a set of so-called edge phenomena. In processes whose trigger is to the left affricates often pattern with stops, while in processes that see affricates from the right they behave similarly to fricatives. Zoque (Penutian; Mexico) provides us with an example: postnasal stops are voiced (e.g., /min-pa/→[minba] 'he comes'), whereas fricatives in the same position are not influenced (e.g., [winsaʔu] 'he received'). Affricates are voiced by a preceding nasal, just like stops (e.g., /pʌn-ʧʌki/→[pʌn-ʤʌki] 'figure of a man'; examples from Sagey 1986 quoted in Kenstowicz 1994 : 500). Preglottalization, typical of post-tonic voiceless stops in English, affects the voiceless affricate [ʧ] as well. English plural and past allomorphy shows that affricates pattern with fricatives from the right: they select the vowelless [t]/[d] past allomorph, but the vowelful [ɪz] for the plural, which is what [s z ʃ ʒ] and the opposite of what [t d] do.

Affrication processes like *t+s→t͡s(ː)* also call for an ordered contour segment analysis, derivable from some kind of merger of the adjacent stop and fricative. The same mechanism, however, cannot be applied to other frequently occurring changes resulting in affricates, e.g., *t+j→ʧ(ː)* in English and Hungarian.

2.3 The unordered-feature contour segment analysis

Besides edge phenomena we also encounter facts that argue against a fixed sequential order in contour segments, more specifically, affricates. Basque is particularly rich in such anti-edge phenomena, some of which are illustrated below based on Hualde (1988).

Basque stops are voiced when preceded by a nasal or a lateral:[10] /neka-tu/ → [nekatu] 'get tired PERF', /ar-tu/ → [artu] 'take PERF', but /afal-tu/ → [afaldu] 'have dinner PERF', /ken-tu/ → [kendu] 'take away PERF'. Contrary to expectations affricates fail to be influenced by a preceding nasal or lateral: /neka-tsen/ → [nekatsen] 'get tired IMPERF', /ar-tsen/ → [artsen] 'take IMPERF', /afal-tsen/ → [afaltsen] 'have dinner IMPERF', /ken-tsen/ → [kentsen] 'take away IMPERF'.[11] Fricatives are not voiced either,

[10] I am using Hualde's transcription of the Basque examples.

[11] It is true that most Basque dialects do not have /d͡z/ in their inventory, but even those which do leave the affricate voiceless.

but they are strengthened to affricates in this position: /mendi-sale/ → [mendisale] 'mountaineer', but /ar̄an-sale/ → [ar̄antsale] 'fisherman'.

Another rule palatalizes coronal noncontinuants that occur after a high front vowel or glide: /itaun/ → [it'aun] 'question', /neska-tila/ → [neskatiʎa] 'girl', /ipin-i/ → [ipiñi] 'put PERF'. Affricates, as well as fricatives, are exempt from this rule: /itsar̄-i/ → [itsar̄i] 'awake PERF', /isen/ → [isen] 'name', despite the fact that [t͡ʃ] and [ʃ] both occur in Basque.

Whereas in the two preceding rules affricates did not undergo a change they were expected to, in the following cluster simplification process the affricate is affected by the rule although it should not be. Basque stop+occlusive[12] clusters are simplified by losing the first stop: /bat paratu/ → [baparatu] 'put one', /bat-naka/ → [banaka] 'one by one'. Fricatives do not take part in the process, while affricates, in this case located to the left of the trigger and thus showing their fricative face, are nevertheless simplified into a fricative: /its-tegi/ → [isteɣi] 'dictionary', /arits-mendi/ → [arismendi] 'oak mountain'.

Lombardi (1990) cites Yucatec Mayan examples, in which the first element of homorganic stop+plosive sequences turn into [h] (*tt͡ʃ→ht͡ʃ, kk→hk*), but affricates in the same environment become fricatives (*t͡st→st, t͡ʃt→ʃt*): both stops and affricates lenite, although the latter show their fricative face towards the trigger. Turkish also offers an example of an anti-edge phenomenon (Hualde 1988, Lombardi 1990). Word-final noncontinuant obstruents are devoiced in this language, but fricatives remain voiced: [kanat] 'wing' ([kanadɯ] 'wing ACC') vs. [kɯz] 'daughter'. Affricates pattern with stops in devoicing word-finally: [pabut͡ʃ] 'slipper' ([pabud͡ʒu] 'slipper ACC'). This defies our expectations, since the trigger, the word boundary, is adjacent to the fricative phase of the affricate.

Proponents of unordered contour segments thus retain the [−cont], [+cont] specifications (or, rather, the [stop] and [cont] privative features), but argue that the two features are not ordered lexically and throughout the phonological derivation. It is only the phonetic interpretation that introduces their order, which is predictable, hence redundant underlyingly.

2.4 An edge–anti-edge phenomenon

Hungarian adaffrication exhibits both edge and anti-edge phenomena. The following chart summarizes the changes, the affricate outputs are set in boldface:

(4) **Hungarian adaffrication**

	s	t͡s	t
s	sː	st͡s	st
t͡s	**t͡sː**	**t͡sː**	t͡st*
t	**t͡sː**	**t͡sː**	tː

*[st] is also possible in fast speech

As the first element of a cluster, affricates pattern with stops, despite the fact that it is their fricative phase which is closer to the other segment involved in the change. As the second element, they pattern with fricatives, although this time it is their stop phase that is towards the other component of the change. Preceding a stop, however, an affricate behaves like a fricative: neither forms a geminate with the stop. An attempt at an explanation will be made in section **3.1,** where the process will also be discussed in more detail.

2.5 Rubach's proposal

Summarizing the predictions of the ordered and the unordered contour segment analyses, Rubach (1994) concludes that the former fares better in the Dental Spreading rule of Polish

[12] I am using the term "occlusive" to include stops, affricates and nasals ([−cont]), while by "plosive" I mean stops and affricates ([−cont, −son]).

(in which [s] spreads its place on the preceding sibilant, [t͡s] does not), and also in Nasal Gliding (*n*→*w̃*, *ɲ*→*j̃* before a fricative, but not before an affricate). Even the ordered contour segment analysis fails, however, in the case of Fricative Assimilation: [s] and [z] assume the place of articulation of any following postalveolar or prepalatal consonant, but [t͡s] and [d͡z] fail to do so, unless the following consonant is [ʂ ʐ ɕ ʑ] or their affricate counterparts. This analysis also runs astray in Strident Assimilation, where [s z t͡s d͡z] assimilate to the place of articulation of the following strident consonant and, in addition, [t d] become affricates.

As a solution Rubach offers the revival of the Jakobsonian idea of affricates as stops distinguished by the feature [+strident]. Although the rules he brings up are better explained by this hypothesis than by any of its competitors, the whole device is set in a framework that applies orthodox rewrite rules that are subject to rule ordering, mechanisms that are probably too strong for the description of natural languages.

2.6 Schafer's model

In a recent paper Schafer (1995) proposes an asymmetrical relationship between Lombardi's two privative features [stop] and [cont]. Stops contain the feature [stop], fricatives [cont], both residing on the primary stricture tier. Affricates on the other hand have two stricture tiers, with the feature [stop] on the primary and [cont] on the secondary stricture tier. The [cont] feature of the secondary stricture tier is dominated by the [stop] of the primary stricture tier. Lenition of stops and affricates to fricatives results from the association of a [cont] feature to the segment, but being located on the primary stricture tier this feature substitutes the [stop] feature of the target. This configurational model thus predicts that affricates and stops pattern together, since both have the feature [stop] on the primary stricture tier. Schafer cites data from the Toscana dialect of Italian and the Tsimshian Salish language Nisgha to show the prediction to be correct.

In discussing the postnasal strengthening in Tswana, Schafer's representation successfully demonstrates why affricates do not strengthen to stops, but has some difficulty in accounting for the different behaviour of fricatives.

2.7 Steriade's model

Steriade (1992) observes that: (i) only plosives (stops and affricates) can be contour segments, (ii) and they can be contour segments only if they are released and (iii) contour segments never exceed two articulatory phases. She claims, in effect, that not only affricates and prenasalized stops but any stop which is released is a contour segment, since all of them contain two aperture nodes, which are "rather similar to the feature-geometric notion of root-node; [they have] the same functions of anchoring segmental features like place of articulation, nasality, and laryngeal features, and of connecting segments to prosodic structures such as syllables and moras" (Steriade 1993 : 401).

For consonants Steriade proposes three types of aperture nodes: A_0 representing "total absence of oral airflow" ([−cont]), A_f for a "degree of oral aperture sufficient to produce a turbulent airstream" ([+cont, −son]), and A_{max}, which is the "maximal oral aperture in consonants" ([+cont, +son]) (*op.cit.* : 402). A released stop contains the two aperture nodes A_0A_{max}, while for an affricate these are A_0A_f, a solution somewhat reminiscent of the SPE's [instantaneous release] vs. [delayed release] features. Plosive releases, however, are not present underlyingly, but are projected during the derivation by the following universal process (*op.cit.* : 404):

(5) **Universal projection of plosive releases**
$A_0 \rightarrow A_0A_{max}$

The projection of A_{max} vs. A_f depends on place of articulation or, less frequently, on aspiration, on a language specific basis. Thus a labial stop typically projects A_{max}, while a labiodental will have an A_f release. Such a solution presupposes that no language contrasts a stop and an affricate at the same place of articulation and with the same laryngeal specification. This position is threatened by the fact that the place of articulation of Hungarian [t] and [t͡s] appear to be indistinguishable by phonological features: both are apical and denti-alveolar. Maddieson lists six other such languages: Tuva, Tamang, Tzeltal, Squamish, Standard Thai and Malgasy (1984 : 207, 221), and Rubach (1994 : 121) points out the same difficulty Steriade has to face in the case of Polish [s] and [t͡s]. The claim that the manner specification of stops and affricates is not distinct underlyingly thus seems untenable.

3 A unary elemental approach

The representation I am to propose for affricates is couched in a framework that posits unary, independently pronounceable elements as phonological primes (Kaye *et al.* 1990, Harris & Lindsey 1995, Brockhaus 1995). In other words, the building blocks of sounds are other, more basic sounds (called elements), which themselves are atomic. It is standardly assumed that one of the elements is special in being the head of the expression forming a segment. The acoustic (and articulatory) properties of the head are modified by the salient properties of the other elements within the expression. Given two elements like **U**=[w][13] with labiality as its salient property and **h**=[s] with noise as its salient property, **U.h** (where the head appears after the dot by convention) yields a labial noise, [f], **h.U**, on the other hand, is a noisy labio-velar, [ʍ].

The following chart introduces the elements relevant for the discussion, based on Harris (1990), Brockhaus (1995 : 105) and Szigetvári (1996):

(6) **Some unary elements**

ʔ = [ʔ]	occlusion, abrupt spectral change
h = [s]	narrowed, noise, stridency
H = [h]	spread glottis, aspiration, rise in pitch
R = [ɾ]/[ɜ]	coronality, rise in spectral amplitude[14]
I = [j]/[i]	palatality, large spectral gap
U = [w]/[u]	labiality, fall in spectral amplitude

These elements can be likened to features of orthodox feature theories: e.g., **ʔ** is similar to [−cont] (or [stop]), **H** is like [+spread glottis] and **R** parallels [+cor]. There is no equivalent of [+cont], [−spread glottis] or [−cor], however. The element **h** represents the noise typically accompanying obstruents: it is present in released stops, affricates and (most) fricatives. If anything then, it can be compared to [−son]. There are, nevertheless, major differences between elements and features. Elements are necessarily privative, we have seen that **ʔ**'s ([−cont]) opposite value, [+cont], cannot be expressed in any way, and the same is true of all other elements. Lombardi's and Schafer's apparently privative [stop] and [cont] features are in fact two denominations for the two values of an equipollent feature. Elements are also different in not being abstract phonological constructs like features, but pronounceable sounds. The element **R**, for example, besides being [+cor] is also [+cont], [+son], etc., it is [ɾ] (when consonantal or [ɜ] when vocalic). Properties internal to the sounds that elements encode are inaccessible to the phonological machinery.

Using the elements introduced in (6) we may posit the segmental representations displayed in (7):

[13] When dependent on a nuclear slot, the interpretation of **U** is [u].

[14] Two comments are due here: (i) the existence of this element is debated, I will, nevertheless, make reference to it for simplicity's sake and since here nothing crucial hinges on it and (ii) the two interpretations depend again on whether a non-nuclear or nuclear slot dominates it.

(7) a. [t]=**Rh.ʔ**
b. [tʰ]=**RHh.ʔ**
c. [t˺]=**R.ʔ**
d. [t͡s]=**Rʔ.h**

The representation of the coronal stop, [t], is **Rh.ʔ**, that is, a coronal noisy occlusion (7a). An aspirated stop includes the element **H** in addition to those yielding its unaspirated version: [tʰ] can be represented as **RHh.ʔ** (7b) (cf. Kaye *et al.* 1990 : 216; Harris 1994 : 133ff.). What an unreleased stop lacks is the noisy burst that accompanies the release phase. Since **h** is responsible for this noise, [t˺] is best modelled as **R.ʔ** (7c) (cf. Harris 1990 : 280). The proposal being made here is that by promoting the noisy **h** element to head position in the segment we obtain a plosive which is different from a normally released plosive by being more noisy, that is, an affricate.

The fact that plosives in word-final consonantal positions may and in word-internal codas must lose (or, rather, simply lack) the **h** element may be an instance of lenition, which is typical of these positions. Hungarian, as we will see in the next section, provides a worrying counterexample to this generalization. It is also intriguing why a stop in onset position followed by a pronounced vowel must contain **h**. Steriade, who also encodes the phonologically nondistinctive difference between released and unreleased stops in the representation, proposes a universal release projection rule (5). In our case this would amount to introducing **h** from outside the representation in certain prosodic configurations, certainly an undesirable development. So we have to content ourselves with accepting the impossibility of an **h**-less stop in prevocalic position.[15]

3.1 Some analyses

One of the arguments in favour of the ordered contour segment analysis was the frequent occurrence of the affrication process: *t+s→t͡s(ː).* This change is part of a set of changes dubbed adaffrication and described by Polgárdi (1991) and Siptár (1994 : 210). The changes are listed in (8):[16]

(8) **Adaffrication**

a. t+s→t͡sː, e.g., *ötször* 'five times', *ötödször* 'for the fifth time'
a′. t+ʃ→ʧː, e.g., *barátság* 'friendship', *szabadság* 'freedom'
a″. c+s→t͡sː, e.g., *füttyszó* 'whistle sound', *négyszer* 'four times'
a‴. c+ʃ→ʧː, e.g., *agysejt* 'brain cell'

b. t+t͡s→t͡sː, e.g., *hat cica* 'six kitties', *vad cica* 'wild kitty'
b′. t+ʧ→ʧː, e.g., *hat csók* 'six kisses', *vad csók* 'wild kiss'
b″. c+t͡s→t͡sː, e.g., *nagy cézár* 'great Caesar'
b‴. c+ʧ→ʧː, e.g., *nagycsütörtök* 'the day before Good Friday'

c. t͡s+s→t͡sː, e.g., *malacszerű* 'pig-like'
c′. t͡s+ʃ→ʧː, e.g., *akácsor* 'row of acacias'
c″. ʧ+s→t͡sː, e.g., *csecsszopó* 'suckling', *bridzsszék* 'chair for playing bridge'

d. t͡s+t͡s→t͡sː, e.g., *malaccomb* '(pig's) ham'
d′. t͡s+ʧ→ʧː, e.g., *malaccsülök* 'pig's hoof'
d″. ʧ+t͡s→t͡sː, e.g., *ácsceruza* 'carpenter's pencil'

[15] If the [t] of a [tr] cluster could be proven not to contain **h**, the nonexistence of affricate+liquid/glide clusters would gain an explanation: in lack of **h** a stop and an affricate cannot be distinguished. Steriade proposes that such [t]'s only have an A_0 aperture node as a result of release merger, that is, they have no release (1994).

[16] Hungarian spelling quite faithfully renders underlying consonantal segments. The idiosyncratic letter-to-sound correspondences involved are the following: *sz*=[s], *s*=[ʃ], *c*=[t͡s], *cs*=[ʧ], *dzs*=[ʤ(ː)], *ty*=[c], *gy*=[ɟ].

I have ignored the laryngeal distinctions in the changes because their inclusion would have made the number of changes almost four times as many without much use: the laryngeal specification of the resulting affricate is always that of the second component of the input. In the examples both voiceless and voiced cases were given when possible. All the processes in (8) result in geminate affricates.[17] The inputs in (8a) are stop+fricative clusters, in (8b) stop+affricate clusters, in (8c) affricate+fricative clusters and in (8d) affricate+affricate clusters. The place of articulation is determined by the second component, similarly to the case of laryngeal properties.

In formulating rules for these changes in the ordered contour segment framework Siptár (1994 : 260ff.) runs into several problems. He has a uniform rule dealing with stop+fricative and the stop+affricate affrication (which could only be done by two SPE-type rules), but then has to formulate a separate rule for stop+affricate affrication, which occurs in itself, too, as (8b) demonstrates. The unary element model copes with all four changes under the influence of two rather universal constraints, as proposed in (9):

(9) **Coda conditions**[18]
   a. Coda cannot independently license **ʔ**.
   b. Coda cannot simultaneously license **h** and **ʔ**.

Condition (9a) states that a noncontinuant segment, which contains **ʔ**, cannot be followed by a continuant, which does not contain **ʔ**. Thus in the optimal coda–onset cluster the onset licenses a **ʔ** element, either on its own or shared with the preceding coda. A situation violating the condition typically arises in nasal+fricative clusters, and can be cured in one of two ways: (i) by postnasal hardening, the coda containing the nasal passes the burden of having to license the **ʔ** to the following onset, thus making it an affricate or a stop (cf. English *prin*[t]*ce*, also see Steriade 1993 : 420ff.) or (ii) by vocalization, deleting the **ʔ**, which may result in the total loss of the nasal consonant and possibly leaving residual nasalization on the preceding vowel (cf. Polish *kunszt* [kuw̃ʃt] 'art', Hungarian *kunszt* [kũst] 'trick', Lithuanian *sąžinė* [saːʒineː] 'conscience', which contains a *saN-* prefix). The second coda condition (9b) is similar to Steriade's (1992) claim that the release phase of plosives is lost: $A_0A_{f/max} \rightarrow A_0$ in coda position. This condition can again be satisfied in two ways: by deleting either **ʔ** or **h**. The choice appears to depend on a language specific parameter, but other factors may modify it. As the following show, Hungarian by default chooses to delete the **h** element of the coda. We will see below that there are cases when condition (9b) is satisfied by the deletion of **ʔ** or it is not satisfied at all.

The processes in (8) can be formalized as shown in (10):

(10) **Adaffrication processes**
(place and laryngeal specifications omitted, heads underlined)

$$
\begin{array}{llllllll}
\text{a.} & \text{t + s} & \text{b.} & \text{t +}\widehat{\text{ts}} & \text{c.} & \widehat{\text{ts}}\text{+ s} & \text{d.} & \widehat{\text{ts}}\text{+}\widehat{\text{ts}} \\
 & \text{x}\quad\text{x} & & \text{x}\quad\text{x} & & \text{x}\quad\text{x} & & \text{x}\quad\text{x} \\
 & |\quad\; | & & |\quad\; | & & |\quad\; | & & |\quad\; | \\
 & \cancel{\mathbf{h}}\quad \underline{\mathbf{h}} & & \cancel{\mathbf{h}}\quad \underline{\mathbf{h}} & & \underline{\cancel{\mathbf{h}}}\quad \underline{\mathbf{h}} & & \underline{\cancel{\mathbf{h}}}\quad \underline{\mathbf{h}} \\
 & |\quad\; | & & |\quad\; | & & |\quad\; | & & |\quad\; | \\
 & \underline{\text{ʔ}}\gg & & \underline{\text{ʔ}}\quad \text{ʔ} & & \text{ʔ}\gg & & \text{ʔ}\quad \text{ʔ}
\end{array}
$$

The coda **ʔ** in (10a and c) spreads to the following onset position. The coda **ʔ** in (10b and d) is fine: it is supported by the following onset's **ʔ** element. (OCP probably merges the

[17] This is a simplification of the facts: the cases in (8a and b) occur practically obligatorily, but those in (8c) and (8d) are effected only with the increase of tempo. This will gain importance below.

[18] Coda here means the first position of the consonant cluster. I ignore the question whether this is in fact a coda position or some other type of lenition site.

two, but this has no bearing on the issue discussed.) The coda's **h** is deleted in all four cases. As a result the codas are all containing **ʔ** and the following onsets **ʔ.h**, that is [tts] (=[t͡sː]).

With the representations and conditions given, the gemination of [tt], (11a), can also be produced: the first [t] loses its **h**, becoming unreleased, the second is not changed, the result is a geminate [tː]. [s]-initial clusters, [st] and [st͡s], are not affected since their first element does not contain both **h** and **ʔ** (11b). Affricate+stop clusters do pose a problem, however. What we expect to happen here is that the **h** deletes and thus the first element becomes an unreleased stop: *t͡s+t→tː*. This is not what happens. If anything, it is the **ʔ** element that deletes (11c), but in careful speech nothing happens (11c′): *strucctoll* [-t͡st-]∼[-st-] 'feather of an ostrich', *becstelen* [-t͡ʃt-]∼[-ʃt-] 'dishonest'. Comparing the representations in (11) with those in (10), there seems to emerge a condition, which is somewhat arbitrary in this framework,[19] stating that the **h** of simultaneous **h** and **ʔ** coda elements can only be deleted if it is not head or if the next segment's head is also **h**:

(11) **Further coda releases**

$$
\begin{array}{lcclcclcclcc}
\text{a.} & \text{t} + & \text{t} & \text{b.} & \text{s} + & \text{t}/\widehat{\text{ts}} & \text{c.} & \widehat{\text{ts}}+ & \text{t} & \text{c}'. & \widehat{\text{ts}}+ & \text{t}\\
 & \text{x} & \text{x} & & \text{x} & \text{x} & & \text{x} & \text{x} & & \text{x} & \text{x}\\
 & | & | & & | & | & & | & | & & | & |\\
 & \cancel{\mathbf{h}} & \mathbf{h} & & \underline{\mathbf{h}} & \mathbf{h} & & \underline{\mathbf{h}} & \mathbf{h} & & \underline{\mathbf{h}} & \mathbf{h}\\
 & | & | & & & | & & | & | & & | & |\\
 & \underline{\textbf{ʔ}} & \underline{\textbf{ʔ}} & & & \textbf{ʔ} & & \cancel{\textbf{ʔ}} & \underline{\textbf{ʔ}} & & \textbf{ʔ} & \underline{\textbf{ʔ}}
\end{array}
$$

The Basque stop deletion and affricate spirantization rules seem to be governed by the same conditions as the Hungarian adaffrication rules. The condition in (9a) is not applicable in this case since there are no plosive+fricative clusters in the input (at least as far as Hualde's data are concerned). The constraint (9b) formulates is satisfied by the other option in Basque: whereas in Hungarian it was the **h** element that was deleted by default, in Basque it is **ʔ**.

(12) **Basque stop deletion and affricate spirantization**
(place and laryngeal specifications omitted, heads underlined)

$$
\begin{array}{lcclcc}
\text{a.} & \text{t} + & \text{p} & \text{b.} & \widehat{\text{ts}}+ & \text{t}\\
 & \text{x} & \text{x} & & \text{x} & \text{x}\\
 & | & | & & | & |\\
 & \mathbf{h} & \mathbf{h} & & \underline{\mathbf{h}} & \mathbf{h}\\
 & | & | & & | & |\\
 & \cancel{\underline{\textbf{ʔ}}} & \underline{\textbf{ʔ}} & & \cancel{\textbf{ʔ}} & \underline{\textbf{ʔ}}
\end{array}
$$

In the representation proposed the difference between the manner structure of a stop and an affricate is one of headedness. If an affricate loses its **ʔ** element, what remains is its head, **h**, interpreted as a fricative (12b). This is the case of /its-tegi/ → [isteɣi] 'dictionary'. When a stop loses the **ʔ** on the other hand, it loses its head,[20] and the remaining headless expression, **h.**_, is uninterpretable in Basque, cf. /bat paratu/ → [baparatu] 'put one'. Following

19 The state of affairs seems to call for an Optimality Theoretic account along the following lines: the coda conditions in (9) are violable constraints. A constraint DON'T-DELETE-HEAD is ranked higher, so when satisfying (9b) would entail deleting the head either nothing happens, thus fulfilling PARSE, or the **ʔ** element is deleted, violating the language specific parameter requiring that **h** be deleted of simultaneous coda **ʔ** and **h**. Somehow — the details are to be worked on — deletion of a head is more feasible if the following onset has the same head, cf. (10c and d). To further complicate the issue, it must be admitted that no change and deletion of **ʔ** is also possible in affricate+affricate clusters (e.g. *malaccomb* [-t͡sː-]∼[-t͡st͡s-]∼[-st͡s-] 'pig's ham'), implying a very intricate hierarchy of constraints.

20 DON'T-DELETE-HEAD is probably lowly ranked in Basque.

a completely unrelated line of inquiry, Backley has proposed **h._** to be the representation of [h] (1993 : 315). This interpretation would explain both the Basque case, which lacks the segment [h], and the Yucatec Mayan examples, where homorganic stop+stop clusters become [h]+stop.

3.2 A problem with place

As we have seen the unary element proposal is far from being without its own disadvantages. A serious problem is caused by the fact that the adaffrication processes formalized in (10) hold only for coronals and palatals, not for labials and velars. There is no formal way of capturing these two places of articulation in this framework. Coronals may be assumed to contain an **R** element, while palatals have an **I**. Even if we further assume that palato-alveolars have both **R** and **I**, we can only involve the place elements if we posit a rule that makes reference to them: there is nothing in **R** (or **I**) in itself that should make coronals more prone to this process than fricatives and stops at other places of articulation. Though including place specification in the rule is the standard way of dealing with the phenomenon, rules involving but not affecting place elements are too strong a device and ought to be eliminated. The problem thus remains but it can be parallelled by a number of other facts that seem connected.

Greek stop+fricative (i.e., stop+[s]) clusters can only contain a noncoronal stop: [ps], [ks] vs. *[ts], and the same applies to morpheme-internal clusters of English and many other langauges. That coronal noncontinuants are less stable than noncoronals is also evidenced by nasal+continuant clusters. Whereas clusters like [ms] usually retain their nasal noncontinuant (or may even cause postnasal hardening in, say, Hungarian: *szomszéd* [som(p)seːd] 'neighbour'), in [ns], as we have seen above, the nasal dissolves into the preceding vowel. The instability of the coronal stop and affricate could well be the cause for their willingness to merge with the following strident fricative or affricate in adaffrication processes in Hungarian.

4 Conclusion

We have seen that phonological models of affricates have changed considerably during the past decades. The false predictions of contour segment analyses called for alternative representations. These likened affricates to stops either by saying that neither are contours (Schafer 1995) or that both stops and affricates are contour segments inasmuch as both have two root nodes (Steriade's works). This paper follows the first of these approaches since it does not distinguish stops and affricates on the one hand and other segments on the other in the number of root nodes they possess, but instead it is claimed that the two types of plosives differ in the dependency relations of their "stricture" elements: stops are noncontinuant (**ʔ**) headed, while affricates are headed by noise (**h**). Examining Hungarian adaffrication we have found that the development of well-formed codas seems to be governed by ranked constraints and that place specifications have their role in the behaviour of the stricture properties of these segments, the exact details remain a mystery.

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Theoretical Linguistics Program
Eötvös Loránd University (ELTE)
1014 Budapest, Színház utca 5–9, Hungary

szigetva@budling.nytud.hu