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Complex Onsets as Single Segments: The Mazateco Pattern

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1 Introduction[1]

1.1 Summary

In 1947, Kenneth and Eunice Pike (PP) published an analysis of syllable structure in Huautla Mazateco, an Otomanguean language of Oaxaca, Mexico. PP's study of Mazateco is the first systematic illustration of the idea that syllables have hierarchically arranged internal structure, or, as PP put it, "successive layers of immediate constituents" (1947:78). In this account, the onsets of Mazateco, in addition to the rimes, were analyzed in terms of headed subconstituents: each complex onset contained a principal and a subordinate constituent, and each principal constituent could in turn be divided into a principal and a subordinate member. I offer here a new analysis of PP's data, which eschews constituent structure in onsets, but does offer an understanding of the basic intuition that led PP to the principal/subordinate distinction.

The analysis I present will rely on the hypothesis that plosives (stops and affricates) have representations in which their closure and release appear as distinct positions, capable of independently anchoring distinctive features. The Mazateco data, along with similar patterns of onset formation from other Amerindian languages, will show that plosives have more clustering possibilities than continuants, because plosives are bipositional.

A distinct ingredient of our account will be the idea that the degree of markedness in onset clusters is at least in part determined by the degree of similarity between the cluster and a single consonant: the better the onset, the closer it is in structure and feature composition to a single segment.

Although most aspects of the onset inventory discussed here are independently attested in other American Indian languages, the overall system, shown below in (1), looks highly unusual when compared to the obstruent-

[1]The material presented here originates as lecture notes for a UCLA seminar in the Spring of 1991. I am grateful to the participants for their comments. I would also like to thank the members of the UCLA phonetics Laboratory, who made possible the completion of this work by providing help and companionship: Dani Byrd, Edward Flemming, Rob Hagiwara, Joyce McDonough and Michael Shalev.

liquid or obstruent-glide clusters found in the better-studied Indo-European or South-East Asian languages:

(1) The Mazateco onset inventory in outline

a. n-plosive h-plosive ?-plosive consonant-h consonant-?
n-plosive-h
n-plosive-?
?-n-plosive
h-n-plosive

b. s-plosive
s-plosive-?

Some Mazateco dialects possess both the (1.a) and the (1.b) clusters, while others are limited to a subset of the clusters in (1.a). The suggestion made here is that onset systems like (1) are governed by the same organizing principles as standard onset inventories of the type {single C; or pr, tr, kr, pl, kl}. If anything, the more unusual cluster set in (1.a) will emerge as better, i.e., structurally closer to the optimal single C onset, than the standard collection of obstruent-liquid clusters.

1.2 Constituent Structure

The aspect of PP's study that I focus on here is their hierarchical analysis of Mazateco onsets. Their claim is that a complex onset divides between a principal and a subordinate constituent. An example is /nts?/ which is analyzed into the subordinate /n/ and the principal unit /ts?/. The principal unit further subdivides into a principal (/ts/) and a subordinate (/?/) member. In bracketed notation, the structure PP assigned to such strings would be [n[[ts]?]].

More recent attempts to find hierarchical structure within the syllable – beyond the widely, though not universally, accepted division into rime and onset – have not met with considerable success. Kiparsky (1979, 1980) and Cairns and Feinstein (1982) have claimed that certain phonotactic properties of the onset can be expressed with the help of constituent structure. But neither proposal would be compatible with Pike and Pike's findings in Mazateco, as we shall see. Levin (1985) has used the X-bar notions of head, complement and specifier to distinguish subconstituents of the syllable. Levin's head/non-head distinction does correspond to PP's principal/subordinate distinction. But Levin did not find compelling reasons to extend this distinction to the onset. In general one expects all prosodic constituents – above and below the level of the syllable – to be the domain

of phonological rule application. But the subconstituents of the onset, in all theories that postulate them, never play this role of prosodic domain.[2] Their only function is to facilitate some characterization of the notion possible onset in language L. This is, in part, why we view them with some doubt.

At the same time, PP were clearly justified in thinking that there are differences of status between the various components of a Mazateco onset. The central observation in this regards is that, while any Mazateco consonant can be the unique occupant of the onset position, larger onset clusters divide into members that are largely unrestricted and members drawn from a very small, systematically restricted set of non-primary articulations: the laryngeals, /h/ and /?/, and nasality, transcribed as /n/. PP called the unrestricted members principal and the restricted ones subordinate. (Hockett (1955), who had adopted some of their ideas, referred to the subordinate members as *satellites*, a term I will occasionally use here.). Thus /ts/ is the principal member of the onset [n[[ts]?]] because any plosive could occupy its position. /N/ and /?/ are subordinate, or satellites, because one cannot randomly substitute segments for them and still obtain a well-formed Mazateco onset: in this particular cluster only /h/ could be substituted for /?/ (yielding /ntsh/) and only /h/ could replace /n/ (yielding /hts/), though not both simultaneously (since all /hCh/ are disallowed). I will review below the grounds for this distinction between restricted and unrestricted members. But two fundamental points can be made immediately. First, any description of Mazateco must explain the restrictions on cluster composition which PP characterized by means of headed constituent structure: we must understand why it is that only /h/, /?/ and /n/ are satellites in the Mazateco onset system and under what conditions they may co-occur with other features. Second, there is no intrinsic connection between the fact that the satellites belong to the small set of non-oral articulations and the hierarchical relations postulated by PP. Neither PP nor Hockett explained what exactly it was that the primary/subordinate distinction contributed to an explanation of the facts they recorded. Any other way of formally encoding the patterning differences would appear to do as well. The analysis proposed below will seek to give a non-arbitrary characterization of these properties.

1.3 Aperture Positions and Patterns of Association

One of the most striking facts about Mazateco complex onsets is that plosives differ from continuants in their clustering possibilities. Although the Mazateco consonant inventory is roughly evenly divided between plosives

[2] CF. Clements and Keyser (1983) and McCarthy and Prince (1986) for discussion.

and continuants, plosives give rise to significantly larger numbers of combinations. In particular, plosives may be followed or preceded by the laryngeal consonants /h/ and /ʔ/, while continuants can be, with minor surface exceptions, only followed by /h/ and /ʔ/. This has nothing to do with relative sonority: the stops /n/ and /t/ function in this respect alike, although their sonority status relative to fricatives like /s/ is quite different.

The observation that clustering possibilities are more extensive for plosives than for continuants is not an isolated one. Cluster patterns similar to those of Mazateco will be examined later in this paper. And I have argued elsewhere (Steriade 1992) that the cross-linguistic realization of nasality occasions a similar contrast between plosives and continuants: plosives can be oral, nasal, prenasal or postnasal whereas continuants can be either oral or fully nasal, displaying no true phonological instances of nasal contours. The suggested interpretation for this fact is that stops and affricates carry two positions – closure and release – whereas continuants carry only one. Nasality, a privative feature, can be realized on closure, on release, on both or on neither thus yielding, potentially, a four-way contrast, as in (2.a). Continuants, on the other hand, because they lack a second position, can display only a two-way contrast: [nasal] is either associated to their unique position or not associated at all, as shown in (2.b). (C= Closure; R=Release)

(2) Nasality and A-positions:

a. nasal stop, prenasal stop, postnasal stop, oral stop

```
 nasal stop   prenasal stop   postnasal stop   oral stop

   [nas]        [nas]            [nas]
    / \           |                 |
   C   R          C R             C R            C R
```

b. nasal continuants, oral continuants

```
 nasal continuants   oral continuants

      [nas]
        |
        R                  R
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As can be inferred from (2), I view released stops as sequences of closure plus release, and continuants as positions identical in type to the release varieties attested on plosives. I refer to closure and release as Aperture (A) positions and assume that they are defined in terms of degree of oral aperture. The total inventory of consonant A positions assumed here is: closure (defined as minimal aperture; A_0), fricative (intermediate aperture,

sufficient to create turbulent airflow; A_f), approximant (maximal aperture for a consonant; A_{max}). I leave open the question of how to represent, in terms of A positions, the distinction between approximants and vowels. Where needed for purposes of illustration, I will represent vowels as A_{vowel} positions, without however making a serious commitment to such a category. Also left open is the question of possible additional stricture distinctions within the approximant class.

(3) Some frequent sound classes represented in terms of A-positions

released stops:	A_0A_{max}	approximants:	A_{max}
affricates:	A_0A_f	fricatives:	A_f
unreleased stops:	A_0		

If the analysis of nasal contours sketched in (2) is on the right track, it suggests that features other than nasality can similarly contrast in their association mode to the A positions of a consonant. An analysis of the Mazateco data will allow us to investigate this possibility for the laryngeal features of aspiration and glottalization. We will encounter in Mazateco and in other North American Indian languages patterns of laryngeal association identical to those seen in (2) for nasality. The findings I anticipate are outlined below, using the feature of glottalization, [constricted (glottis)]:

(4) Glottalization and A-positions

```
stops:  fully glottalized   preglottalized   postglottalized   plain

          [constricted]      [constricted]    [constricted]
               /\                  |                 |
             A0 Amax             A0 Amax          A0 Amax       A0 Amax

continuants:          glottalized                    plain

            [constricted]     [constricted]
                  |                 |
                  Af       or      Amax             Af or Amax
```

The Mazateco data will show that plosives display three of the four patterns of association shown in (4) – plain, preglottalized and postglottalized – whereas continuants are systematically restricted to only a two-way contrast, which we shall identify as plain vs. glottalized. The full range of contrasts between plain, preglottalized, postglottalized and fully glottalized plosives is attested in Kashaya (Southwestern Pomo), a language whose laryngeal clusters have been recently analyzed by Buckley (1992), and which we shall discuss below. In Kashaya, as elsewhere, the continuants contrast with the stops in displaying no more than a binary contrast between plain and glottalized. This systematic difference in the anchoring possibilities offered by plosives and continuants is one of the central points of this study.

Since the presence of release is not distinctive for the plosives of any language,[3] I will assume that releases are projected from underlying representations in which the stops are mere closures:

(5) Release Projection

$$A_0 \rightarrow A_0\ A_{max}$$

Most languages disallow released stops in rime position. The result are unreleased stops, whose representation is that of simple closures: A_0. The prohibition against released rime stops could be expressed as below, using the moraic notation to refer to rimes (cf. Hyman (1985), Hayes (1989), Zec (1989) and others).

(6) No released stops in rime

$$*\ \underbrace{A_0\ A_{max}}_{\mu}$$

An alternative account of the distribution of unreleased plosives is that stop releases are disallowed before A positions involving a greater degree of oral stricture: one possibility is the constraint below, inspired by Flemming (1991).

(7) No released stops before stops or fricatives

$*A_0\ A_{max}$ / __A_n, where A_n is more constricted than A_{max}

[3]On this point, see McCawley (1967), the first phonologist who has explicitly argued that stop releases are phonologically relevant.

It is possible that both (6) and (7) are operative, perhaps in different languages. An indication of this is the fact that the distribution of released stops varies somewhat from language to language. Korean, for instance, disallows any stop releases in word-medial as well as word-final rimes, regardless of what follows (McCawley 1967, Kim-Renaud 1986). This behavior points to (6). On the other hand, Italian and Marshallese (Byrd 1992) allow word-final but not word-medial released coda stops, a fact which is inconsistent with (6) and suggests (7).[4] This is clearly a subject that awaits fuller study. The derivational position of filters like (6) and (7) is also open to a variety of interpretations: one may assume that these filters operate to block the projection of releases in the positions they designate, or that they block only the surface occurrence of plosive releases in those positions, or that both functions are instantiated, in different languages.

Under circumstances discussed elsewhere (Steriade 1989, 1992), the approximant releases of normal stops turn into the distinctive fricative releases that characterize affricates: a plain stop (A_0A_{max}) becomes an affricate (A_0A_f). There are three claims being made: first, affricates are, like stops, sequences of closure plus release; second, affricates have releases consisting of positions identical to those carried by fricatives (A_f); third, stops and affricates are underlyingly distinguished not by the quality of their release but by their other specifications, primarily those involving place features. The simplest case illustrating the non-distinctive nature of fricated releases involves the most widespread affricate type, the palatoalveolar [ʧ] (Maddieson 1984). In the segment inventories of most languages – including English, Turkish, Sanskrit, Irish, Spanish, Farsi, Hindi, Bengali etc. – [ʧ] is the only affricate type as well as the only palatoalveolar plosive. It would be redundant to differentiate it underlyingly from other stops both in place of articulation and in stricture features. Further, in languages like English where the [ʧ]/[t] opposition is mirrored by that between [ʃ] and [s] it would be odd to claim that the underlying distinction between [ʧ] and [t] involves stricture (the contrast between a coronal stop and a coronal affricate), while at the same time admitting that the underlying contrast between [ʃ] and [s] involves place features ([+anterior] vs. [-anterior]). The optimal system is clearly one in which both the [s] : [ʃ] and the [t] : [ʧ] contrasts are identically described. The conclusion then is that, for such widespread cases at least, the affricate [ʧ] is nothing but an underlying palatoalveolar stop: its affricate nature is derivative from its place specifications.

I claim that this is the case not only in such transparent plosive systems as the ones mentioned above, but also across the board, for all affricates. This claim cannot be defended in detail here, but we can note two facts

[4]Byrd (1992) also demonstrates that the contrast between released word-final codas and unreleased medial ones cannot be attributed to extrametricality.

that bear on one of its aspects: the hypothesis that affricates are, like the stops, sequences of closure and release. Affricates and stops pattern alike in allowing nasal contours: affricates, unlike genuine continuants, can be pre- and postnasalized (cf. Poser (1979) and Steriade (1992)). They can be, because they carry two aperture positions, each of which is separately available for association to [nasal]. Affricates and stops are also identical in their ability to be pre- and postaspirated, or pre- and postglottalized. In this respect too, they are different from the continuants. Much of the present study documents this claim.

The notational framework sketched above is still being developed; many of the assumptions made here for the sake of explicitness may have to be abandoned later, when we gain a better understanding of the typology and phonetic realization of consonant clusters. For this reason, I would like to emphasize the essential element in my proposals: *released plosives – in contrast to all other sound classes – have two positions that can anchor distinctive features.* Their second position, the release, is identical in type to the unique position projected by continuant consonants, the approximants or the fricatives. The main reason these ideas seem worth exploring is that they promise to eliminate a long-standing question in modern phonology: why is it that the only reliably attested segmental contours – for nasality and continuancy – are found among released plosives? The emerging answer is simple. There are no true segmental contours. There are no intra-segmental sequences of the form [α F] [-α F]. The apparent contour segments involve two distinct positions – closure and release – each of which can be separately characterized by the relevant feature or stricture degree.[5]

1.4 Segmental Contours and Privative Features

The three satellite features involved in the composition of most Mazateco complex onsets are aspiration, glottalization and nasality. My analysis of the role they play in the formation of onsets will rely on the claim that they are privative, or single-valued features: that only [+spread glottis], [+constricted glottis] and [+nasal] are phonological values. This assumption is sufficient to explain why contours for these features – of the type illustrated in (2) and (4) – can be realized only on released plosives, that is, on bipositional segments. What we call contour segments emerge as segments possessing two aperture positions, of which only one is associated to a given feature. When the feature giving rise to contours is privative, as we claim [nasal], [constricted] and [spread] are, the only segments that can display contours will necessarily be those possessing two A positions.

[5]There is more discussion of this subject in San (1990) and Steriade (1992). San's view is that many instances of tonal contours can also be reanalyzed when a better understanding of syllable weight in the relevant languages is gained.

These are the released plosives. Since a significant amount will ride on the claim that nasality, aspiration and glottalization are privative, I sketch here some of the motivation behind it.

Some discussion of the privative nature of [nasal] is provided by Trigo (1992) and Steriade (1992). Lombardi (1991) argues that all laryngeal features are single-valued.[6] In the case of glottalization and aspiration, a simple argument for privative status can be based on the observation that all dissimilatory or assimilatory processes involving these features require reference to [+constricted] and [+spread] as the active value, never to [-constricted] or [-spread]. Thus root constraints involving aspiration[7] or glottalization[8] refer exclusively to the presence of [+constricted] or [+spread] segments, never to that of [-constricted] or [-spread] ones. The case has yet to be found in which a language disallows the occurrence, within a given domain, of more than one unaspirated or unglottalized segments. This should, by itself, be sufficient to suggest that such segments do not carry, in any language, any values for the relevant features.

A distinct consideration favoring privative status for laryngeal features is the fact that there exist segments – /h/ and /ʔ/ – which contain, on the surface, no more than one phonological specification, [+spread] for /h/ and [+constricted] for /ʔ/ (cf. Keating (1988) on the phonetic evidence to this effect, and Steriade (1987) on the phonological side of the argument). If [spread] and [constricted] were binary, we would have to ask why we are missing two other conceivable segments: the one containing nothing but [-spread] and the one containing just [-constricted].

Finally, we note that plain consonants – unaspirated and unglottalized – are always available as landing sites for the features of aspiration or glottalization, as long as the general co-occurrence constraints of the language are not being violated. If plain consonants were specified as [-spread, -constricted], we would expect that such specifications would block – at least occasionally – the linking of the conflicting values [+spread] or [+constricted]. An instance of this argument is provided by the behavior of aspiration in Ancient Greek, a language that contrasts {p^h, t^h, k^h} and {p, t, k}. If [spread] is privative, we understand why a plain stop becomes aspirated in Greek when morpheme or word concatenation creates an in-

[6]The privative status of [voice] was earlier discussed by Mester and Ito (1989). I do not discuss [voice] here because the languages analyzed in this study make little reference to this feature and because the nature of the arguments bearing on this point is rather different from the evidence establishing that [constricted] and [spread] are single-valued. See Lombardi (1991).

[7]Examples are Grassmann's Law in Indo-European, on which see Collindge (1985) for references; the constraints holding within Harauti nominals, on which see Allen (1970); and the Kashaya aspiration and glottalization disharmony discussed by Oswalt (1976:3).

[8]On Yucatec glottalization disharmony, see Lombardi (1990).

termediate stop-h cluster. If, on the other hand, [spread] is binary and {p, t, k} are [-spread], the aspiration process can perhaps be described – by means of rules delinking [-spread] or assumptions about underspecification – but not explained, since no particular outcome is being predicted. The examples below illustrate only two subcases of this phenomenon: (a) plain stops directly followed by /h/; (b) plain stops followed by a vowel – which elides – followed by /h/.

(8) /h/ linking in Ancient Greek:

(a) ouk ho:s → ouk^{h}o:s 'not thus'
(b) kata horao: → kat^{h}orao: 'to look down'
kai hiketeuete → k^{h}iketeuete 'and ye beseech'

Note that voiced stops do not become aspirated when followed by /h/.

(9) No effect on voiced stops
oude heis → oudeis 'not one', not *out^{h}eis.

The reason for this is that the [+voice] value of /d/ is incompatible with the [+spread] specification of /h/: aspirated stops cannot be voiced in Greek. What happens in such cases, as in all cases where an /h/ follows a consonant that cannot be linked to [spread], is that /h/ is simply lost. This indicates that, in the process of associating [spread] to a consonant, it is not possible to override the consonant's specifications for an incompatible feature. This reasoning leads us once again to conclude that plain unaspirated stops do not contain a specification incompatible with [spread]. A similar argument involving glottalization is provided by the behavior of underlying sequences of consonant plus glottal stop in Klamath (cf. Barker 1964), Kashaya (Buckley 1990) and elsewhere: in Klamath, for instance, the plain consonants become glottalized when followed by an underlying /ʔ/, whereas the underlying aspirated ones remain unchanged.

One might attribute observations such as these to the effect of markedness: [-constricted] and [-spread] are widely considered the unmarked values, [+constricted] and [+spread] the marked ones. Perhaps marked values can override specified unmarked ones. Perhaps, but there is no a priori reason to expect this as one of the reflexes of markedness. The most restrictive view compatible with the data I am aware of is that [-constricted] and [-spread] are permanently missing values, not just unmarked ones. I will consequently assume here that the correct interpretation of statements

such as "α is the unmarked value of F" is that F is a privative feature and [α F] refers to its absence. The burden of proof is clearly on those who wish to draw a distinction between unmarked values and non-existent ones.

1.5 Onset Markedness, A Position and Merger Mechanism

The suggestion that released plosives contain two positions leads one to speculate that the distinction between single segments and segment clusters might not be as clear-cut as it is generally assumed. If a released stop /p/ consists of a closure and an approximant release then perhaps it bears some structural similarity to a cluster such as /pr/, which consists of a stop released into an approximant /r/. I will now outline in more detail this speculation, which ultimately bears on the analysis of Mazateco onsets.

My hypothesis is that the relative markedness of different types of onset clusters is determined by the structural and featural similarity between single consonants and consonant clusters. I suggest that the least marked onsets are identical in structure (i.e., sequence of A positions) and feature composition to single segments. The best onset cluster is one consonant.

An onset cluster is an underlying sequence of several distinct segments that end up in onset position. This cluster of distinct segments will produce an unmarked onset to the extent that the consonants of the cluster can acquire the structure of a single segment. Here is an example: an onset like /pr/ – one of the most frequently encountered onset types – consists underlyingly of two distinct segments, each of which will project its own aperture positions. The stop /p/ will carry a closure and project a release yielding a $A_0 A_{max}$ sequence; the approximant /r/ will carry an A_{max} slot. Once concatenated, the approximant releases of /p/ and /r/ can merge, given that they are identical in type, non-distinct in feature composition and adjacent.

(10) Release merger in /pr/

$$\begin{array}{cc} p & \\ | & \\ A_0 & A_{max} \end{array} \quad \begin{array}{c} r \\ | \\ A_{max} \end{array} \rightarrow \quad \begin{array}{cc} p & r \\ | & | \\ A_0 & A_{max} \end{array}$$

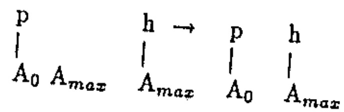
The result in (10) is a cluster of articulations which is structurally identical to a single stop – in that it contains the same sequence of aperture positions that /p/ would have generated by itself. It is not however, featurally identical to a single stop, given that it contains two distinct sets of place of articulation features. It follows then that /pr/ will be a more marked onset than either /p/ or /r/ by themselves. This is of course true. It also follows that /pr/ will be a less marked onset type than /pn/, since /pn/

is composed of two stops and cannot be straightforwardly reduced to a sequence that is even structurally, let alone featurally, identical to a single consonant.

One bonus of this type of analysis is that, in addition to explaining the markedness ranking p > pr > pn – without recourse to complex computations of sonority distance[9] – we explain why the stop in /pr/ onsets is released *into* the liquid rather than separately released. Notice that this is not a fact of phonetic realization that we can ignore in the phonology: this appears to be the invariant realization of onset clusters consisting of stop followed by approximant. As such it deserves an explanation, and the analysis sketched here provides it straightforwardly.

Consider now a different case: that of the underlying cluster /p + h/. From a cluster like this, an onset cluster can be derived by merging the two adjacent approximant releases. The mechanics will be identical to those generating a /pr/ onset but the output is different in one respect: we now have an onset that is both featurally and structurally identical to a single segment.

(11) Release merger in /ph/ clusters



The /ph/ sequence representing the output of (11) is featurally identical to a single segment because it contains a single set of place of articulation features and a single set of laryngeal features. It is structurally identical to one because it contains the same sequence of aperture positions that /p/ alone would have been entitled to. The prediction then is that the markedness ranking of onset clusters will be p > ph > pr > pn. (In this ranking /ph/ is ranked lower than /p/ simply because it is featurally a more complex single segment.)

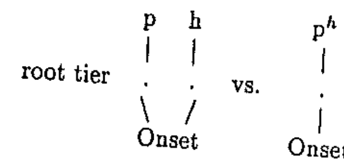
Although we cannot investigate in detail all aspects of this predicted markedness scale, one observation that supports it is the fact that, in languages where /ph/ sequences are provably underlying clusters – rather than underlying aspirated stops – the /ph/ onsets are the least restricted in their distribution, because they are the least marked. An instance of this is Kammu (a Mon-Khmer language), whose phonology and morphology have been carefully analyzed by Svantesson (1983). Svantesson shows that /stop-h/ clusters are separable by various morphological processes in Kammu and

[9] On sonority distance and its putative role in determining onset systems, see Selkirk (1984), Steriade (1982), and Clements (1991).

concludes from this that they are underlying clusters. But, as Svantesso shows, the /stop-h/ onsets occupy a peculiar place in the complex onse inventory of Kammu: unlike the other onset clusters, which consist of stop followed by the approximants /r/, /l/, /w/, the stop-h clusters are allowe not only in major syllables (syllables with a full nuclear vowel) but also i minor syllables (reduced syllables whose nucleus is a consonant). I attribut this effect to the markedness rank of the two onset types: the more marke onset clusters (stop-liquid, stop-glide) are subject to additional distributional restrictions and thus disallowed in minor syllables. The least marked onsets, single segments and stop-h clusters, are distributionally free: they are least marked because they are indistinguishable from single segments.

According to the hypothesis advanced here, the only distinction between a single segment /p^h/ and an onset sequence /p-h/ is their underlying representation: on the surface, they are non-distinct. Indeed, no language displays contrasts such as the one shown below.

(12) Unattested contrast



The absence of surface contrast between /C-h/ onset clusters and aspirated stops is a fact left unexplained by standard views on feature geometry and cluster composition. (The point obviously carries over to the case of stop-ʔ onsets.) Our explanation is that the contrast in (12) is unheard of because (a) syllable structure is defined on A positions and (b) the merger of non-distinct A-positions (such as the A_{max} release of /p/ and the A_{max} position carried by /h/) is obligatory, at least in the case of tautosyllabic sequences.

The cases considered so far involve clusters created through the merger of identical, adjacent, and featurally non-distinct A positions. I believe that several other cases of A position merger can be identified in the cross-linguistic study of consonant clusters. However, only one of these will be relevant for our present concerns: Mazateco will exemplify the possibility that any two adjacent A positions – distinct in type or not – may merge, provided that the features they carry are drawn from the complementary sets of nasality, place and laryngeal features and therefore represent, at least in principle, mutually compatible articulations. The general motivation for this type of merger is discussed in the next section.

1.6 Single Segments and Segment Clusters

It is standard in contemporary phonology to identify the notion of single segment with a position serving as anchor for distinctive features. The root node, introduced in Clements' (1985) and Mohanan's (1984) studies of feature organization, plays exactly this role.

The proposal central to this study – that closure and release in plosives are distinct phonological entities – is roughly equivalent to the claim that plosives have two root nodes, one for closure and one for release. One of these positions, the release, has clearly an auxiliary and disposable status: it is not distinctive and it is not necessarily present in all contexts. But in contexts where plosive releases are present, the following question arises: what identifies a released stop as a single segment?[10] The empirical interest of this question will become apparent below, in the discussion of Mazateco. For the moment I propose a general answer to it, outlined earlier in Steriade (1992), which can be used as a reference point in later discussion. In trying to characterize the structures that will count as single segments, we must define a number of terms:

(13) Derived and basic A positions

(a) Derived A position: an aperture position attributable to the projection mechanisms (e.g. (5)).

(b) Basic A position: all other aperture positions.

(14) Feature compatibility

Two autosegments F and G are compatible in some language L iff:

(a) the corresponding articulatory gestures can be realized simultaneously and

(b) there is no filter blocking the co-occurrence of F and G in the inventory of L.

We can now define what structures can be identified as single segments. Bear in mind that this definition is relevant for derived representations: in underlying representations, segments are trivially distinguishable from

[10]Thanks to Daniel Silverman for first raising this questions.

clusters, since, prior to the projection of stop releases, there is a one-to-one correspondence between segments and A positions.

(15) Single segments in derived representations
A string of adjacent A positions and associated autosegments is a single segment iff:

(a) It contains at most one basic A position.
(b) Any derived A positions it contains are attributable to projection by the basic A position.
(c) It contains at most one place node.
(d) For any pair of autosegments F and G that it contains, F and G are compatible.

The clauses (a-b) in (15) insure that released plosives (i.e., sequences such as A_0A_{max} or A_0A_f) can count as monosegmental, in contrast to sequences such as A_fA_{max}, or $A_{max}A_f$, A_fA_0, $A_{max}A_0$, in which neither A position could have been projected by the other. The notion of structural similarity between a string of A positions and a single segment that I alluded to earlier in discussing onsets like /p-r/ is now defined by clauses (a-b). The notion of featural similarity between a cluster and a segment, also mentioned earlier, is defined by clauses (c-d) in (15) . These clauses are meant to guarantee the articulatory coherence of the cluster of features that represents a single segment. The claim I make in defining single derived segments in these terms, is that even features that are not simultaneous on the surface must pass a test of mutual compatibility in order for the structure encompassing them to count as monosegmental. The evidence for this claim is presented below.

The definition in (15) has a certain global derivational flavor, in that the ability of a surface structure to pass as monosegmental depends on whether it is attributable to the operation of a projection rule. But (15) is not a mechanism for reconstructing derivational origin. The aim of this definition is not to discover which sequences come from underlying single segments and which ones do not. Rather, we refer to the notion of (derived) single segment defined by (15) in order to explain why certain surface articulatory sequences are well-formed onsets and, as the saying goes, *pattern as single segments*, while others are not and do not. As we shall see below, many types of underlying clusters of distinct consonants can yield, through merger, surface sequences that will satisfy the criteria of single segmenthood.

To illustrate the notion of single segment defined by (15) I provide below an annotated list of representative structures:

(16)

	structure	example	mono-segmental?	comments
(a)	place place | | A_0 A_{max}	pr	no	two place nodes
(b)	place [constricted] | | A_0 A_{max} | [nasal]	$^{n}t'$	yes	
(c)	place [constricted] | | A_0 A_{max} | [spread]	$^{h}t'$	no	incompatible: [spread] and [constricted]

I have not explored here the more challenging possibility that segments – and therefore the distinction between single segments and clusters – can be entirely dispensed with by using the syllable and its subconstituents as the minimal concatenative units. This hypothesis was originally suggested by Fujimura and Lovins (1978) and is currently being investigated by Fujimura (1992a,b). The fact that the dialect of Mazateco considered here contrasts onsets such as /ht/ and /th/ raises obvious difficulties for Fujimura's idea that features are predictably linearized within the demisyllable. This should not however obscure the similarity between Fujimura's approach and ours: both theories claim that it is impossible to identify surface segments as single anchoring positions.

The remainder of this study seeks to document two points: first, the existence of aspiration and glottalization patterns similar to those anticipated above in (4)—with a binary contrast among continuants and a ternary or quaternary one among plosives; second, the phonological relevance of the notion of derived single segment outlined in (15) in the analysis of an unusual type of onset inventory.

2 Mazateco

2.1 Segments and Syllables

My source on Mazateco is PP's study (1947). The dialect described is that of Huautla de Jimenez. I have replaced PP's notation with the corresponding IPA symbols.

(17) Mazateco consonants

labial	alveolar	strident alveolar	post-alveolar	retroflex	velar	laryngeal
v	t	ts	ʧ	tʂ	k	
m	n					
			ɲ			
		s	ʃ			
	l			ʂ		
				y		h ʔ

In addition to these segments, the stops /p/, /b/, /d/, /g/ appear in Spanish loans, as do the trill /rr/ and the tap /r/.

The native spirant written <v> is described as a "bilabial fricative with flat (i.e., not markedly rounded) lips" (1947:80). A more accurate phonetic transcription would then be [β]. This [β] occupies an odd position in the Mazateco consonant system: it is the only voiced fricative of a language in which an oral bilabial stop is strikingly absent. Very few languages lack a bilabial oral stop; and relatively few have, in their phonemic inventories, voiced bilabial fricatives. Mazateco seems to have reversed the markedness status of /b/ and /β/: this suggests that [β] is the surface realization of an underlying stop, /p/ or /b/. In the absence of other voicing contrasts among Mazateco stops, /p/ seems the logical choice for the underlying inventory. But, given that our interest here concerns only the input to the processes of onset-cluster formation, /b/, which is phonetically closest to the recorded [β], seems an equally good candidate.[11] The stop chart relevant here will then be the following:

(18) Mazateco plosives

b	t	ts	ʧ	tʂ	k	oral plosives
m	n		ɲ			nasal stops

[11] Languages with a surface inventory comparable to the one I attribute to Mazateco – comparable in that the bilabials stops are either invariably voiced or represent the only voiced plosives – include Arabic and Arapaho, an Algonquian language (Salzmann 1956).

The vowel inventory of Mazateco includes /a/, /e/, /o/, /i/ and the corresponding nasalized vowels. From PP's comments on vowel allophony one gathers that /o/ has high as well as non-high allophones. We shall see that it behaves somewhat ambiguously as a potential target of glide formation, a rule that affects high vowels.

According to PP, Mazateco syllables are always open. We can confirm this: words end invariably in vowels and medial clusters closely mirror those attested initially.[12] Onsets are obligatory: "every nucleus is preceded by its consonantal margin" (1947:83).

Nuclei may contain from one to three vowels. PP refer to the initial member in two- or three-member nuclei as weak or subordinate. The final vowel in three-member nuclei is also subordinate. There are restrictions on possible vowel combinations within a nucleus, but these will not be dealt with here. According to PP, the overall duration of the nucleus is constant, regardless of the number of vowels or tones it carries. It is unclear how to translate this observation into a proposal for phonological representation, since the facts are consistent with a number of divergent structures.

2.2 Complex Onsets: An Overview

The complete list of complex onsets attested in Mazateco is given below, using the principles of PP's sequential notation.

(19) Two member onsets:

a. ht hk hts hʧ htʂ hv hy hm hn hɲ
ʔv ʔy ʔm ʔn ʔɲ
nt nk nts nʧ ntʂ
tʔ kʔ tsʔ ʧʔ tʂʔ vʔ yʔ mʔ nʔ ɲʔ sʔ ʂʔ ʃʔ
th kh tsh ʧh tʂh vh mh nh sh ʂh

b. sk ʃk ʃn

Three members onsets:

a′ hnt hnk hnts hnʧ hntʂ
ʔnt ʔnk ʔnts ʔnʧ ʔntʂ
ntʔ nkʔ ntsʔ nʧʔ ntʂʔ
nth nkh ntsh nʧh ntʂh

b′ htsʔ hʧʔ
skʔ ʃkʔ ʃtʔ

[12] PP note that /ʔm/ and /ʔn/ sequences are found only intervocalically: but more complex clusters, like /ʔnt/ /ʔnts/, are attested initially, and this suggests that the gap is accidental.

A look at the list in (19) reveals two major subgroups:

(i) Sequences whose global feature composition is monosegmental, according to the definition in (15), in that the entire cluster contains at most one set of place specifications, at most one (distinctive) laryngeal feature and at most one [nasal] value. These sequences include the /hC/ and /Ch/, /ʔC/ and /Cʔ/ clusters as well as /(h)nC/, /ʔnC/ and /nC(ʔ)/ and /nCh/.
(ii) Sequences that must count as featurally bisegmental according to (15), in that they contain either two distinct sets of place features (as in /sk/, /ʃt/) or two distinct and incompatible laryngeal specifications (as in /htsʔ/). In section (2.6.) we will discover that the /hCʔ/ clusters originate as /sCʔ/. Anticipating this result, we may state now that the only featurally bisegmental clusters of Mazateco are fricative-stop-(ʔ) sequences.

Although PP don't formulate the monosegmental principle governing the clusters in (19.a′) in exactly the same terms, they are clearly aware of something akin to it. They state (1947:p.80) that the /h/, /ʔ/, and /n/ elements of the clusters in (19.a′) are subordinate elements "because the articulation of the subordinate one tends to be secondary [or] tertiary [...] in relation to the primary articulations of the other members of the clusters." (Primary articulations are defined as oral constrictions, secondary ones are nasal gestures and tertiary ones are laryngeal gestures.) In other words, the primary member of the cluster contributes the oral gesture, while the satellites – /h/, /ʔ/, /n/ – contribute the complementary featural components of nasality and aspiration/glottalization. Implicit in this analysis is the view that the whole cluster functions as *one coherent ensemble of features* rather than as a sequence of featurally independent elements. It is this idea that I will try to incorporate in my analysis.[13]

What is most striking about the clusters in (19) is that a large number of them violate the Sonority Law, whereby sonority must steadily increase from the beginning to the center of the syllable.[14] This observation may suggest that phonetic clusters like /ht/, /ʔnt/, /nt/, /ʃt/ represent underlying unit phonemes. PP reject this interpretation: they point out that a large subset of Mazateco consonants may be both preceded and followed by /ʔ/ and /h/. If /nʔ/ is interpreted as a glottalized /n'/ then how are we to interpret the contrasting sequence /ʔn/? The same question applies to clusters like /hk/ vs. /kh/ or /ʔnk/ vs. /nkʔ/. I would endorse this argument, with the following limitation: contrasts like /hk/ vs. /kh/ demonstrate that

[13] A related intuition was later expressed in work by Fujimura and Lovins (1978), Fujimura (1992a, b) and, under the name of *prosodic licensing*, by Goldsmith (1989:123ff). PP's notion that oral constrictions function as superordinate to nasal and laryngeal ones will also find its counterpart in this study, as we shall see. It should be noted, however, that PP do not consider the fricative-stop clusters or the /hCʔ/ sequences to have a distinct status from that of other Mazateco clusters, as I do.

[14] See Clements (1991) for references and recent discussion of the Sonority Law.

such sequences cannot both be *underlying* single segments. Their surface status as single segments or clusters remains to be established.

PP's own assumption is that the Mazateco consonantal sequences are surface clusters. This hypothesis runs into even greater difficulties. If the onsets in (19) are polysegmental, why do they violate the Sonority Law? Equally puzzling on the cluster analysis is the fact that /h/ and /ʔ/ do not co-occur within a Mazateco onset:[15] if /ht/ and /tʔ/ are clusters, we would expect the product of their concatenation – */htʔ/ – to be attested as well. Why isn't it? The same point can be raised in relation to the attested /ʔn/, /nh/ vs. the unattested */ʔnh/. Our reasoning in such cases is based on the principle that the overall wellformedness of a cluster is an exclusive function of the wellformedness of the segment sequences composing it (cf. Clements and Keyser 1983 for discussion). This principle, when applied to Mazateco, predicts that /ht/ and /tʔ/ jointly imply */htʔ/—in the same way that /pr/ and /sp/ in English jointly imply /spr/. Why is this prediction wrong for Mazateco? Similarly, given the joint presence of /hn/, /nh/ and /ht/ in Mazateco, we expect */hnht/ as well as a contrast between */nht/ and /hnt/ sequences. The cluster analysis has no meaningful ways of nullifying these wrong predictions.[16]

The analysis I will propose claims that all complex onsets in Mazateco are underlying clusters: they originate as underlying sequences of distinct feature matrices linked to distinct A positions. However, in the process of onset formation, these clusters merge into structures that correspond to single segments. Thus, /ht/ and /th/ are both segment sequences underlyingly. This is why they can be lexically distinct. But they are both monosegmental on the surface: one a preaspirated, the other a postaspirated stop, whose A-position structure and feature composition satisfies the requirements for single segmenthood spelled out in (15).

[15]The surface clusters /htsʔ/, /htʃʔ/ will emerge as surface realizations of /stsʔ/ and /stʃʔ/. Aside from these cases, /h/ cannot precede or follow /ʔ/ in a cluster.

[16]Could a sequential analysis of C clusters succeed in Mazateco, if it were to abandon the claim that wellformedness is always computed on *adjacent* pairs of C's? Perhaps, but it is by no means clear what principles can be employed in a sequential analysis in order to rule out onsets like /htʔ/, /nhk/, /Chn/. My claim is that even if such principles could be found, they would essentially import into a sequential analysis the basic claim to be made here: that this class of Mazateco onsets are not surface sequences but rather single segments.

(20) Surface structures for Mazateco /ht/ and /th/ (place component omitted)

[ht]	[th]
[spread] linked to A_0 in $A_0\ A_{max}$	[spread] linked to A_{max} in $A_0\ A_{max}$

Only certain underlying clusters can yield, through A position merger, single segments: for instance, the merger of /h/ and /t/ can produce one monosegmental unit, whereas that of /h/ and /ʔ/, or /h/ and /t/ and /ʔ/, or /p/ and /y/ cannot, for reasons spelled out in (15). It is this factor that will explain the limitations on possible onsets in Mazateco. The observation made above, that aspiration and glottalization do not co-occur within a single Mazateco cluster, follows from the claim that the clusters become surface single segments: in virtue of (15), they cannot contain incompatible feature values, such as [spread] and [constricted], even in cases like /htʔ/ where these values would be realized as temporally sequenced (cf. (16.c)).

I will suggest then that the group of clusters in (19.a) are generated by the merger of any sequence of adjacent aperture positions, subject to one constraint on the immediate output : the result of merger must be monosegmental.

2.3 Prenasal Onsets

The set of complex onsets which best illustrates the claim that Mazateco onsets are surface unit phonemes involves nasals followed by a plosive. We analyze first the clusters /nk/, /nt/, /nts/, /ntʃ/, /ntʂ./, leaving the laryngeally specified clusters like /nkʔ/, or /hnk/ for later consideration. The nasal is always homorganic to the following stop: this is explicitly mentioned by PP (1947:80) for /nk/ clusters and can be assumed to hold for /nts/, /ntʃ/ and /ntʂ./.[17] Thus the NC sequence contains a single set of place features. The plosive is voiced in these cases, although not recorded as such by PP: /nk/ stands for [ŋg], /nt/ for [nd], /nts/ for [ndz] etc. (PP 1947:79): the nasal and the plosive share one [+voice] specification.[18] Given

[17]Jamieson (1977), who analyzed the related dialect of Chiquihuitlan Mazateco, notes that all /nC/ cluters are homorganic in Chiquihuitlan, including /ntʃ/.

[18]PP and Jamieson (1977) note that the plosive in /nCh/ onsets is not voiced. I suspect that what these writers are reporting is the delay in the onset of voicing on the following vowel – a delay made inevitable by the fact that the stop release is aspirated – rather than the absence of vocal cord vibration during the closure interval of the stop. For this reason, I continue to assume that the prenasal stops have voiced closures in

that the stricture, place and laryngeal features of the nasal and the stop are identical, we can identify these NC clusters as standard prenasal segments. The examples below are given in PP's notation.

(21) Prenasal onsets:

PP's notation (adapted)	Phonetic	Example	Gloss
<nt>	[nd]	nta	'good'
<nts>	[ndz]	ntsa	'my hand'
<ntʃ>	[ɲdʒ]	ntʃao	'tomorrow'
<nts̢>	[ɳɖʐ]	nts̢ati	'comb'
<nk>	[ŋg]	nkahao	'water hole'
loans: <mb>	[mb]	mba	'grandfather' (from /compadre/)

A comparison between the list of prenasal onsets and the larger list of Mazateco consonants reveals that all and only the surface plosives can form complex onsets with a preceding nasal. If we leave aside the less well entrenched loans (e.g., /ganʧo/, or /seda/), a second generalization emerges: of the plosives, all and only those with nasal closure are voiced in Mazateco.[19]

These observations lend themselves to a simple two-step analysis in the framework sketched above. The prenasal onsets are single plosives arising from the association of nasality to a closure. And the [+voice] value of prenasals is derived by the same redundancy rule that must in any case be associated to [nasal] is specified as [+voice].[20]

Mazateco, regardless of what follows.

[19]The voicing process affects certain loanwords, perhaps the earlier ones, though not all: contrast /mba/ 'grandfather', from Spanish /compadre/, displaying the effects of prenasal voicing, with /ganʧo/ 'crochet hook' in which /ʧ/ is – according to PP – voiceless.

[20]I assume, following Keating (1990), that the feature [voice] associates invariably to closure.

(22) Analysis of prenasalized onsets (preliminary):

a. Closure merger:

```
[nas]                   [nas]
  |                       |
  A0     A0      →        A0
         |                |
       place            place
```

b. Nasal voicing:

```
[nas][voice]
  | . ·
  A0
```

The partial derivation of an onset like [nd] (spelled as <nt> in PP's materials) appears below:

(23) Derivation of [nd]

a. Closure merger:

```
[nas]                     [nas]
  |                         |
  A0     A0        →        A0
         |                  |
       place              place
         |                  |
      Coronal            Coronal
```

b. Nasal voicing:

```
[nas][voice]
  | . ·
  A0
  |
place
  |
Coronal
```

Two questions must be answered now. First, is this the right way to represent prenasal consonants, in Mazateco and elsewhere? PP perceived not only a nasal closure and an oral release, as represented in (23.b), but actually two distinct phases in the closure, a nasal and an oral one: does our analysis do justice to the facts they recorded? Second, where does the [nasal] closure in the input to (22-23.a) come from? If it's an underlying nasal stop, why does it lack release and place features?

The first question – which concerns the proper representation of prenasals in general – has been considered more carefully elsewhere, in Maddieson and Ladefoged (1993) and Steriade (1992). Notations like [nd] or [ⁿd] – the appropriate transcriptions for PP's <nt> – reflect the perception that only the first part of the closure phase is significantly nasalized. The velum raises before the oral release, yielding three different stages: oral closure first accompanied by nasal airflow, then accompanied by nasal closure, then oral release. This articulatory reality cannot be faithfully reflected in the phonological representation: given our decision that [nasal] is privative, the closure phase – like any other phonological anchoring point – can be represented as either associated to [nasal] or unassociated. It is phonologically either oral, or nasal, and cannot be part-nasal part-oral. But a phonological representation like (23.b) is compatible with three distinct phonetic realizations, representing three ways of synchronizing the actual articulatory gestures involved: (a) the velum may raise slightly before the oral release (yielding a brief oral interval of closure); (b) the oral release may strictly coincide with the lowering of the velum (yielding a fully nasal closure and a fully oral release); (c) the velum may raise slightly after the oral release (yielding a fully nasal closure and a release whose beginning is lightly nasalized). Option (c) is perhaps attested but it yields a barely distinct result from the realization of a fully nasal stop, whose closure and release are both nasalized, and for that reason it is probably avoided in languages like Mazateco where prenasals and nasals must contrast. Option (b) is indeed attested, as indicated by Maddieson and Ladefoged (1993), who call the relevant segments *post-stopped nasals* and transcribe them as [mᵇ], [nᵈ], etc. It is not widely attested, presumably because it requires a very precise synchronization between articulatory gestures. Option (a) is, as shown by Maddieson and Ladefoged (1993), the most widespread phonetic realization of prenasal plosives. The reason for its popularity is precisely the fact that it allows for the most secure contrast between prenasals and full nasal stops: only this class of prenasals has a fully and reliably oral release.

We may conclude then that transcripts like [nd] stand for the most common phonetic realization – option (a) – of a stop whose closure is nasal and whose release is oral: the output of (23.b). Supporting this conclusion is the observation that the three ways of realizing this phonological structure do not contrast in any language: in particular, the standard prenasals like [ⁿd] (option (a)) do not contrast with the corresponding poststopped nasals like [nᵈ] (option (b)), even though the two segment classes are perceptually quite distinct.[21] They do not contrast precisely because they represent the

[21]This point is made in Maddieson and Ladefoged (1993).

same phonological structure: a nasal closure and an oral release.

I turn now to the second question: what is the source of the unreleas nasal stop in (22-23.a)? If it's an ordinary nasal stop, why does it la release?[22] The answer is that most preconsonantal stops will lack relea if filter (7) is operative in Mazateco. The effect of (7) is to disallow st releases before other stops or fricatives. Why then does this unrelease nasal stop lack point of articulation features? It is frequently the case tha unreleased nasal stops cannot support perceptual point of articulation di tinctions (Ohala and Ohala 1992), a process we can formalize as the remova of their place component. Let's assume that this happens in Mazateco: the any nasal-stop cluster will yield a sequence of two closures in which the firs lacks any specifications other than [nasal] while the second is specified fo place. Since the two closures carry complementary specifications, they car be viewed as subject to the same merger of identical, featurally non-distinct A positions which is responsible for the creation of /pr/ or /ph/ onsets discussed above. The result of merger in the case of structures like (22-23.a) is a sequence that passes the test of monosegmentality. In that sense, the prenasal onsets are maximally unmarked.

What happens with nasals preceding a fricative? We expect them to be unreleased and thus to lose place features. Why then do they fail to yield nasalized fricatives, through merger with the Af position of the following fricative ? The most plausible answer is that Mazateco, like many other languages, allows nasality on vowels and closures, but not on positions of intermediate stricture (approximants and fricatives).[23] This hypothesis will prove useful at other points in the analysis.

[22]Note that we cannot assume that the [nasal] feature yielding prenasals is underlyingly floating: it must be ordered in underlying representation relative to the oral segments of the string, as shown by pairs such as /ntsati/ 'comb' vs. /tsinka/ 'shirt'. If the nasality of prenasals was underlyingly floating, we could not devise a coherent linking algorithm that would generate such pairs.

[23]We would have to qualify this by stating that [nasality] on the A_{max} release of plain stops is licensed by its association to closure: this is what accounts for the presence of nasal stops in the language, where nasality extends from closure to release. However, the prohibition against nasalized A_f is absolute, as we see in the next section: all A_f positions must be oral, regardless of whether they represent the release of a nasal closure or not. This distinction fits what we know about the relative markedness of nasalized approximants vs. fricatives: many languages allow nasalized approximants, at least in their derived representations, but few permit nasalized fricatives.

2.3.1 Excursus: Merger of Oral Stop with Following C in Mataco

If nasal stops lack release when they precede segments involving a significant oral constriction, we expect oral stops to behave identically: hypothetical sequences like /k-s/ should contain an unreleased /k/. Although PP provide no information on the morphology and morphophonemics of Huautla Mazateco, we must still consider what would happen if such underlying sequences were to arise in the underlying representations of the language. One possibility is that the oral stops, just like their nasal counterparts, would lose their place component when they lack release. In such a case, the stop would be reduced to a bare A_0 position which cannot be realized in the absence of any associated features. If so, the /k-s/ sequence would surface as a simple /s/. But even if the unreleased oral stop maintains its place component, sequences like /k-s/ are not expected to survive as such in a language where surface onsets must be monosegmental: the only uncertainty we are left with is exactly how such clusters are eliminated.

One strategy for turning clusters of oral stop + C into monosegmental sequences is illustrated in Mataco, an Indian language of Argentina whose phonology was briefly described by Najlis (1971). Morpheme-internal clusters consisting of stop-C become monosegmental by place assimilation: "within morpheme boundaries the first member necessarily assimilates to the second in place of articulation and *the cluster becomes a single phone*. Under these circumstances, /t/ and /q/ irretrievably merge." (Najlis 1971:128; italics mine, D.S.). The following table, provided by Najlis, illustrates the fact that the stop's closure is maintained, although its place features disappear, while the following continuant becomes the release of the newly formed plosive. (A note on Najlis's notation: /q/ is probably a velar, /c/ a palatal stop; /x/ a 'frictionless continuant', i.e., a glottal fricative possessing both [x] and [h] allophones (Tovar 1979). On clusters with /p/ see below.)

(24) Mataco merger in /stop-C/ clusters:

{t, q}	s	→	ts
	l		tl
	j		kj
	x		qx
	w		qw

The results of (24) are affricates (ts, qx), laterally released stops (tl), and plain stops like /kj/, /qw/, where palatality and rounding are phonetically present on the release, as well as the closure. I represent below the regressive

assimilation process that yields the outcomes given in (24). As before, A stands for an A_f or A_{max} position:

(25) Merger via place assimilation:

$$\begin{array}{cc} & \text{place} \\ & \cdot^{\cdot^{\cdot}} \mid \\ A_0 & A_n \end{array}$$

The overall effect of the rule in (24) is to eliminate the bisegmental clusters in its input. What then of the /p-C/ clusters? Of these, only two are discussed by Najlis. The sequence /px/ is maintained intact because it contains, according to Najlis, an "orally neutral" /x/: I interpret this to mean that /x/ = [h] and /px/ = [p^h]. The sequence /pw/ is dissimilated to /fw/ - which Tovar (1979) identifies as a rounded bilabial fricative [ϕ^w], not a cluster. According to Najlis, /fw/ may optionally become /xw/, which I assume to be also the sequential transcription of a labiovelar spirant [x^w], also a unit phoneme. The source of the difference between the bilabial and the other stops remains unclear. But the overall picture is significant in any case: all stop-C clusters yield surface single segments, even though the treatment of labial stops diverges from that of other stops, in that the former maintains its place features.

The Mataco case illustrates what may be expected to happen to preconsonantal oral stops in languages like Mazateco where the occurrence of bisegmental sequences is either limited or entirely prohibited.

2.4 Onsets with Aspiration

2.4.1 Overview

I analyze next the class of complex onsets generated by a pre- or postposed /h/. The examples in (26) are given in PP's transcription. They are preceded by indications of what PP's transcriptions represent phonologically and what I reconstruct them to represent phonetically. Comments on the phonological representation and phonetic realization of these clusters follow in sections (2.3.2) and (2.3.3.).

(26) Preaspirated onsets

a. Two-member onsets

PP's	Phonological	Phonetic	Example	Gloss
<hv>	/hb/	[hβ]	/hva/	'watery'
<ht>	/ht/	[ʰt]	/hti/	'fish'
<hts>	/ht͡s/	[ʰt͡s]	/htse/	'a sore'
<hʧ>	/hʧ/	[ʰʧ]	/hʧi/	'small'
<htʂ>	/htʂ/	[ʰtʂ]	/hahtʂo/	'in the opening'
<hk>	/hk/	[ʰk]	/hka/	'stubble'
<hm>	/hm/	[m̥m]	/hma/	'black'
<hn>	/hn/	[n̥n]	/hno/	'corn'
<hɲ>	/hɲ/	[ɲ̊ɲ]	/hɲa/	'woods'
<hy>	/hi/	[hy]	/hyona/	'I want'

b. Three-member onsets

PP's	Phonological	Phonetic	Example	Gloss
<hnt>	/hnt/	[n̥d]	/hnti/	'dirty'
<hnk>	/hnk/	[ŋ̊g]	/hnka/	'wing'
<hnts>	/hnts/	[n̥d͡z]	/wihntsi/	'you look for'
<hnʧ>	/hnʧ/	[n̥d͡ʐ]	/hnʧa/	'salty'

I have omitted from this list the clusters /htsʔ/ and /hʧʔ/, which Pike and Pike record as "tending to vary to /tsʔ/ and /ʧʔ/" (1947:82). In a later section they will emerge as surface realizations of /stsʔ/ and /sʧʔ/. Aside from these, preaspirated clusters cannot be either pre- or post-glottalized.

With the exception of /hy/ and /hβ/, the preaspirated clusters involve only surface plosives. There are no /hs/, /hʃ/, /hl/, or /hr/ preaspirated clusters. We therefore need to explain the place of /hy/ and /hβ/, the sole apparent preaspirated continuants in the Mazateco system.

2.4.2 Preaspirated Glides?

As it turns out, the contrast between /hyV/ and /hiV/ sequences is tenuous in Mazateco. I will show now that there is in fact little reason to analyze the string in /hyona/ – the unique example of a /hy/ cluster – as involving /hyo/ rather than /hio/. PP discuss a related issue at some length and thus provide some considerable evidence bearing on this point. Their concern is to establish that /y/ and /i/ are distinct phonemes, a fact that seems beyond dispute. But in the course of settling this issue, they

note that "/y/ and weak /i/ as first of a vowel cluster are quite similar" (1947:86). Their evidence also reveals that /yV/ and /iV/ sequences do not contrast in all environments. I turn to this point next.

PP believe that Mazateco contrasts /hyV/ and /hiV/ sequences, but this opinion is based on one pair of items which, on closer analysis, turns out to be irrelevant: /hyona/ 'I am willing' vs. /-hĩõ/ 'not you (pl)'. The pair is irrelevant because the nucleus in /-hĩõ/ is nasalized. More generally, oral /hiV/ sequences (where /h/ is syllable initial) are not attested in Mazateco. The same restriction holds, as we shall see, of syllable initial /ʔiV/ sequences. The last piece in the puzzle is PP's observation (1947:79) that one clue they use for the distinction between /y/ and /i/ is that /i/ can be nasalized whereas /y/ may not be.

Taken together these facts suggest that underlying syllable initial /hiV/ and /ʔiV/ sequences are subject to a rule that turns nuclear /i/ into onset /y/. This rule applies (or is perceived to apply) to oral /i/ but not to nasalized /ĩ/.

The motivation for this process of glide formation is that /hiV/ and /ʔiV/ syllables lack a supralaryngeally articulated onset: by turning /i/ into /y/ they will acquire one. Mazateco is not unique in discounting /h/ and /ʔ/ as optimal onsets: Ancient Greek allows /h/ syllable-initially only in word-initial position. In other contexts, hV sequences behave as if they represent onsetless syllables. The laryngeal /h/ may be a segment, but cannot qualify as onset. In Mazateco, unlike in Greek, the laryngeals /h/ and /ʔ/ are allowed to stand alone in onset position, but their defective distribution – i.e., the absence of /hiV/:/hyV/ and /ʔiV/:/ʔyV/ contrasts – indicates that onsets lacking supralaryngeal articulations are allowed only as a last resort.

The Mazateco rule that turns /hiV/ to /hyV/ fails to apply to nasalized /i/. We could explain this by noting that all nasalized continuant consonants are disallowed in this language: [nasal] in consonants must have an association to A_0. Alternatively, given PP's admission that they cannot easily distinguish between /y/ and weak /i/, we might think that the nasality of /i/ in sequences like <hĩõ> led them to *assume* that they heard [hĩõ] rather than [hỹõ]: PP admit elsewhere that they use the nasality of vocoids as a clue to syllabicity.

I conclude then that the /hy/ cluster in /hyo-na/ represents a basic /hio-na/. More generally, my claim is that preaspirated /y/ is not created by the same cluster formation processes responsible for other pre- or postaspirated segments, and does not exist until a very late stage in the derivation. The process responsible for /hy/ is glide formation in syllables lacking supralaryngeally articulated onsets.

What then of the /hβ/ clusters? There are two possibilities here. The surface /β/ may originate as a bilabial stop. As mentioned above, there is good reason to believe that Mazateco does have an underlying oral bilabial stop. If at least some instances of /β/ represent an underlying stop, then we expect this stop to pattern like other plosives and allow preaspiration. We shall see below that /b/ permits preglottalization as well, as plosives do. If so, /hβ/ represents /hb/ or /hp/ rather than an underlying /hw/. Alternatively, /hβ/ represents phonological /hw/ and its derivation is parallel to that of /hy/: its /β/ originates as an underlying rounded vowel. The chief difficulty to overcome in this case is the apparent existence of surface contrasts between /hoV/ and /hβV/ sequences. The one relevant pair cited by PP is /hva/ 'watery' vs. /hoa/ 'we are two', where both nuclei are oral. Recall that /o/ is the only surface rounded vowel in Mazateco. If /hvV/ comes from underlying /hoV/ by glide formation, the contrast between /hoV/ and /hvV/ cannot be explained. Although there are possible ways around this problem, the account favored by the information PP provide appears to be the former: /hβ/ is /hb/.

This reasoning eliminates the only preaspirated continuants recorded by Pike and Pike and allows us to maintain that only plosives, or segments that originate as plosives, can be preaspirated.

2.4.3 Analysis of Preaspirated Clusters

One other striking restriction observable on preaspiration is that it does not co-occur with either preposed or postposed /ʔ/. We might expect clusters like /hkʔ/, /htʔ/, /hnʔ/, since their components (/hk/ and /kʔ/, etc.) are attested. But – with the apparent exception of /hʧʔ/, /htsʔ/ – such sequences are impossible in Mazateco.

The observations made so far on the Mazateco preaspirated onsets are summarized below:

(27) Generalizations on preaspirated onsets
- a. All simple plosives can be preaspirated.
- b. All prenasals can be preaspirated.
- c. Only (underlying) plosives can be preaspirated: /hy/ = /hi/ and /hβ/ = /hb/.
- d. Preaspiration is incompatible with either pre- or postglottalization.
- e. In sum, all and only plosives and plosive clusters can be preaspirated, provided they do not contain /ʔ/.

I suggest that these observations follow from an analysis in which preaspirated onsets are represented as plosives with aspiration associated to their closure. The general structure underlying the hC clusters is given below (A_n is a variable over release types, A_{max} and A_f):

(28) Representation of hC onsets

```
[spread]
  |
  A0  An
```

The structure in (25) results from the merger of the A_{max} position of /h/ with the A_0 closure of a following plosive. A preliminary statement of the merger is given below:

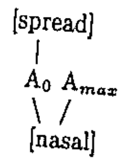
(29) Merger deriving hC onsets (preliminary)

```
Merge:     Amax A0
             |
          [spread]
```

The output of merger is always a single A-position, the one involving the greatest degree of stricture. All features of the input sequence are associated to it. This means that the merger of A_0 and A_{max} in (29) will yield a single A_0 to which are associated both the original features of the closure and the [spread] feature originally belonging to the approximant /h/.

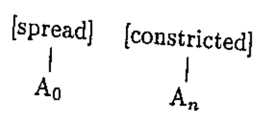
My claim then is that /h/ in /hC/ clusters is not sequentially ordered before C but rather phonologically simultaneous with its closure. One bit of phonetic evidence supporting this is PP's observation that /h/ becomes "a voiceless nasal fricative" when it occurs before nasals (1947:80). In a different passage, PP note that /hn/ sometimes sounds like /nhn/, once again suggesting that the first half of the nasal stop is both aspirated and nasalized. In his description of the Chiquihuitlan Mazateco dialect, Jamieson (1977:94) makes a similar observation: "/h/ is the voiceless counterpart of a following ... sonorant", where sonorant turns out to mean nasal stop. Jamieson's transcriptions for /hma/, /hne/, /hɲa/ are [Mmã], [Nnẽ] [Nɲã]. I interpret digraphs like [Mm] to indicate that aspiration is phonetically realized as simultaneous with at least the first half of the stop closure. The corresponding phonological representation for the /h-nasal/ onsets of Huautla and Chiquihuitlan is given below:

(30) The structure of /h-nasal/



The representation proposed in (28) for the /hC/ onsets of Mazateco explains all but one of the generalizations listed earlier: the incompatibility between preaspiration and pre- or post-glottalization. Anticipating a bit, we note that /ʔC/ onsets have one of the essential properties of /hC/ onsets: they involve stops only. Preglottalization will accordingly be analyzed as association of [+constricted] to the closure of a stop. From this it follows that a preaspirated stop cannot be simultaneously preglottalized: and this explains the absence of /hʔC/ or /ʔhC/ onsets. More challenging is the absence of postglottalized preaspirated stops /hCʔ/. Such sequences will emerge from the discussion of /Cʔ/ onsets as having the following structure:

(31) Putative /hCʔ/



There is no absolute constraint against such structures, since the incompatible specifications [spread] and [constricted] are sequenced rather than simultaneous. Indeed such sequences are encountered in Mazateco as transforms of underlying fricative-postglottalized stop sequences (e.g., /stsʔ/ → /htsʔ/), a cluster type discussed below. Why is it then that the /h-stop-ʔ/ sequences cannot be generated directly by the conjunction of preaspiration and postglottalization? Why can their *only* source be the underlying fricative prefix on a stop? The answer is that the onsets with aspiration or glottalization are generated by a merger process whose immediate output must be a monosegmental sequence of A positions: the structures outlined in (31) are not monosegmental, in virtue of (15.d). In contrast, the fricative-plosive-(ʔ) clusters – the source of /hCʔ/ onsets – will be shown to have independently observable bisegmental properties: given this, the co-occurrence of aspiration and glottalization in such sequences is not surprising.

2.4.4 Postaspirated Clusters

I turn next to the post-aspirated clusters. PP's list of examples is given below:

(32) Postaspirated clusters

Two-member onsets

PP's	Phonological	Phonetic	Example	Gloss
<vh>	/bh/	[ɸh]	/vhi/	'he goes'
<th>	/th/	[t^h]	/tha/	'light in weight'
<tsh>	/tsh/	[ts^h]	/tshe/	'clean'
<ʧh>	/ʧh/	[ʧ^h]	/ʧha/	'brother-in-law'
<tʂh>	/tʂh/	[tʂ^h]	/tʂhoa/	'skin'
<kh>	/kh/	[k^h]	/kha/	'bad smelling'
<mh>	/mh/	[m^h]	/vʔa.mhe/	'I walk'
<nh>	/nh/	[n^h]	/nhe.na/	'it is gained by me'
<sh>	/sh/	[s^h]	/sha/	'bitter'
<ʃh>	/ʃh/	[ʃ^h]	/ʃhao/	'dew'

Three-member clusters

PP's	Phonological	Phonetic	Example	Gloss
<nth>	/nth/	[^{n}d^h]	/nthao/	'wind'
<ntsh>	/ntsh/	[^{n}d͡s^h]	/ntshao/	'rust'
<nʧh>	/nʧh/	[^{n}d͡ʒ^h]	/nʧha/	'fat'
<ntʂh>	/ntʂh/	[^{n}dʂ^h]	/yantʂhi/	'meat hook'
<nkh>	/nkh/	[^{ŋ}g^h]	/nkhi/	'many'

The most significant observation here is that continuants can be postaspirated in Mazateco. Not all are recorded with postaspiration: /yh/ and /lh/ are left unmentioned by PP. There are gaps among the stops as well: /ŋh/ is missing. We will seek to explain most of these gaps below.

PP do not discuss the phonetic realization of the postaspirated clusters except to note that /v/ in /vh/ is voiceless. The analysis I propose will claim that /h/ is phonologically simultaneous with the last A position of the onset: it is superimposed on the release of stops and on the unique A position of continuants.

(33) Representation of postaspirated onsets

a. Plosives

A_0 A_n
|
[spread]

b. Continuants

A_n
|
[spread]

The representations in (33) explain why /β/ in /βh/ is voiceless: on the surface /β/ is a spirant and thus necessarily simultaneous with /h/. The same assumption may also explain the absence of /yh/: if /y^h/ is aspirated /Y/, rather than a sequence of /y/ plus /h/, then it may become indistinguishable from /$ʃ^h$/. The process that will neutralize the distinction between /y^h/ and /$ʃ^h$/ will look as follows:

(34) Fricativization: /y^h/ → /$ʃ^h$/

[spread]
|
A_{max} → A_f
|
Coronal
|
[-anterior]

The rule of Fricativization states that laminopalatal aspirated releases are realized with frication.[24] This process may also be assumed to turn the postaspirated stop /ɲh/ – whose absence was noted above – into the postaspirated affricate /$ɲʧ^h$/. I assume here that nasality is removed from the A_f position of /$ɲʧ^h$/ after (34) applies, since fricatives (i.e., A_f positions) cannot be nasal in Mazateco. Note that (34) takes crucial advantage of the assumption that intermediate /y^h/ and /$ɲ^h$/ are not true clusters on the surface, but rather aspiration associated to a pre-existing release.

I conclude then that postaspirated stops result from the association of /h/ to the last A position of an existing consonant. Preaspirated stops have been analyzed as the effect of the symmetric operation: the association

[24] Phenomena comparable to (34) are attested elsewhere: see, for instance, Trubetzkoy's (1939) discussion of Nama affricates as the realization of underlying Nama aspirated stops. In Nama, the aspirated A_{max} release of an underlying stop turns into a fricated release, A_f. This is exactly what (34) does, only to a more limited class of segments.

of /h/ to the first A position of a consonant. A process of bidirectional merger between an A position and /h/ will cover both cases. Bearing in mind that the number of A positions ranges between two (for plosives) and one (for all others), we note that this extension of our analysis will explain why plosives can be pre- or postaspirated whereas continuants can be only postaspirated. To see this, we examine the derivation of /hm/, /mh/ and /sh/. No direction is specified in (35.a) and no restrictions are imposed on the nature of the second A position: merger will take place in all /hC/ and /Ch/ clusters.

(35) a. Analysis of pre- and post-aspirated onsets

Merge: A_{max} // A
|
[spread]

b. Derivations

	h + m	m + h
Input:	[spread] [nasal] | /\\ A_{max} $A_0 A_{max}$	[nasal] [spread] /\\ | A_0 A_{max} A_{max}
Output:	[spread][nasal] \\/ | A_0 A_{max}	[nasal][spread] / \\/ A_0 A_{max}

	h + s	s + h
Input:	[spread] | A_{max} A_f	[spread] | A_f A_{max}
Output:	[spread] | A_f	[spread] | A_f

The derivations in (35.b) show that, under merger with /h/'s position, a stop can become preaspirated, if /h/ originates on its left, or postaspirated, if /h/ originates on its right. A continuant will become simply aspirated, whether /h/ came from its left or right, since merger will cause aspiration to become simultaneous with all other features of the continuant.[25] We explain in this way the differences in clustering possibilities between plosives and continuants.

2.4.5 Preaspirated Prenasalized Clusters

The assumption that /hC/ and /Ch/ onsets have surface structures in which aspiration is superimposed on one of C's aperture positions can explain another interesting fact about Mazateco onsets. There is no contrast between /hnC/ and /nhC/ onsets. The lack of contrast is predicted if nasality and aspiration are simultaneous on the closure of prenasals, as indicated below.

(36) Representation of /hnC/ onsets

```
 [nasal]
    |
  A0 An
    |
 [spread]
```

The absence of /hnC/: /nhC/ contrasts is unexpected if the complex onsets are analyzed as true sequences of articulations: that is, if /hnC/ is analyzed as /h/ followed by /n/, followed by C. Given that /nh/, /hn/ and /hk/ are all possible onsets, a sequential analysis will lead one to expect that both /nhk/ and /hnk/ will be well-formed and distinct from each other. This expectation is informed, as noted above, by the observation that well-formedness conditions governing systems of complex onsets operate in general only on adjacent pairs of segments: this means that, if C_1C_2 and C_2C_3 are well-formed onsets, then $C_1C_2C_3$ is also expected to be well-formed. In light of this principle, the absence of a distinction like /hnk/ vs. /nhk/ is striking. This is not an accidental gap: none of the five surface plosives of Mazateco shows such a contrast, even though each one of them displays all conceivable combinations of prenasalization, pre- and postaspiration or pre- and postglottalization.

A sequential analysis of pre- and post-aspirated clusters must explain two other systematic gaps. First, the presence of /C-h/ and /h-n/ clusters predicts the unattested /C- h-n/. The logic of this prediction was outlined

[25] The assumption I am making throughout is that all autosegments linked to the same A position are phonologically simultaneous. Therefore A positions linked to [spread] and [nasal] in the output of (35) are understood to be simultaneously aspirated and nasalized, rather than first aspirated and then nasalized, or the other way around.

above: in sequential analyses, C_1C_2 and C_2C_3 jointly imply $C_1C_2C_3$. Second, the presence of /C-h/ and /h-stop/ predicts /C-h- stop/ sequences. Such clusters are also unattested, for any choice of C.

Our analysis rules out /C-h-n/ sequences by noting that their final member /n/ will be prevocalic and therefore, necessarily, a released nasal stop. Since the stop is released, it will have a full set of point of articulation features. The input sequence for putative /stop-h-n/ or /fricative-h-n/ clusters will have the representations shown in (37):

(37) Representation of putative /C-h-n/ sequences in Mazateco

a. stop-h-n

```
          [spread]   [nasal]
              |        / \
A0 Amax  -  Amax  -  A0 Amax
|                    |
place               place
```

b. fricative-h-n

```
[spread] [nasal]
   |       / \
Af-Amax - A0 Amax
|          |
place     place
```

Merger with /h/ can take place in any one of the structures shown in (37) but its outcome is irrelevant: both the input and the output structures of merger differ substantially from all other onsets of this class, in that they will possess two place nodes. Our working assumption is that surface clusters with [nasal], /h/ and /ʔ/ are well formed in Mazateco only to the extent that they are analyzable as monosegmental. The clusters shown in (37) are not and cannot become monosegmental.[26] The same assumptions explain the absence of /C-h-stop/ sequences: both C and the stop will have independent specifications for place and thus could not pass for single segments, even if subjected to merger.

The account sketched so far has explained several phonological properties of Mazateco aspirated onsets: the fact that pre- and postaspirated plosives are allowed, while only "postaspirated" (i.e., fully aspirated) continuants are permitted; the absence of contrast between /h-N-C/ and /N-h-

[26] There is an alternative explanation for the absence of /stop-h-n/ clusters. We may assume here, as we have assumed earlier for /n-h-stop/ sequences, that the stop will be unreleased. If so, it is conceivable that the process removing the place features of an unreleased nasal stop applies to oral stops as well. In that case the /stop-h-n/ cluster will reduce to a sequence consisting of a placeless A_0 (a remnant of the original stop, relieved of its release and place features), followed by /h/, followed by /n/. Such a sequence will turn into preaspirated /hn/, an attested Mazateco onset. The general point emerging from either this analysis or the one offered in the text is this: the clusters containing two underlying sets of place features will either lose one place component, in which case they will yield, through merger, a structure identifiable as a single consonant and hence well formed; or, if they don't, they will be eliminated as ill-formed.

C/; and the absence of /C-h-N/ and /C-h-stop/ clusters. The fundamental assumption made here, that the glottal feature of /h/ becomes phonologically simultaneous with a pre-existing A position, will be further confirmed in the analysis of ʔ-onsets, to which I turn next.

2.5 Onsets with Glottalization

The preglottalized onset clusters of Mazateco involve the nasals, the prenasals, the voiced fricative /v/ (= /β/) and the glide /y/.

(38) Onsets with preglottalization

b. Two-member onsets

PP's	Phonological	Phonetic	Example	Gloss
<ʔm>	/ʔm/	[ʔm]	/soʔma/	'earthen jar'
<ʔn>	/ʔn/	[ʔn]	/naʔni/	'brier'
<ʔɲ>	/ʔɲ/	[ʔɲ]	/niʔɲa/	'writing pen'
<ʔv>	/ʔb/ or /ʔo/	[ʔβ]	/ʔva/	'hook'
<ʔy>	/ʔi/	[ʔy]	/ʔya/	'rainbow'

b. Three member clusters

PP's	Phonological	Phonetic	Example	Gloss
<ʔnt>	/ʔnt/	[ʔnd]	/ʔnta/	'good'
<ʔnk>	/ʔnk/	[ʔŋg]	/ʔnka.ha/	'water hole'
<ʔnts>	/ʔnts/	[ʔnd͡z]	/ʔntsa/	'my hand'
<ʔnʧ>	/ʔnʧ/	[ʔnd͡ʒ]	/ʔnʧiʔe/	'bee'
<ʔnʦ̢>	/ʔnʦ̢/	[ʔn ɖʐ]	/ʔnʦ̢ati/	'comb'

With the exception of /ʔy/ and /ʔβ/, preglottalization is permitted with plosives only: there are no /ʔs/, /ʔʃ/, /ʔl/, /ʔr/ clusters in Mazateco. An additional restriction is that the closure of a preglottalized stop must be nasal.

The preglottalized /ʔy/ is clearly an underlying sequence /ʔi/, in which /i/ is the first member of a complex nucleus. There is no contrast between /ʔyV/ and /ʔiV/ syllables in Mazateco, as PP note: "The combinations /oV/ and /iV/ may follow /Cʔ/ but not /ʔ/ or /Vʔ/; this restriction does not apply to /õa/ or /ia/ etc., nor to simple /o/ and /i/. Thus one finds /ʧʔoa/ 'his mouth' /ntʔia/ 'house', /ʔõa/ 'we are five', /toncoʔo/ 'spider', /ʔivi/ 'here' but not */ʔoa/ or */ʔia/." (1947:87).

The suggestion was made earlier that onsets lacking supralaryngeal ar ticulations are disfavored in Mazateco; and that syllables containing such onsets turn a high oral vowel into a glide, provided that this does not entirely eliminate the nucleus. This analysis explains every aspect of PP's observations. Glide formation is not needed in syllables beginning with /Cʔ/ (or /ʔC/) since these onsets do contain a supralaryngeal gesture: this is why /tsʔoa/ does not become */tsʔwa/. Glide formation is needed in forms like /ʔi(-vi)/ but cannot apply without eliminating the nucleus of the initial syllable. On the other hand, glide formation, although needed in forms like /ʔõa/, cannot apply there because it would yield a nasalized continuant /w̃/ : *ʔw̃a/. Finally, glide formation does apply in underlying /ʔia/, /ʔoa/ and yields /ʔya/ and intermediate /ʔwa/ respectively, the latter spelled <ʔva> by PP.

PP's remarks indicate that at least some instances of [ʔβV] originate as /ʔoV/ and represent an intermediate sequence /ʔw/. Since /β/ represents not only a glide but also an underlying bilabial stop, I will assume that /ʔβ/ clusters have a diverse derivational source: some originate as /ʔb/ while others come from /ʔoV/, via glide formation. For instance, glide formation may have applied in /ʔva/ 'hook', in which case this item originates as /ʔoa/, to become intermediate /ʔwa/. The information provided by PP does not allow us to tell whether the two classes of surface [ʔβ] differ in their phonological behavior.[27]

Having eliminated the preglottalized continuants, we turn to the plosives. There is a predictable relation between preglottalization and nasality in Mazateco, which suggests that preposed /ʔ/ induces prenasalization in a plosive. The simplest statement of this relation will be based on the assumption that preglottalized plosives have /ʔ/ superimposed on their closure rather than linearly ordered before it:

(39) Preglottal nasalization

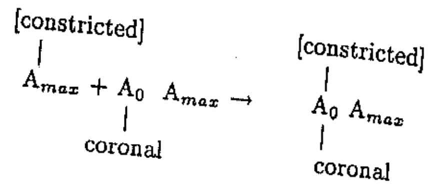
$$\begin{array}{c}\text{[constricted]}\\ |\\ A_0\\ \vdots\\ \text{[nasal]}\end{array}$$

[27]One point that remains unclear is the fact that Glide Formation applies to /ʔoV/ sequences (since PP observe that /ʔoV/ does not surface as such) but not to /hoV/ sequences (given the surface contrast between [hβV] and [hoV]). Glide Formation applies to /i/ in both/ʔiV/ and /hiV/ sequences. Perhaps this difference between /i/ and /o/ is attributable to the fact that only /i/ is unambiguously a high vowel.

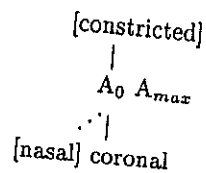
The rule in (39) allows us to assume that every Mazateco segment endowed with a closure can be preglottalized. The surface absence of /ʔt/, /ʔts/, /ʔk/ etc., is due to Preglottal Nasalization: /ʔt/ becomes /ʔnt/, and finally [ʔnd]. This simplifies considerably the analysis.[28]

(40) How /ʔt/ becomes [ʔnd]

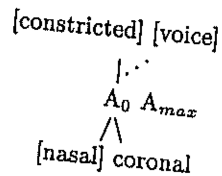
(i) Merger:



(ii) Preglottal nasalization:



(ii) Prenasal voicing:



The absence of surface contrast between preglottalized prenasals (e.g. underlying /ʔ-N-t/), prenasalized preglottals (e.g., underlying /N-ʔ-t/) and preglottalized stops subject to (39) (e.g., underlying /ʔ-t/ becoming prenasalized) is explained by the nature of the representations we propose: in all three cases nasality and glottalization will end up being simultaneously present on A_0. Such structures will be necessarily identical.

[28] Since we assume that some instances of /ʔβ/ originate as /ʔb/, we must explain why /ʔb/ does not become /ʔmb/. This appears to require the assumption that the spirantization of /b/ precedes and bleeds rule (39). A better explanation is that the primary step in the derivation of the prenasalized /ʔC/ onsets is the voicing rather than the nasalization of the closure. Prenasalization is simply an enhancement strategy for voicing, needed for stops with a relatively small supraglottal cavity, but not needed for bilabial stops, whose supraglottal cavity is sufficiently large to maintain vocal cord vibration.

The list of Mazateco postglottalized onsets is given below. As before, I omit the /hCʔ/ clusters, whose status will be discussed separately.

(41) Postglottalized onsets

a. Two-member onsets

PP's	Phonological	Phonetic	Example	Gloss
<tʔ>	/tʔ/	[tʔ]	/tʔi/	'go' (imperative)
<tsʔ>	/tsʔ/	[tsʔ]	/tsʔe/	'lazy'
<ʧʔ>	/ʧʔ/	[ʧʔ]	/ʧʔoa/	'parrot'
<tʂ>	/tʂʔ/	[tʂʔ]	/tʂʔoale/	'pieces left over'
<kʔ>	/kʔ/	[kʔ]	/kʔia/	'then'
<mʔ>	/mʔ/	[mʔ]	/mʔẽ/	'he is sick'
<nʔ>	/nʔ/	[nʔ]	/nʔo/	'rope'
<ɲʔ>	/ɲʔ/	[ɲʔ]	/ɲʔãi/	'difficult'
<sʔ>	/sʔ/	[sˀ]	/sʔoi/	'fiesta'
< ʃʔ>	/ʃʔ/	[ʃˀ]	/ʃʔi/	'man'
<lʔ>	/lʔ/	[lˀ]	/lʔi/	'fire'
<vʔ>	/bʔ/	[βˀ]	/vʔe/	'I hit'
<yʔ>	/yʔ/	[yˀ]	/yʔa/	'I carry'

b. Three member onsets

PP's	Phonological	Phonetic	Example	Gloss
<ntʔ>	/ntʔ/	[ⁿdʔ]	/ntʔe/	'industrious'
<ntsʔ>	/ntsʔ/	[ⁿdzʔ]	/ntsʔe/	'his brother'
<nʧʔ>	/nʧʔ/	[ɲdʒʔ]	/nʧʔã/	'cold'
<ntʂʔ>	/ntʂʔ/	[ⁿdʐʔ]	/ntʂʔoe/	'he hears'

For postglottalized clusters, PP's information about phonetic realization are limited to the following: "there is usually a very slight open transition between the stop and the /ʔ/ in the same syllable, so that the stops are not phonetically glottalized - i.e., they are not made with egressive pharynx air [...] and [...] this phonetic gap between the stop and the /ʔ/ in clusters is often further accentuated in that /ʔ/ may be actualized as the laryngealization of the following vowel rather than as a separate stop, while often there is a slight prearticulation of the vowel before the /ʔ/ (but after the glottal stop in the sequence of oral plus glottal stop)." (1947:81) . I interpret this statement about /stop-ʔ/ clusters to indicate that the glottal gesture is phonologically aligned with the stop release, as shown below, but phonetically realized at the boundary between the release interval and the following vowel. The "slight prearticulation of the vowel" occurring between the end of stop closure and the glottal is simply an indication that the phonetic transition between the oral constriction of the stop and that of the vowel takes place *simultaneously* with the glottal gesture. As in the case of postaspirated onsets, I will assume that the glottal gesture in /C?/ onsets is phonologically simultaneous with the rightmost A position of the preceding consonant.

(42) Phonological representation of C? onsets

a. Plosive - ?
$A_0\ A_n$
|
[constricted]

b. Continuant - ?
A_{max}
|
[constricted]

or

A_f
|
[constricted]

The analysis of pre- and post-glottalized onsets emerging from this section is entirely parallel to that of pre- and postaspirated onsets. We may assume then that a single process is responsible for their formation: an extension of the merger in (35). But rather than complicate the statement of the rule by mentioning a disjunction of features (i.e., Merge A_{max} // A, iff the former dominates only [spread] or only [constricted]) we will assume that A-position merger takes place wherever its immediate output is a single segment. This formulation will cover both the merger with /h/ and /?/ and the merger with unreleased placeless nasal A_0, the former (22.a).

(43) Merger (final)

Merge any adjacent pair of A-positions iff the immediate output is monosegmental according to (15).

The unique condition imposed on (43) – the monosegmental quality of the output – will ensure that only three elements will be able to freely merge with the Mazateco consonants: a placeless nasal closure and the placeless approximants /?/ and /h/. All other segments carry a place component and will necessarily yield bisegmental outputs when in combination with another consonant.

2.6 S-stop Onsets

2.6.1 A Preliminary Analysis

A final class of Mazateco clusters consists of sequences in which the spirants /s/ and /ʃ/ (abbreviated below as S) precede a stop. We will observe in what follows that the /S-stop/ clusters fall under different generalizations from the other Mazateco onsets. They are not featurally monosegmental,

insofar as the spirant and the stop contain each its own distinctive pl specifications. Whether these onsets are structurally monosegmental i harder point to settle. What I propose below is primarily a description the relevant sequences in Mazateco, focussing on the source of /hC?/ cl ters and, as an aside, a speculation about the phonological representati of the /S-stop/ clusters. Because several fundamental questions about t cross-linguistic properties of fricative-stop sequences remain unanswere the main goal of this section is merely to verify that our analysis of tl monosegmental onsets of Mazateco is compatible with the generalizatio holding of the bisegmental /SC/ sequences.

The following are the transparent examples of the class of /S-stop clusters:

(44) Mazateco surface /S-C/ onsets

a. Two member onsets

sk: ska 'crazy'
ʃt: ʃti 'children'
ʃk: ʃka 'trousers'
(ʃn): nkaʃni 'Chiquihuitlan'

b. Three-member onsets:

sk?: sk?ao 'It will break'
ʃt?: haʃt?a lanka 'good bye'
ʃk?: ʃk?e 'thin'

According to PP, the example of /ʃn/ is unique in the Huautla dialect. This, the fact that the example is a toponym, and the absence of /sn?/, /sm/, /sm?/, /ʃm/, /ʃm?/, /sɲ/, /sɲ?/ casts doubt on the presence of /S-nasal/ onsets in this dialect. The Chiquihuitlan dialect studied by Jamieson (1977) has a number of better attested /S-n/ onsets: the gloss makes it obvious that /nkaʃni/ 'Chiquihuitlan' represents an unassimilated loan.

2.6.2 An Outline of the Analysis

The most obvious gap in the paradigm of (44) are sequences in which the spirant and stop are either [α anterior] or else are both strident. The following clusters, although structurally identical to those in (44), remain unattested.

(45) Missing S-onsets: coronal clusters

st		
sts	sʧ	stʂ
ʃts	ʃʧ	ʃtʂ
stʔ		
stsʔ	sʧʔ	sʧʔ
ʃtsʔ	ʃʧʔ	ʃtʂʔ

We may now recall the clusters /htsʔ/ and /hʧʔ/, set aside earlier as unique and aberrant cases of coexistence between aspiration and glottalization. The complementary distribution between /S-C-ʔ/ and /h-C-ʔ/ clusters suggests strongly that the latter are surface realizations of the former.

(46) h-C-ʔclusters

/stsʔ/ = [htsʔ] htsʔe 'sprout'
/sʧʔ/ = [hʧʔ] ʔntihʧʔa 'orphan'

The process that replaces in these examples a spirant with preaspiration can be identified as dissimilation: two coronals may not remain adjacent if they are either homorganic ([α anterior]) or strident. When they do co-occur in intermediate representations, the spirant loses its place features but leaves behind its laryngeal component, which surfaces as preaspiration. This will explain the absence of the clusters in (45), most of which are attested as surface preaspirated onsets, indistinguishable from underlying /hC/ clusters. A distinct advantage of this idea is that it accounts for the complete absence of /ʔCh/ clusters in Mazateco: these could not have a debuccalized fricative as their underlying source, since /(ʔ)-stop-fricative/ clusters do not exist anywhere in the language. The process of debuccalization is formulated and explored in further detail in section 2.6.2.

Another gap attributable to dissimilation is that involving clusters consisting of a sibilant attached to a pre- or postaspirated stop: sequences like /shk/ or /skh/ are also systematically missing. I propose to explain this by noting that, although Mazateco fricatives are not distinctively aspirated, they are clearly phonetically aspirated, as indicated by the fact that they yield /h/ under debuccalization. A dissimilatory process comparable to debuccalization is probably responsible for the absence of clusters in which /h/ co-occurs with an /S-stop/ cluster. However, in the absence of information about the morphophonemics of Mazateco, we cannot tell whether underlying /skh/ becomes /kh/ or /sk/. This explanation for the

absence of /sCh/ raises an interesting question for our analysis: if /s/ is phonetically aspirated, what explains the surface contrast between /s/ and post-aspirated /sh/? I address this issue in section (2.6.4).

Also systematically missing are the onsets listed below, in which the closure is nasalized. I omit from this list clusters in which the fricative and the stop are homorganic: the absence of /sn/ or /sntsʔ/, for instance, need not be mentioned again, since it is parallel to the absence – discussed above – of /st/ or /stsʔ/.

(47) More missing S-onsets: S-nasal

sm	sɲ		
smʔ	sɲʔ		snk
sʔm	sʔɲ		snkʔ
ʃm		ʃnt	sʔnk
ʃmʔ		ʃntʔ	ʃnk
ʃʔm		ʃʔnt	ʃnkʔ
			ʃʔnk

A feature common to the missing /S-C/ clusters in (47) is the presence of nasality on closure: both /ʃnt/ and /ʃn/ are disallowed, in contrast to /ʃt/.

Preglottalization (i.e., glottalization linked to closure) also blocks the attachment of the sibilant: there are no /sʔC/ clusters. This could be plausibly attributed to the fact that preglottalized stops are subject to prenasalization (rule (39)). There are no /sʔC/ sequences because they would all surface as /sʔnC/: whatever explains the absence of the clusters in (47) will explain the lack of /sʔC/. I summarize now the observations made on the restrictions to which /S-stop/ clusters are subject in Mazateco:

(48) Generalizations about S-stop onsets

(a) S is attached to a closure: */sl/, */sy/, */sr/ */sʃ/ (the latter realizable as debuccalized *[hʃ]).
(b) S may not attach to a nasalized closure: */ʃnt/, */sʔm/
(c) S does not surface if attached to an aspirated stop: */skh/, */shk/.
(d) S and the stop may be heterorganic: cf. /ʃt/.
(e) S and the stop must be heterorganic on the surface: cf. /st/ → /ht/.

There are two types observations here: one class, (48.c and e), involves OCP-style dissimilatory conditions imposed on the surface feature composition of S-stop sequences. Such conditions appear to follow the attachment of the sibilant to the closure of the following stop. For instance, the constraint in (48.e) does not block the attachment of /s/ to /tsʔ/: it merely repairs the OCP violation resulting from this attachment, by removing the place component of /s/. The second class of conditions holding of the S-stop clusters of Mazateco involves the nature of the position to which a sibilant may be prefixed in the first place: this position is a closure, bare of any features other than [place].

We may briefly compare the Mazateco /S-C/ clusters to their counterparts observed elsewhere, in languages like English, Latin and in modern Romance. The Mazateco sequences are typical of this class in three respects: (a) they attach only to closures, (b) they attach to closures that are minimally specified, carrying place features but not nasality or voicing, and (c) they precede the closure. The Mazateco /S-C/ onsets are somewhat atypical – though not unique – in one respect: they display a place contrast between /ʃ-C/ and /s-C/, absent from many languages where /fricative-stop/ clusters coexist with place distinctions within the fricative series. Thus English allows /s-stop/ but not /ʃ-stop/, /f-stop/ or /θ-stop/ onsets. Sanskrit has numerous /s-stop/ clusters, as well as homorganic /ʃʧ/ and /ʂt/ but no heterorganic /ʃ-stop/, /ʂ-stop/ sequences.

Given the need to distinguish the place features of the fricative from those of the stop, we will assume that the /S-C/ clusters are linearly ordered sequences rather than phonologically simultaneous components. One possibility then is to analyze the /S-C/ clusters as $A_f A_0$ sequences. This structure leaves one important question unanswered: why are the /S-Stop/ clusters significantly more widespread than other structurally bisegmental sequences, such as A_{max}Af, $A_f A_{max}$, $A_{max} A_0$, $A_f A_f$ etc. A possible alternative analysis is that the fricative occupies not the expected A_f position but a segment-internal slot previously unidentified: that of Approach-to-Closure, or Approach.[29] On this hypothesis, the full structure of Closure would look as follows:

(49) Approach as a subconstituent of Closure

[[Approach [Closure Proper (A_0)]] Release (A_{max})]

[29] Ian Maddieson first suggested to me the idea of an Approach position. He is not to blame for its use in this context.

Like the release of the stop, the Approach position would not necessarily carry features distinct from those present on the closure proper: this would be the case, for instance, with plain stops, for which we might assume a featurally bare Approach position. The presence of Approach would manifest itself phonologically only in case a distinct set of point of articulation features would come to lodge there, as in the case of /S-stop/ clusters, which could be represented as follows:

(50) S-stop clusters

```
Approach   A0 Amax
   |        |
 place    place
```

The principal merit of this type of analysis is that it helps explain why /S-stop/ clusters are widespread onsets and even more widespread intervocalic clusters: they are structurally monosegmental, in that the place features of the fricative occupy a position projected by the stop. In this respect, they are structurally parallel to the stop-liquid clusters, where the liquid occupies the release position of the plosive. If this idea is adopted, the derivational origin of the /S-Stop clusters/ could be the merger of a stop's approach with a preceding fricative's A_f position. A distinct consideration that favors the analysis in (50) is the fact that it will allow us to express what *all* Mazateco onset clusters have in common: they are structurally monosegmental.

Whether or not the Mazateco /S-Stop/ clusters are analyzed as in (50), they are clearly bisegmental in feature composition, as they contain two distinct place components. Another argument to the same effect is the joint presence of the two incompatible features of aspiration and glottalization in /htsʔ/, /hʧʔ/, the outputs of debuccalization. The monosegmental onsets of Mazateco – resulting from prenasalization, pre- and postaspiration and pre- and postglottalization – do not allow aspiration and glottalization to co-occur, precisely because they must be monosegmental (cf (43) above). On the other hand, the /S-stop-ʔ/ clusters, whose bisegmental feature composition has been established independently, are not constrained by any considerations of feature compatibility. There is therefore no reason to expect /h/ and /ʔ/ to exclude each other in such structures. Note that the aspiration is present in the /S-stop-ʔ/ sequences even before debuccalization applies: the effect of the latter is simply to eliminate all features of the sibilant other than its aspiration.

Before turning to the specifics of the analysis, we should address an important typological question. The overall view of Mazateco clusters emerging from the discussion is that the language possesses numerous underlying clusters but only one set of surface bisegmental clusters, the /S-stop/ sequences. The question that arises is whether this situation is attested elsewhere: are there other languages whose only bisegmental onsets are /fricative-stop/ sequences? I raise this issue because our exposure to the cluster systems of Indo-European languages – in which /S-stop/ is frequently not an allowable onset cluster – may create the impression that /S-stop/ is a very marked variety of onset, allowed only in the company of other, less marked, onset types, such as /obstruent-liquid/. Among the North American-Indian languages the onset inventory we attribute to Mazateco – single C's and /S-stop/ clusters – is in fact encountered elsewhere. Haida (Sapir 1922) possesses onset clusters which may consist only of /s/ followed by a stop or by /ɬ/ followed by a stop. Since /ɬ/ is the only spirant of the language other than /s/, the Haida inventory of surface onsets can be described in terms identical to that of Mazateco: single segments and fricative-plosive clusters. Similar onset inventories are attested in Havasupai (Kozlowsky 1976), Yuchi and Chiquihuitlan Mazateco, the latter two discussed below. What this indicates is that there is no implicational relation – and hence no markedness ranking – between /S-stop/ and /stop-liquid/ onsets: a language may possess one or the other type, both or neither. This lends further support to the Approach hypothesis, which succeeds in identifying the fact that onsets like /ʃt/ and /tr/ are structurally equivalent, and hence equivalent in degree of markedness.

2.6.3 Debuccalization

It was suggested above that the absence of the homorganic or nearly homorganic clusters in (45) stems from a process in which the sibilant loses its point of articulation features. I call this type of rule debuccalization, adopting McCarthy's (1988) term, and attribute its application in the Mazateco onsets to the requirements of the Obligatory Contour Principle.

(51) Debuccalization (preliminary)

place tier   .   .
                     ǂ |
                     A   A

Trigger: OCP violation on [anterior] and/or [strident] tier
Condition: A-positions are adjacent.

Rule (51) will turn not only postglottalized /stsʔ/, etc. into /htsʔ/ but also plain /sts/, /st/ into /hts/, /ht/ etc. In this case however, the preaspirated output of the rule is inevitably identical to a basic preaspirated plosive. I indicate below the possible derivational sources of the Mazateco coronal preaspirates:

(52)

Surface	Underlying
ht	s t
	h t
hts	sts
	hts
	ʃts
hʧ	sʧ
	hʧ
	ʃʧ
htsʔ	stsʔ
	ʃtsʔ
hʧʔ	sʧʔ
	ʃʧʔ

PP note (1947:82) that the /htsʔ/ and /hʧʔ/ clusters they recorded are infrequent and that they "tend to vary to /tsʔ/ and /ʧʔ/". This could be explained rather simply in the framework of our analysis. If the distributional restrictions on /hCʔ/ are the only indication as to their underlying source as /SCʔ/ clusters, the Mazateco speakers may misanalyze them as ill-formed outcomes of the merger process in (43), ill-formed because they contain the incompatible specifications of aspiration and glottalization. If so, the speakers will tend to eliminate either /h/ or /ʔ/: and it is likely that /h/ is being eliminated because its association to closure makes it less salient perceptually.

The tendency to drop preaspiration in /hCʔ/ clusters may explain the absence of recorded /htʔ/ and /htʂʔ/, sequences predicted to occur as debuccalized outcomes of underlying /stʔ/ and /stʂʔ/, /ʃtʂʔ/. The fact that they were not recorded as such could easily be attributed to the fact that the entire class of postglottalized preaspirates resulting from debuccalization is only occasionally distinguishable from underlying postglottalized coronals: /htʔ/ and /htʂʔ/ are probably there but PP may have recorded them only as /tʔ/, /tʂʔ/, indistinguishable from underlying postglottalized /tʔ/, /tsʔ/. With this proviso, I conclude that debuccalization accounts for each one of the missing onsets listed above in (45).

It was mentioned earlier that the /S-stop/ clusters of Mazateco must be featurally bisegmental. The surface contrast between /sk(ʔ)/ and /ʃk(ʔ)/ and that between /ʃk(ʔ)/ and /ʃt(ʔ)/ are sufficient to indicate that both the stop and the spirant have their own distinctive place specification. The dissimilation rule in (51) makes the same point: dissimilation would be inapplicable in the absence of some [αF][αF] sequence. Such a sequence is, according to (15), the trademark of a bisegmental cluster.

2.6.4 Excursus on [strident]

The dissimilatory debuccalization in (51) appears unusual in that it is triggered by identity in either point of articulation or in one stricture feature, [strident]. The problem stems directly from our use of the feature [strident].

I suspect that in this and other cases where the sibilants (/s/, /ʃ/) and the coronal affricates (/ts/, /ʧ/, /tʂ/) act as a natural class they do so for one of two reasons: they are either all [laminal] in articulation (as in Yucatec Mayan: cf. Straight 1976) or they share [+strident]. We cannot tell whether the sibilants and affricates of Mazateco are laminal and, for this reason, we cannot pursue the first possibility.

In what follows I will suggest the possibility that the behavior of [strident] in the Mazateco debuccalization is due to the fact that this feature is always a dependent of the coronal node: in effect, a place feature. The general motivation for this is the fact that [strident] is, for all practical purposes, restricted to coronal consonants. This renders it suspect as a genuine stricture feature, since one expects stricture distinctions to be freely distributed across points of articulation. A more likely possibility is that [strident] – if it exists at all – is a coronal dependent, like [laminal] or [anterior]. The immediate consequence of this proposal for Mazateco is that we can eliminate the disjunction between [anterior] and [strident] as the tiers where OCP violations may trigger debuccalization: [anterior] and [strident] are the only terminal features present in the place component of Mazateco which may occasion an OCP violation inside an /S-C/ cluster. We may assume then that the debuccalizing dissimilation applies between adjacent consonants that dominate *any identical pair of terminal place feature specifications.*

(53) Debuccalization (final)

```
place tier   .   .
             ≠   |
             A   A
```

Trigger: OCP violation on any terminal tier
Condition: A-positions are adjacent.

Let us clarify now the relation between the facts described and the reformulated rule (53). We note first that Coronal is not a terminal feature: it has either [anterior] or [strident] dependents or both. This allows the dissimilar coronals /ʃ/ and /t/ – distinct in both anteriority and stridency – to coexist in the clusters /ʃt/ and /ʃtʔ/. All other clusters that can be generated in Mazateco by prefixing /s/ or /ʃ/ to a coronal plosive will be identical with respect to the terminal feature [strident] or [anterior] or both: this will trigger (53). Because of the monosegmental nature of the Mazateco onsets other than the /s-C/ clusters, no other allowable consonant sequences will contain two sets of specifications – identical or not – for any feature F. Therefore no other obvious possibilities for the application of (53) exist. However, an extension of (53) to non-place features may explain the absence – noted above – of /S-Stop/ onsets involving pre- or postaspirated stops.

2.6.5 A Further Remark on the Aspiration of /s/

The co-occurrence restriction barring /s/ and /ʃ/ as prefixes on pre- and postaspirated plosives was explained above by postulating that Mazateco spirants are aspirated, a common phonetic characteristic in voiceless fricatives. The aspiration is clearly redundant in this case, but its phonological presence is also fairly clear: no other assumption will explain the absence of /S-stop-h/.

This fact must however be reconciled with our treatment of postaspirated continuants. Recall from section 2.4.4., that the analysis of aspirated continuants /sh/, /ʃh/, /lh/ is based on the hypothesis that aspiration becomes simultaneous with the features of the existing A-position. We claimed that the distinction between surface /s/ and /sh/ is not that between a single segment and a cluster but rather that between a plain unaspirated consonant and its aspirated counterpart. Since this requires that surface /s/ and /ʃ/ be unaspirated, we seem to have derived a contradiction.

The solution is this. Vowels are laryngealized after /ʔ/ and aspirated after /h/, as noted, in the case of laryngealization, by PP (1947:79-80) and demonstrated, for aspiration and laryngealization, by Kirk, Ladefoged and Ladefoged (1984). However, no amount of vocalic aspiration is reported after the plain spirants or affricates and the instrumental data reported by Kirk, Ladefoged and Ladefoged indicates that the plain, unaspirated, fricative and affricates (i.e., /s/, /ʃ/, /ts/, /ʧ/, /tʂ/) do not induce aspiration of the following vowel. This suggests that *only distinctive laryngeal features* spread onto following vowels. The redundant aspiration associated to A_f positions is not involved in this process. The rule ordering sketched below is one way of accomplishing this:

(54) Ordering of Mazateco processes involving aspiration

(i) Formation of /C-h/ onsets through merger of A-positions (cf. (43) above).

(ii) Spread glottal features onto adjacent A position of tautosyllabic vowel.

(iii) A_f is redundantly aspirated: [+spread]
⋮
A_f

(iv) Delink [+spread] where OCP is violated.

The scenario sketched above will derive surface sequences such as [s^hA] and [s^ha] in which the spirants themselves are both aspirated but in which the following vowel is aspirated only after /sh/, the fricative with *distinctive* aspiration. The surface phonological representations of [s^hA] and [s^ha] are shown below.

(55) Derivation of /s^hA/ and /s^ha/ (post merger (43))

	/sha/	/sa/
	[spread] | A_fA_v	A_fA_v
Spread glottal features:	[spread] |⋱ A_f A_v	n/a
Aspirate A_f:	n/a	[spread] | A_f A

This analysis, which Kirk, Ladefoged and Ladefoged's data support independently, reconciles our claim that /s/ and /ʃ/ have phonologically represented aspiration with the idea that "postaspirated" /sh/ onsets are monosegmental and possess a single A position. The contrast between what PP transcribed as /sh/ and /s/ exists, but resides in the vocalic context rather than the consonantal articulation.[30]

2.7 Summary of the Analysis

I conclude that PP were justified in deciding that the Mazateco onsets contain underlying sequences of distinct consonants: the only reasonable explanation for the surface contrast between pre- and postaspirated stops or pre- and postglottalized nasals is the existence of underlying /C-h/, /h-C/, /C-ʔ/, /ʔ-C/ sequences. I have suggested however that the vast majority of these underlying clusters – all those involving the satellites /h/, /ʔ/ and /n/ – are allowed to surface as onsets because the merger of A positions in (43) turns them into articulatory sequences that are analyzable as monosegmental.

Aside from these derived monosegmental onsets, Mazateco possesses true bisegmental clusters: the /S-Stop/ sequences. The major question left open is to understand why these are the only bisegmental onsets Mazateco tolerates. More concretely, if both /ʃt/ and /tr/ are bisegmental, then why does Mazateco allow one of these to surface but not the other? I have

[30] A final assumption is that glottalized /sʔ/ blocks the application of the redundancy rule introducing aspiration.

suggested above that it is not in fact predictable whether a language will allow bisegmental onset clusters consisting of only /S-Stop/ (as in Haida) or of only /Stop-Approximant/ (as in Latin and Romance) or of both /S-Stop/ and /Stop-Approximant/ (as in English). Thus the question raised now is not whether we can *explain* the choice made in Huautla Mazateco among possible types of bisegmental onsets: that choice is clearly arbitrary. Rather, the question is whether we can globally characterize which clusters are allowed to surface in Huautla, since, without such a characterization, we cannot *describe* the fact that /tr/ is absent from this language. A possible answer emerges if /S-stop/ sequences are analyzed as in (50), as resulting from the merger between an A_f position and the Approach of a following stop. If (50) is adopted, then we can assume that a minimal condition of well-formedness for all Huautla onsets is that they must be *structurally* monosegmental. The /S-Stop/ sequences, when analyzed as in (50), as well as the /nC/, /hC/, /ʔC/, /Ch/ and /Cʔ/ onsets, share this property. The answer to our earlier question – why /ʃt/ but not /tr/ – reduces in that case to this. Huautla allows the merger of A positions in only two circumstances, neither of which fits the case of /tr/: it allows the merger of A_f and Approach, regardless of whether the outcome of merger is featurally monosegmental, and it allows the merger of any two A positions, but only in case the result is featurally monosegmental.

3 Comparison with Pike and Pike's Account

The analysis presented here departs significantly from that proposed by PP. The principal point of difference between the two approaches is that PP take at face value the phonetic sequencing of articulatory gestures within a Mazateco onset and attribute segment status to almost every single consonantal gesture that could be temporally isolated in a sequence. Thus PP appear to have perceived two sequenced gestures in a Mazateco /ht/ cluster and they conclude from this that the cluster contains two segments . The present study, without denying the accuracy of the phonetic observations made by PP, has experimented with the idea that the phonetic sequencing of gestures is less important for the phonological analysis than the need to explain the properties of the overall cluster system. The system as a whole can be coherently described only if articulatory sequences like /ht/, /ʔnt/, /sʔ/ are viewed as phonologically simultaneous or overlapping. The theory of aperture positions presented at the beginning of this study has allowed us to maintain the claim that /h/ overlaps phonologically with /t/ both in /ht/ and in the distinct /th/ sequences.

A second point of difference revolves around PP's claim that that the onset clusters of Mazateco are hierarchically organized. There are two aspects to this claim. One is the principal/subordinate distinction – referred

to below as headedness – and the other is the subconstituency involved in three-member onsets. PP claim that a tripartite onset like /ntsʔ/ consists of the multiply embedded structure [n[tsʔ]]. The evidence cited in favor of this structure is the fact that occasionally, the first member of three-consonant onsets is syllabified with the preceding vowel, as a coda.

The analysis presented here does not employ constituent structure, for a very simple reason: we found no need for it and, besides, no structure *could* be defined within one segment. The occasional heterosyllabicity of /n/ in /ntsʔ/ and perhaps other clusters may simply indicate that the closure – hence the nasal interval of the consonant – sometimes geminates, as appears to happen in Tlacoyalco Popoloca (Stark and Machin 1977), a language discussed below. (Some suggestions about the analysis of geminate consonants within our aperture position framework can be found in Steriade 1992.) Nor did we find any reason to define a head segment in either the cluster that represents the input to A position merger or in the structure resulting from merger.

But in several interesting respects, there is convergence between our analysis and PP's ideas. PP assume that the head of the onset is the consonant carrying the features of the oral constriction. It seems clear that PP relied here on the implicit assumption that bracketed structures may possess only one head, in order to explain why only one set of place features will exist within a Mazateco onset. The head consonant, according to their analysis, is the one carrying place and stricture specifications: if clusters are headed structures, then the limitation to one set of place features follows from the limitation to one head. We have attempted to capture this same intuition more directly, without the intermediary of a head-satellite distinction: our claim is that Mazateco onsets (other than the /S-stop/ clusters) contain only one set of place features because these onsets are single segments and single segments necessarily possess only one place node. The second point of convergence between the two analyses is this: PP's head consonants find a counterpart within our analysis as *the consonants which preserve their underlying A positions and features*: the satellites either lose their own A positions through merger (as in the case of /h/ in the derivations in (35.b)) or lose their underlying place components (as in the case of the unreleased nasals stops, which preserve only their nasality: cf. (22)). Finally, PP's characterization of the major components of Mazateco onsets – nasality, laryngeal features and oral constriction – indicates awareness of the featurally monosegmental character of these clusters.

The differences between PP's analysis and ours – differences which follow directly from the decision to incorporate a closure-release distinction in the phonological representations – were pointed out above. PP did not explain why plosives can head twice as many clusters – involving pre- and postglottalization, pre- and postaspiration – as continuants can. PP also failed to explain why prenasalized clusters combine in only two distinct ways with aspiration – as /nCh/ and /hnC/ – rather than in all three ways that seem compatible with the principles of their analysis: they did not explain the absence of /nhC/ as a third possibility. Finally, PP conflate the categories of monosegmental and bisegmental onsets into a single class: for them, /SC(ʔ)/ and /hCʔ/ are not distinct from the other onset types of Mazateco. This makes it impossible to understand, among other things, why the /hCʔ/ onsets are so few and unstable and why /ʔCh/ – the mirror image structures – remain completely unattested.

4 Other Mazatecan and Popolocan Onset Systems

A number of other dialects of Mazateco have been described briefly, along with dialects of the closely related Popolocan language. None of the descriptions available to me match in richness of detail PP's account of the Huautla de Jimenez dialect analyzed above. However, I will consider briefly three of these dialects, as a means to verify the main elements of the analysis of Huautla onsets. All the dialects of Mazateco-Popolocan I have encountered differ from Huautla in lacking a widespread and systematic contrast between pre- and postaspirated or pre- and postglottalized onsets. Consequently, most of their onsets can be analyzed as involving sequences that are monosegmental both on the surface and in underlying representations.

4.1 Western Popoloca

The phonology of this dialect of Popoloca has been described by Pierson (1953) and Williams and Pike (1968). Its consonant inventory (culled from Williams and Pike) is essentially identical to that of Huautla Mazateco:

(56) Western Popoloca consonants

p	t	ts	ʧ	tʂ	k		
	d	dz	dʐ				
m	n		ɲ				
v		s	ʃ	ʂ	ɣ		
	r						
					y	h	ʔ

Notes

- p: only in loans
- dz, dʐ: possibly realizations of z, ʐ.
- v: in free variation with w.

The Western Popoloca onsets are listed below. On the few points where Pierson's description differs from that of Williams and Pike, I followed the latter.[31]

(57) Western Popoloca onsets

a. voiceless plosive + h:	th, tsh, ʧh, tʂh, kh
b. nasal + plosive	nd, ndʐ, nk, mp
c. h + sonorant	hn, hm, hɲ, hv, hy
d. h + nasal + stop	hnd, hnk
e. ʔ + nasal	ʔn, ʔm, ʔɲ
f. ʔ + nasal + plosive	ʔnt ʔnʧ
g. ʔ + y	ʔy
h. C + ʔ	tʔ, tsʔ, ʧʔ, kʔ, sʔ, ʃʔ, ʂʔ, nʔ, mʔ, ɲʔ, gʔ, rʔ, yʔ, hʔ
i. voiceless plosive + h + ʔ	thʔ, tshʔ, khʔ
j. h + nasal + ʔ	hmʔ, hnʔ, hɲʔ
k. nasal + plosive + ʔ	nkʔ, ntʔ, nʧʔ

Unlike Huautla Mazateco, Western Popoloca allows a coda segment: /ʔ/. Examples such as /tiʔ/ 'fresh corn', /riyeʔ/ 'a boil' illustrate the word-final coda /ʔ/. In forms like /tuʔʧʔia/ 'my knee', /tuʔsʔi-na/ 'our (exclusive) necks', we must assume a coda /ʔ/ in the initial syllable, since /ʔts/, /ʔs/ onsets are not independently attested. The existence of coda /ʔ/ renders ambiguous all word-medial examples of /ʔ-nasal/ or /ʔ-nasal-plosive/ clusters.[32] I have listed them in (57.e-f) only because some instances of word-initial /ʔ-nasal-(plosive)/ are in fact encountered. Unattested initially remain the clusters /ʔ-nasal-(plosive)-ʔ/ which one might expect on the basis of the joint existence of /ʔ-nasal-(plosive)/ and /nasal-(plosive)-ʔ/ clusters: it is possible that such clusters are well-formed and only accidentally missing in initial position. Medially they are attested in forms such as /ʧaʔnkʔinaa/ 'my necklace'.

The prenasal stops have phonetically voiced closures, as in Huautla Mazateco: /nk/ is [ŋg]. The analysis given for Huautla prenasals appears

[31] In particular, Pierson records two clusters /pn/ and /py/ which Williams and Pike do not mention.

[32] Williams and Pike make no explicit statement about syllabic division in the ambiguous VʔN(C)V sequences but on page 375 they list them among the heterosyllabic clusters. On page 369, they mention that the first vowel in VʔCV' sequences, where C is voiced and the second syllable bears stress, fails to be laryngealized. Normally, coda ʔ laryngealizes slightly a preceding nucleus. This suggests that in the cases where VʔCV' contains a voiced consonant, the ambiguous clusters belong to the onset in their entirety.

to apply to Western Popoloca as well: the prenasals may arise from the merger between a placeless nasal closure – the remnant of an unreleased nasal stop – and a following A position. We will reconsider this possibility below.

We note next that the position of aspiration within the onset is not distinctive in Western Popoloca: among the aspirated plosives, those with voiceless closure are postaspirated, while those with voiced (i.e., nasal) closure are preaspirated. This distribution can be explained by assuming that /hC/ and /Ch/ are underlying single segments, containing [spread] in their matrix. In this respect, we must assume that Western Popoloca and Mazateco differ: there is no need to postulate underlying /hC/, /Ch/ clusters of distinct segments in Popolocan.

(58) Underlying /hn/ and /th/ in Western Popoloca

```
[spread]
   |            [spread]
   A0              |
   |               A0
[nasal]
```

Once releases are projected, [spread] gravitates towards a [voiced] (or [nasal]) closure; and, in its absence, towards the plosive release. Note that the prenasals realize aspiration on the closure: we get /hnk/ rather than /nkh/. This confirms our hypothesis that it is nasal closures (rather than oral releases) which get first shot at anchoring aspiration. I leave open the question of explaining why [spread] seeks out [nasal] or [voiced] closures in this language.

(59) Realization of [spread] on Western Popoloca plosives

Associate [spread] to release, unless closure is [nasal].

The analysis suggested for Huautla Mazateco /hy/, /hv/ and /ʔy/ appears to carry over to a large extent to Western Popoloca. As in Huautla, /y/ and /v/ are the only preaspirated continuants, /y/ is the only attested preglottalized continuant. As in Huautla, there is no contrast between /hia/ and /hya/, /hua/ and /hva/, or /ʔia/ and /ʔya/ sequences. As in Huautla, onsets lacking supralaryngeal articulations are disfavored: in sequences where glide formation could not apply – because the high vowel is either nasalized or alone in its nucleus – Williams and Pike indicate (p.376) that /uʔi(V)/ sequences may be realized [uʔwi(V)], with an excrescent glide

originating in the preceding syllable. We may assume then that the preaspirated or preglottalized continuants originate from glide formation: there are no underlying aspirated glides.

Preglottalization has the same properties as in Huautla: it surfaces on nasal closures only. I assume therefore that the process of preglottal nasalization is active in Western Popoloca as well. I defer a full analysis of the Western Popoloca onsets with glottalization until after the /Cʔ/ sequences have been discussed.

We must consider now what is clearly the most striking property of Western Popoloca onsets: the fact that aspiration and glottalization are apparently allowed to co-occur within a cluster, in sequences such as /hʔ/, /hnʔ/, /thʔ/.[33] Less obvious but equally important is that /h/ and /ʔ/ may co-occur only if glottalization follows aspiration: clusters such as */ʔh/ or */ʔCh/ or */ʔhC/ are not recorded. The absence of contrast in the linear ordering of /h/ and /ʔ/ might suggest that the two are phonologically simultaneous in clusters transcribed with digraphs such as /hʔ/, /Chʔ/.

(60) An underlying structure for (C)h(C)ʔ clusters?

```
  [spread]
     |
     A
     |
[constricted]
```

This structure, however, incorporates an untenable claim: under any theory of phonological representations,incompatible features like [spread] and [constricted] may co-occur only if sequenced.[34] This alone explains facts like the universal absence of plosives that are underlyingly both aspirated and glottalized: although the two incompatible features can be phoneti-

[33]Note that Western Popoloca and Huautla Mazateco differ in the types of /h(C)ʔ/ they allow and in the relation between these clusters and other onsets present in the language. First, practically all conceivable /h(C)ʔ/ sequences are present in Western Popoloca, provided that the /hC/ subsequence is independently attested. In contrast, Huautla permits only two unstable instances of /hCʔ/, /htsʔ/ and /hʧʔ/. Second, the attested Huautla /hCʔ/ clusters occupy obvious gaps in the system of /S-stop-ʔ/ clusters, whereas the /h(C)ʔ/ sequences of Western Popoloca are not distributionally related to any other class of clusters. In particular, /S-stop/ onsets are completely absent in this dialect of Popoloca. Thus, despite the superficial similarity between Huautla /htsʔ/ and Western Popoloca /tshʔ/, the two clusters must be analyzed differently.

[34]See, however, Lombardi (1990) for a theory of affricate structures in which [+cont] and [-cont] are phonologically simultaneous values. Lombardi avoids facing the general question raised by such structures by claiming that [+cont] and [-cont] are distinct privative features, rather than different values of the same feature.

cally realized as sequenced, with one realized on the closure and the other on the release, their underlying representation would necessarily involve simultaneity of aspiration and glottalization. We must seek an alternative account for the fixed order between the /h/ and /ʔ/ elements.

My suggestion is that all sequences transcribed as /Cʔ/ – including those in which the stop is pre- or postaspirated – have glottalization associated not to the onset but to the following nucleus. If so, aspiration and glottalization do not co-occur within the onsets transcribed /hʔ/, /Chʔ/ etc. much less within a single A position. The fixed order between /h/ and /ʔ/ is explained by the fact that onsets necessarily precede nuclei.

(61) The structure of (C)h(C)ʔV sequences

```
[spread]        [constricted]
   |                 |
 A (A)            A_vowel
```

There is considerable evidence for such an analysis in Williams and Pike's study. These writers note that all Cʔ onsets are realized with a considerable lag between the release of stop and the /ʔ/ element. It is not just the case that the plosives are fully released before the glottal gesture in /ʔ/ is initiated: continuants are also followed by a vocoid transition when postglottalized, as indicated in transcriptions like [ruʔa] 'mouth' for /rʔua/. In this respect, the /Cʔ/ sequences differ from the /Ch/ clusters. Moreover, the transitional vocoid preceding a /ʔ/ has the vowel qualities of the first nuclear vowel and carries mid tone. If the nucleus contains two vowels, the /ʔ/ is heard between the first and the second: thus /ʧʔu/ is narrowly transcribed [ʧuʔu] whereas /tʔie/ and /nʔue/ are transcribed [tiʔe] and [nuʔe]. In contrast, a /Ch/ cluster such as /th/ is transcribed [th] (e.g. [thate] p.377), without any indication of a lag between the stop release and the glottal gesture. To further illustrate the difference in behavior between postaspiration and postglottalization, Williams and Pike state that in /ChʔV$_1$V$_2$(V)/ sequences with distinct V$_1$ and V$_2$, the aspiration affects completely the initial vowel, turning it into a voiceless vowel, which is followed by /ʔ/: /khʔuia/ is transcribed [kUʔiaa]. Given this, it appears that the glottal gesture is timed, at least in heterorganic nuclei, to coincide with the beginning of the second vowel: such timing would be incomprehensible if /ʔ/ belonged to the onset. A final argument for the analysis in (61) is the observation that postglottalized consonant clusters induce a tonal shift in nuclei that contain tone contours: "If the [CʔVV, D.S.] syllable has a tone cluster, the two tones are actualized as a glide on

the last vowel: /rʔùá/ [ruʔǎ] 'your sing. mouth'" (p.373). We may explain this by assuming the phonological representation in (61) – in which glottalization occupies the first mora – plus a rightward shift of the tones in CʔVV(V) syllables: the tone of the first vowel migrates rightward whenever it co-occurs with glottalization. Phonetically, the glottal feature is realized not as laryngealization of the vowel but as a glottal stop at the boundary between the first and the second vocalic gesture. In monovocalic nuclei, it appears that the glottal stop occurs in the middle of the vocalic gesture. I leave open the question of representing such cases.

How then do we distinguish /CʔV/ from /CVʔ/ and /CʔVʔ/ sequences? We must assume that the coda /ʔ/ carries its own A_{max} position and, possibly, its own mora. Representations for all three cases are given below:

(62) Syllables with nucleus and coda /ʔ/

```
CʔV                 CVʔ                        CʔVʔ[35]

A_n A_vowel         A_n A_vowel A_max          A_n A_vowel A_max
      |                         |                     \      /
[constricted]            [constricted]             [constricted]
```

As Williams and Pike note (p.369-370), the vowel is more heavily laryngealized in the /CʔVʔ/ syllables, where the [constricted] feature spans the entire rime, than in /CVʔ/ cases, where [constricted] is not, according to our representations, phonologically associated to the nucleus. This observation is sufficient to exclude an interpretation which would identify /ʔ/ in /CVʔ/ as a phonological property of the nucleus.

Otomanguean languages in which vocalic glottalization is realized in a fashion similar to the one I attribute to Western Popoloca include Chiquihuitlan (discussed below), Choapan Zapotec (Lyman and Lyman 1977) and Guelavila Zapotec (Jones and Knudson 1977). Choapan provides the closer parallel: in this language a checked vowel – the term for the relevant structures – is realized prevocalically with the glottal gesture positioned between it and the following vowel (i.e., [V$_1$ʔV$_2$]) and otherwise with the glottal closure in its center, as [V$_1$ʔV$_1$]. This was exactly what the transcriptions indicated to be happening in Western Popoloca. But could one claim perhaps that, despite its odd timing relative to vowel gestures, the glottal stop of *both* Western Popoloca and Choapan [CVʔVX] syllables belongs structurally to the preceding onset? The Choapan data eliminate

[35]Nothing hinges on my decision to adopt representations in which /CʔVʔ/ contains a single [constricted] value rather than two. I am simply assuming that, in the absence of evidence to the contrary, the Obligatory Contour Principle obtains.

this possibility: any one of the three vowels in a Choapan nucleus may be distinctively checked. Thus /rue/ 'give' (with checked /u/; realized [ru?e]) contrasts with /rdue/ 'be ashamed' (with checked /e/; realized [rdue?e]). The glottal is clearly an individual vowel's property, with no connection to the onset.

Aside from explaining the distribution of tonal contours within /C?VV/ and the timing of the glottal gesture in bivocalic nuclei (/C?V_1V_2/), the analysis of postglottalization proposed in (61) allows us to understand the apparently odd co-occurrence of /h/ and /?/ at the beginning of Western Popoloca syllables, as well as the source of the main difference between Popoloca and Mazateco syllables. The fact that /h?/ occurs as a tautosyllabic sequence in Popoloca, but not in Mazateco, reflects not a difference between the organizing principles of their onset structure but rather the fact that Popoloca has, and Mazateco lacks, glottalized nuclei. We can therefore maintain that /h?/ – as well as /?h/, /?Ch/, /hC?/ etc. – are impossible onsets in any language that requires tautosyllabic clusters to be monosegmental.[36]

Having understood that Western Popoloca postglottalization is a feature of the nucleus, we may conclude that the only onsets containing glottalization are the preglottalized plosives with nasal closure /?n(C)/. This means that the position of glottalization is not distinctive within the onsets of this dialect: the /?n(C)/ onsets can be viewed as underlyingly glottalized plosives rather than as clusters of /?/ plus plosive.

(63) Underlying /?n/ in Western Popoloca

[constricted]
|
A_0
|
[nasal]

Western Popoloca emerges from this discussion as a language which essentially lacks underlying clusters. What our sources represent as sequences of distinct consonants turn out to be, for the most part, single consonants – aspirated or glottalized plosives – or, in the case of /C?/, single consonants followed by glottalized nuclei.

To complete the picture, we must consider the possibility that the prenasal onsets {/nC/, /hnC/, /?nC/} are also monosegmental. The difficulty we have to face here is that the underlying contrast between /t/, /d/, /n/, and /nt/ (i.e. [nd]) cannot be represented if we maintain that plosive releases are non-distinctive: /nt/ and /n/ differ only in the oral vs. nasal quality of their release, while /nt/ and /d/ differ only in the presence of nasality on closure. In Western Popoloca the solution to this problem is clearly tied to the limited occurrence of the voiced obstruents, which fail to cluster with anything and have, for the most part, spirant realizations. Additionally, plain /d/ without prenasalization is attested by only one example in Pierson's article and fails to appear at all in the better documented study by Williams and Pike. I suggest then that Pierson's /d/ can be disregarded in the analysis, either because it is a continuant or, more likely, because it is not there: if so, the contrast between /t/, /n/ and [nd] can be characterized underlyingly as that between a voiceless oral stop, a nasal stop and a voiced stop, realized with surface prenasalization. (This is also Jamieson's (1977) proposal for the remarkably similar system of Chiquihuitlan Mazateco). The contrast between /?n/ and /?nt/ is then that between a glottalized nasal and a glottalized oral stop, whose glottalized closure induces voicing and prenasalization, as in Huautla. Similarly, the contrast between /hn/, /hnt/ and /th/ is that between an aspirated nasal, an aspirated voiced oral stop – whose voicing triggers prenasalization – and an aspirated voiceless oral stop. The overall conclusion then is that there are no underlying or surface onset clusters in Western Popoloca.

4.2 Tlacoyalco Popoloca

Stark and Machin (1977) have provided a brief description of a different Popoloca dialect, spoken in the village of San Marcos Tlacoyalco, of Puebla, Mexico. The Tlacoyalco dialect differs from Western Popoloca in displaying underlying clusters. It differs from Huautla Mazateco in having a surface inventory of complex onsets that represents a proper subset of the one analyzed in section 2. We will see that the difference in onset clusters has two sources: the different segmental inventories of Huautla and Tlacoyalco and the restricted nature of A-position merger in Tlacoyalco.

[36] Note that heterosyllabic clusters, which at least in this language, are not subject to any constraint, may have co-occurring aspiration and glottalization. Williams and Pike (p.375) cite numerous examples of coda /?/ followed by onsets with pre- or postaspiration: /kunta?ʧhee/ 'buzzard', /ku?hwa?/ 'egg', /kusi?hna/ 'deer', /tink?ihn?a/ 'I help'. The absence of coda /?/ followed by preglottalized onset is perhaps attributable to cross-syllabic dissimilation. Dissimilation of /?/ applies between the adjacent positions of coda and following onset but not between the nonadjacent coda and following nucleus. This is why /??C/ is absent while /?C?/ clusters are attested: /tu?t?ee/ 'his foot', /ʃo?ʃ?onaa/ 'my glass', /tinki?hn?a/ 'I help'.

(64) Tlacoyalco Popoloca phonemes (after Stark and Machin 1977)

oral plosives	p	t	T	ts	ʧ	tʂ	k			
voiceless fricatives	f			s	ʃ	ʂ				
voiced fricatives	b		d	z	ʒ		g			
nasal stops	m	n			ɲ					
approximants			l		y		r, rr		h	ʔ
oral vowels			i	e	a	o				
nasal vowels			ĩ	ẽ	ã	õ				

Note: /T/ = interdental stop

The onset sequences of Tlacoyalco, as presented by Stark and Machin, include the following:

(65) Tlacoyalco complex onsets

(a)	Nasal plus plosive:	nt	nT	nts	nʧ	ntʂ	nk
(b)	Plosive plus /h/:	th	Th	tsh	ʧh	tʂh	kh
(c)	Nasal plus plosive plus /h/:	nth	nTh	ntsh			nkh
(d)	/h/ plus nasal plus plosive:	hnt					hnk
(e)	/h/ plus nasal:	hm	hn	hɲ			
(f)	/ʔ/ plus nasal:	ʔn					
(g)	/ʔ/ plus nasal plus plosive:	ʔnt					ʔnk
(h)	/h/ plus glide:	hy					

If we leave aside the contrast between /hnC/ and /nCh/ in (65.c-d), the system appears identical to that of Western Popoloca. The prenasal plosives – whose closures are phonetically voiced – may well represent prenasal realizations of voiced stops. The postaspirated stops and preaspirated nasals should be analyzed as underlying aspirated closures—as in (58). If so, we must also assume the realization rule in (59), which insures that aspiration will surface on a nasal closure and, in its absence, on an oral release. The preglottalized plosives can be represented underlyingly as in (63). The unique /hy/ is an underlying /hi/ sequence, as in Huautla and Western Popoloca: onsets are obligatory in Tlacoyalco and /hiV/ sequences are absent. I summarize part of the analysis in the list of representations given in (66). The underlying representations proposed below are followed by several derivational steps: the projection of releases, the alignment of aspiration with release in oral plosives, the spreading of nasality onto the release of underlying nasals and the nasalization of underlying voiced closures.

(66) Underlying monosegmental sources for (65.a,b,e,f)

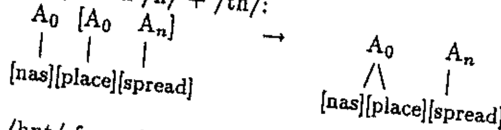
complex onset	underlying	project releases	alignment
(a) /nC/	A_0 | [voice]	(→ A_0 A_n → | [voice]	A_0 A_n) / ˙. [voice] [nasal]
(b) /Ch/	A_0 | [spread]	(→ A_0 A_n → | [spread]	A_0 A_n) | [spread]
(e) /hn/	A_0 / \\ [spread][nasal]	(→ A_0 A_n → / \\ [spread][nasal]	A_0 A_n) / \\ / [spread][nasal]
(f) /ʔn/	A_0 / \\ [constr][nasal]	(→ A_0 A_n → / \\ [constr][nasal]	A_0 A_n) / \\ / [constr][nasal]

Let us return now to the contrast between /hnC/ and /nCh/. The merger analysis given for such sequences in Huautla Mazateco was based on the observation that all plosives – oral, nasal or half-nasal – could be pre- or postaspirated. This is clearly not the case in Tlacoyalco: only prenasal onsets have a contrast between pre- and postaspiration. Why?

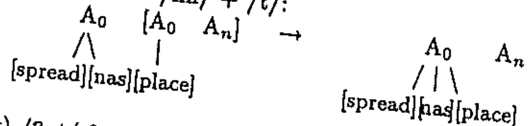
Before addressing directly this question, we can observe that the onsets composed of prenasalization, a plosive and a laryngeal feature – the set {hnC, nCh and ʔnC} – can be analyzed as composites of any surface nasal closure, which may carry a laryngeal feature, as in (66.e-f), and any surface stop release, which may carry aspiration, as in (66.b). Such composites can be viewed as the result of the merger of adjacent closures, if we assume that this process is subject to the restriction observed in Huautla: its immediate output must be monosegmental. Note that, although only one of the cluster types {hnC, nCh, ʔnC} must be analyzed as an underlying sequence of consonants – since the others are analyzable as their monosegmental counterparts in Western Popoloca – the simplest analysis we can provide indicates that the other two types have may have bisegmental sources as well. The data provided by Stark and Machin does not help resolve this potential ambiguity as to derivational source. (The brackets in the input sequences below help identify the boundaries of the original segments entering merger.)

(67) Some underlying bisegmental sources for (51.c-d-g)

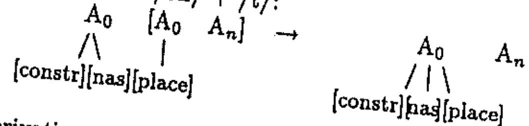
(c) /nth/ from /n/ + /th/:



(d) /hnt/ from /hn/ + /t/:



(g) /ʔnt/ from /ʔn/ + /t/:



The derivations sketched in (67) imply that the closure merger which yields the surface contrast between /nth/ and /hnt/ takes place after the linearization process (equivalent to (59)) which associates aspiration to the release of oral stops: otherwise the contrast between /hnt/ and /nth/, derived through closure merger, will be neutralized.

As in the analysis of Huautla prenasals, I assume that underlying $stop_1$-$stop_2$ sequences in Tlacoyalco will contain a necessarily unreleased instance of $stop_1$; and further, that an unreleased nasal stop will lose place features. What then will be left of the original closure? Anything other than place features: nasality, voicing, aspiration, glottalization or any licit combination of these. Closure merger will be able to combine the nasality and/or laryngeal features of the first A_0 with the place component (as well as, possibly, other features) of the second A_0.

(68) Closure merger

Merge A_0 A_0 iff output structure is monosegmental (cf. (15)).
(Ordering: after Tlacoyalco equivalent of (59).)

The monosegmental condition explains the fact that only one set of place features emerges from the combination of two closures, as well as the fact that certain combinations of laryngeal features are not amenable to merger. I list some of these below:

(69) Merger blocked: immediate output is not monosegmental

(a) /ʔn/ + /hn/ or /hn/ + /ʔn/
(e.g. */ʔhn/, */hʔn/):
[spread] and [constricted] are incompatible

(b) /ʔn/ + /th/ (e.g. */ʔnth/):
[spread] and [constricted] are incompatible

(c) /hn/ + /th/ (e.g. */hnth/): two distinct [spread] values.

A further point explained by this analysis is the absence of /nCʔ/ clusters in Tlacoyalco. We have assumed that only closures merge in this dialect: therefore the only source of the unattested /nCʔ/ would have to be postglottalized oral stops, which do not exist in Tlacoyalco.

As far as onset clusters go, then, Tlacoyalco = Western Popoloca + A_0 merger.

4.3 Chiquihuitlan Mazatec

The syllable structure of Chiquihuitlan Mazatec was described by Jamieson (1977). This dialect shares with Huautla the presence of /S-stop/ onsets and with Western Popoloca the absence of A position mergers of any other type.

(70) Chiquihuitlan Mazatec phonemes (after Jamieson 1977)

oral plosives:		t	ts	ʧ	ţ	k		
nasal stops:	m	n		ɲ				
fricatives:	β		s	ʃ				
approximants:		r		y			h	ʔ

vowels:	i	u	ĩ	ũ
	e	o	ẽ	õ
	æ	a	æ̃	ã

Chiquihuitlan syllables are open. Nuclei may contain distinctive aspiration or glottalization, indicated orthographically by Jamieson as syllable-final /h/ and /ʔ/: thus /suiʔ/ 'holiday' represents a glottalized nucleus, /ntoh/ 'soap' an aspirated one. In monovocalic nuclei, the aspiration or glottalization is realized in the center of the vowel and perceived as an interruption in the vocalic gesture: [VhV], [VʔV]. In complex nuclei, glottalization appears to be realized on the last vocalic element, although Jamieson provides no explicit statements on this score: /sĩũʔ/ 'we in grind' is realized as [sĩũʔũ]. Vowel glottalization and onset preglottalization contrast, as we shall see below.

Most of the complex onsets of Chiquihuitlan can be identified as monosegmental. The full list appears below, with annotations regarding the underlying source of the sequence. The orthography is Jamieson's: some comments on phonetic realization follow.

(71) Chiquihuitlan Mazatec complex onsets

a.	/plosive+h/ =	aspirated plosive: th, ch, ch, ṭh, kh
b.	/h+sonorant/ =	aspirated sonorant: hm, hn, hɲ, hβ, hy
c.	/ʔ+ sonorant/ =	glottalized sonorant: ʔm, ʔn, ʔɲ, ʔy, ʔb
d.	/n + plosive/ =	voiced plosive realized with prenasalization: nt, nts, nʧ, nṭ, nk
e.	/ʔ+n + plosive/ =	voiced glottalized plosive realized with prenasalization: ʔn, ʔnṭ, ʔnts, ʔn, ʔnk
f.	/s + plosive/ =	st, sk, sm, sn
g.	/ʃ + plosive/ =	ʃt, ʃk, ʃn
h.	/r + plosive/ =	rk, (rn)

The aspirated onsets are realized, in the case of plosives, as in Western Popoloca: aspiration stays on a nasal closure, and otherwise migrates to an oral release. The aspirated continuants, although written sequentially, are realized simultaneously with the oral articulation: /hβ/ = [f] and /hy/ = [ç]. Similarly, Jamieson's narrow transcriptions for the glottalized continuants /ʔβ/, /ʔy/ indicate that laryngealization persists throughout the period of oral constriction: there is therefore no reason to analyze these as involving underlying or surface clusters.

The absence of distinctively aspirated or glottalized fricatives can be recorded as a constraint against laryngeal features linked to A_f, rooted in the phonetic aspiration of the voiceless fricatives. The remarks made in section 1.3 about affricates representing underlying stops apply rather strikingly to this case: /ʧ/ can be aspirated, but homorganic /ʃ/ cannot. The reason is that /ʧ/ starts out as a plain stop, lacking underlying frication, whereas /ʃ/ is an underlying A_f: what they have in common is point of articulation, not stricture. The same will have to hold for the pair /s/ vs. /ts/, whatever turns out to be the proper point of articulation distinction between /ts/ and /t/. The absence of /hnC/ or /nCh/ onsets – i.e., a voiced plosive accompanied by aspiration – can be attributed to a constraint against the co-occurrence of these two laryngeal features within

one segment. This means that in /h-nasal/ onsets the nasality is primary, and voicing non-distinctive.

No plausible monosegmental sources can be offered for the clusters listed in (71.f-h). The main lines of the analysis suggested for Huautla /S-plosive/ onsets can be extended to Chiquihuitlan: there are obvious differences only regarding the possibility of [nasal] on the stop closure following /S/ and the limited scope of debuccalization in Chiquihuitlan. The absence of /S-nC/ onsets in Chiquihuitlan can be attributed to the fact that aspiration - including the redundant aspiration of /s/ - is incompatible with the distinctive voicing instantiated as prenasalization. The /r-C/ onsets seem too limited in occurrence and too isolated typologically to speculate about: only /rk/ is attested in more than one lexical item and at least /rn/ clearly originates in the syncope of rVC sequences.

The Chiquihuitlan onset system represents the combination of possibilities already encountered in languages analyzed above. The onsets with prenasalization, /h/ or /ʔ/ are monosegmental at all levels of phonological representation, as in Western Popoloca. Those consisting of a sibilant attached to a closure instantiate the possibility of generating structurally monosegmental onsets by placing the features of a fricative on the approach position of a stop. The global characterization of possible surface onsets is identical to that of Huautla: surface onsets clusters are all structurally monosegmental, whether or not they are featurally monosegmental.

4.4 A Summary of the Parameters Observed

All Mazateco-Popolocan languages considered here allow on the surface only onset clusters that can count as structurally monosegmental. The observed differences between the four languages can be summarized as corresponding to the following parameters.

(72) Some onset parameters in Mazateco-Popolocan:

a. Are there *underlying* bisegmental clusters in onset?
(Yes: Huautla, Chiquihuitlan, Tlacoyalco.
No: Western Popoloca)

b. Are there *surface* bisegmental clusters in onset?
(Yes: the Huautla, Chiquihuitlan /SC/ clusters are featurally bisegmental;
No: Tlacoyalco, Western Popoloca)

c. Is there merger of A_f with Approach?
(Yes: Mazateco (Huautla and Chiquihuitlan);
No: Popoloca (Western and Tlacoyalco))

d. Is there generalized merger (cf. (43))?
(Yes: Huautla.
No: Tlacoyalco, Western Popoloca, Chiquihuitlan)

e. Is there closure merger (cf. (68))?
(Yes: Tlacoyalco, possibly Huautla (subsumed by (43)).
No: Western Popoloca, Chiquihuitlan)

The differences outlined above bear on three fundamental points: the allowable degree of complexity of underlying representations (72.a), the degree of complexity of surface structures (72.b) and the choice of mapping mechanisms between underlying and surface sequences, or, differently put, the choice of relevant optimization mechanisms (72.c-e).[37]

It is premature to conclude that all dialectal differences between the onsets of this language family can be reduced to those enumerated in (72). But the possibility of characterizing succinctly the differences observed between these four dialects – the only ones for which we had reliable descriptions – clearly supports the general framework of the analysis.

[37] On the concept of optimization, see, among many others, Yip (1988), Goldsmith (1989), Prince and Smolensky (1992), Kirchner (1992). It is clear that all instances of merger listed in (71) qualify as optimization strategies, since they promote the creation of clusters that are at least structurally monosegmental and hence closer to the optimal cluster: one segment.

5 Beyond Mazateco: Other Instances of Multiple Contrast in the Association of /h/ and /ʔ/ to Plosives

At least two other Amerindian languages display clear contrasts between pre- and post-aspirated or glottalized plosives. They are analyzed below. It is anticipated that the study of Otomi dialects, in particular Tenango (Blight and Pike 1976) and Temoayan (Andrews 1949), will yield further instances of such patterns of laryngeal association. The more complex cluster structure of Otomi is not discussed here.

5.1 Yuchi

A contrast between pre and post-glottalized plosives has been documented by Wolff (1948) in Yuchi, a language of Oklahoma distantly related to Siouan. Yuchi syllables are invariably open. Consonant clusters found intervocalically are also, for the most part, present initially. Words end in vowels. The consonant inventory of Yuchi is given below, in Wolff's notation.

(73) Yuchi consonants

p	t	ʦ	ʧ	k		
b	d		ʤ	g		
	ƫ					
f		s	ʃ			
w	n		y			
	l					
					h	?

This list reflects Wolff's decision to phonemicize all Yuchi consonant sequences, including items such as /th/,/tʔ/, /sʔ/, as clusters rather than as unit phonemes. The clusters he reports fall into several classes: (a) distinctively pre- and post-glottalized plosives; (b) glottalized continuants, realized with preglottalization in the case of the sonorants /ʔy/ and /ʔl/ and with postglottalization otherwise (/sʔ/,/ʃʔ/, /fʔ/); (c) postaspirated stops; (d) obstruent-glide sequences, which include both Cw and Cy sequences; and (e) sibilant-stop clusters. I focus here on the clusters containing a laryngeal.

(74) a. Onsets with glottalization:
Plosives + ʔ:

ʔ+ voiceless plosives:	pʔ, tʔ, tsʔ, ʧʔ, kʔ, bʔ, dʔ, gʔ, tlʔ
	ʔp, ʔt, ʔts, ʔk
Voiceless continuants + ʔ:	fʔ, sʔ, ʃʔ
ʔ+ voiced continuants:	ʔl, ʔy

b. Onsets with aspiration:

Voiceless stops + h:	ph, th, kh

Most of these phonetic sequences could be analyzed as monosegmental at all levels of the derivation. The /Ch/ sequences may be aspirated stops, while the /Cʔ/ and /ʔC/ clusters involving a continuant C may be viewed as glottalized, since the linear order between cluster members in /sʔ/ and /ʔy/ is clearly non-distinctive. For continuants, the glottal gesture is produced before the oral constriction in sonorants (or A_{max} segments) and after it in obstruents (i.e., A_f).

We may now consider the contrast between pre- and postglottalized stops: /pʔ/, /tʔ/, /tsʔ/, /kʔ/ vs. /ʔp/, /ʔt/, /ʔts, /ʔk/. While one of these two series may instantiate an underlying series of glottalized plosives, the other cannot. Wolff notes that the /ʔ-stop/ clusters are frequently realized as preaspirated rather than pre-glottalized. Thus, /bʔaʔte/ 'horse' is alternately realized as [bʔaʔte] and as [bʔaxte] – where [x] stands for a fricated realization of [h]. Wolff gives no compelling reason for considering glottalization – rather than aspiration – as the basic allophone in this case. The point being developed here – that the contrast between pre- and postposition of laryngeal features is available only in plosives – goes through either way. I will assume in what follows that the plosive series with preposed laryngeal features represents basic preglottalized stops and affricates.

Since either the pre- or the postglottalized plosives result from underlying clusters, the simplest analysis will be to assume that all onsets with glottalization may originate as underlying clusters, via bidirectional merger.

(75) Yuchi merger with /ʔ/

Merge A_{max} with adjacent A position
|
[constricted]

(76) a. Merger applied to plosives:

input:
p + ʔ
$[A_0\ A_{max}]\ A_{max}$
|
[constr.]

ʔ + p
$A_{max}\ [A_0\ A_{max}]$
|
[constr.]

output:
$A_0\ A_{max}$
|
[constr.]

$A_0\ A_{max}$
|
[constr.]

b. Merger applied to continuants:

input:
s + ʔ
$A_f A_{max}$
|
[constr.]

=

ʔ + s
$A_{max}\ A_f$
|
[constr.]

output:
A_f
|
[constr.]

A_f
|
[constr.]

The remainder of the Yuchi complex onset system involves bisegmental sequences consisting of s-plosive. The analysis of Mazateco /S-plosive/ onsets appears to carry over to Yuchi. Since there are numerous gaps in this class of Yuchi onsets, we cannot tell if the absence of /S-C-h/ is significant or not. There are also palatalized and labialized obstruents in the list of clusters given by Wolff, but their status as clusts, rather than complex unit segments, is by no means clear.

In the typology defined by the parameters in (72), Yuchi is a language that allows both underlying clusters of distinct consonants (at least /ʔ/ + C, C + /ʔ/, /s+C/) and surface bisegmental onsets (/s-Stop/).

5.2 Kashaya

Further support for the idea that laryngeal features can associate to either the closure or to the release of plosives is provided by Kashaya, a Pomoan language spoken on the coast of Northern California. The consonant system of Kashaya has been analyzed in a series of recent publications by Buckley (1990, 1992). Kashaya is a language with simple CV(V)(C) syllable structure. Its consonant inventory is given below, following Oswalt's (1964) and McLendon's (1973) analyses:

(77) Kashaya consonantal phonemes
(after Oswalt 1964, McLendon 1973)

p	t	ṭ	ʧ	k	q	
pʰ	tʰ	ṭʰ	ʧʰ	kʰ	qʰ	
p'	t'	ṭ'	ʧ'	k'	q'	
b	d					
(f)	s		ʃ			
	s'					
m	n					
w	l	(r)	y			h, ʔ

Notes: /f/ and /r/ attested in loanwords only.

Buckley (1990) shows that the surface voiced stops of Kashaya [b] and [d] are realizations of the glottalized nasals /n'/ and /m'/, which belong to a class of sequences we discuss below. According to Buckley, syllable-final /n'/ and /m'/ are preserved as such, while the syllable-initial variants become oral, non-glottalized [b] and [d]. Some of the evidence supporting this analysis will appear below.

5.2.1 Laryngeal Increments

In addition to the sounds listed in (77), Kashaya possesses *laryngeally incremented consonants*, clusters involving a consonant and a laryngeal, /h/ or /ʔ/. The incremented consonants function as tautosyllabic clusters – and, hence, pattern as single C's – in the deeper stages of the phonology. They surface, when word-medial, as heterosyllabic sequences of /h.C/ and /ʔ.C/. The laryngeally incremented clusters I have encountered in the sources cited above are listed in (78) in a notation that is similar to Oswalt's and McLendon, in that it transcribes the laryngeal increment *before* the consonant.[38]

(78) Some Kashaya laryngeally incremented clusters:

hp	ht		hʧ	hk	hq						
hph	hth	hṭh	hʧh	hkh	hqh		hm	hn	hl	hy	hw
ʔp	ʔt	ʔṭ	ʔʧ		ʔq						
ʔp'	ʔt'	ʔṭ'					m'	n'	ʔl	ʔy	ʔw
				ʔk'	ʔq'	ʔs'	ʔm'	ʔn'			

The intermediate clusters /ʔm'/ and /ʔn'/ surface as [ʔb] and [ʔd]: this is exactly what Buckley's analysis predicts, given that the /ʔC'/ incremented clusters occur, as far as one can tell, only in onset position. A further point about phonetic realization is that the glottalized /s'/ is realized with affrication (E. Buckley, personal communication). Thus the incremented /ʔs'/ could be identified as a pre- and postglottalized affricate. Some of the contrasts listed in (78) are exemplified below:

[38] Buckley does not provide in his papers a full list of the attested incremented clusters. However, it is possible to form a clear picture of the permissible patterns of incrementation by simply reading through the materials published in Oswalt (1964): the laryngeal increments have a very high text frequency and this allows one to tell apart accidental from systematic gaps.

(79) Contrasts between incremented and non-incremented consonants (data from Buckley 1990, 1992; unglossed forms from Oswalt 1973)

a.

	plain	aspirated	h-incremented	h-C^h
ʧ	-ʧa- 'sit-sg.'	-ʧ^{h}iʈ- 'fall out'	-hʧa- 'fly'	-hʧ^{h}a:- 'knock over'
k	kolo: 'hollow'	nayak^{h}ulu:lu 'thrasher'	hku 'one'	-hk^{h}iʈ' 'choke'
q	ʃaqa: 'valley quail'	q^{h}aʔaylo 'ogre'	hqowe (unglossed)	hq^{h}a 'water'
n	ʈ' an		ʔp' ahn	

b.

	plain	glottalized	ʔ-incremented	ʔ-C'
ʧ	-ʧa- 'sit-sg.'	-ʧ' o:q- 'stab'	-ʔʧoq- 'shoot'	
k	kolo: 'hollow'	-k' i:- 'scratch'		-ʔk' ol^h 'spill'
s	si:ʈoʈʈo 'robin'	s' uʔnuʔnu 'huckleberry'		ʔs' ohn 'dent'
m	mayaltow 'by you (pl)'		dolom' 'wild cat' - m' a 'after'	ʔm' ahl 'turn'

The last two forms listed, /m' a/ and /ʔm' ahl/ contain glottally incremented nasals in onset position and surface, in accordance with Buckley's law, as [ba] and [ʔbahl] respectively.

The incremented clusters differ from other Kashaya consonant sequences in forming tautosyllabic clusters in the first stages of the phonology. This point is carefully established by Buckley (1992), who shows that this assumption sheds light on both the phonotactics of Kashaya and its reduplicative processes. We will note here only two significant facts: the incremented consonants are the only clusters attested word-initially and, for some of them, word-finally. They are also the only ones copied in toto by a process of CV reduplication. The contrast between the effect of reduplication on genuine clusters vs. laryngeally incremented ones is illustrated below:

(80) CV reduplication and cluster types:

a. single C's and true clusters
/biye:/ → biye:ye 'flower'
/hisimta/ → hisimtata 'myth creature' (*hisimtamta)
/q^{h}aʔaylo/ → q^{h}aʔaylolo 'ogre' (*q^{h}aʔayloylo)

b. incremented consonants
/hihla/ → hihlahla 'gossip'
/suhmi/ → suhmihmi 'glimmer'
/ht^{h}e/ → ht^{h}eht^{h}e 'spread out'

The incremented clusters also differ from other consonant sequences in their segmental composition: as can be seen from inspecting (78), the laryngeal elements must be compatible with the laryngeal features of the consonant they increment. Thus aspirated stops may be incremented by /h/ but not by /ʔ/: sequences like /ʔkh/ do occur in Kashaya but are systematically heterosyllabic and thus pattern differently from the laryngeally harmonic clusters /ʔk'/ or /hk^h/. Nor can glottalized stops be incremented by /h/: sequences like /ht'/ may be attested but, according to Buckley, do not pattern as a tautosyllabic cluster. Oswalt (1976) and McLendon (1973:54) are aware of this generalization about the synchronic situation in Kashaya; McLendon attributes a similar pattern of clustering to Proto-Pomo.

The laryngeally incremented clusters recorded by Oswalt and Buckley are interestingly restricted to certain consonant classes. Of the continuants, only /s/ displays more than a two-way contrast between plain and incremented: /s/ can be glottalized /s'/, as well as glottalized and incremented /ʔs'/. There is no clear data on h-incremented clusters with /s/ or /ʃ/: but we can safely assume that at least /hs^h/ and /hʃ^h/ are impossible onsets. Also, there appear to be no plain, unglottalized /s/'s that occur incremented with /ʔ/: no /ʔs/ onsets distinct from glottalized /s'/ . The other continuants do not display any contrast between postaspiration (C^h), preaspiration (hC) and pre-cum-postaspiration (hC^h) or between the same three options involving the feature of glottalization. Rather, the liquid /l/ and the glides /y/ and /w/ contrast plain and aspirated or plain and glottalized variants, with no further options.[39] On the other fricative, /ʃ/, see below.

The analysis of laryngeally incremented consonants in Kashaya requires only two assumptions: that plosives have closure and release and that, in Kashaya, the glottalized fricatives, /s'/ and /ʃ'/, are realized with affrication, as [ts'] and [ʧ']. Granted this, we can identify Kashaya as the language which displays the full range of contrasts between modes of laryngeal association anticipated in (4). Plosives have four options in the association of /h/ and /ʔ/ (to closure, to release, to both, to neither), while continuants have only two (associate or not). The representations in (81) illustrate this analysis of incremented consonants of Kashaya: /k/, /w/ and /n/ stand for oral stops, approximants and nasals. The fricatives are discussed separately.

[39] As indicated above, these generalizations were not expressed by any of the Pomoists whose work on Kashaya I have consulted. They derive entirely from my observations on the material presented by Buckley and from reading Oswalt's (1973) texts. However, Buckley has confirmed (personal communication, 1991) that /hCh/ and /ʔC'/ onsets are allowed only with the plosives and, in the case of /ʔC'/, with /s/.

(81) Representations for Kashaya incremented consonants

a. h-increments

k:	A_0 A_{max} | h [hk]	A_0 A_{max} \ / h [hk^h]	A_0 A_{max} | h [k^h]
w:		A_{max} | h [W]	
n:	A_0 A_{max} | h [hn]	A_0 A_{max} \ / h /hn^h/	A_0 A_{max} | h /n^h/

b. ʔ-increments

k:	A_0 A_{max} | ʔ [ʔk]	A_0 A_{max} \ / ʔ [ʔk']	A_0 A_{max} | ʔ [k']
w:		A_{max} | ʔ [w']	
n:	A_0 A_{max} | ʔ /ʔn/ [ʔn]	$A_0$$A_{max}$ \ / ʔ /ʔn'/ [ʔb]	A_0 A_{max} | ʔ /n'/ [b]

The postaspirated nasals, as well as the pre-and-postaspirated ones (/hn^h/), remain unattested, or at least, appear non-distinct from the preaspirated ones: this is probably a systematic gap, though I will not attempt to explain it. Aside from this, all and only the linking possibilities predicted by the theory of A positions presented here are instantiated in Kashaya.

As in Mazateco and Popoloca, Kashaya onsets must be monosegmental, not only structurally but featurally as well. The absence of incremented onsets like */hk'/ or */ʔp^h/ is explained as a direct consequence of their monosegmental nature: /h/ and /ʔ/ would be incompatible within one segment.

5.2.2 Excursus: Affrication of Glottalized Fricatives, a Proto-Pomo Sound Law

The patterning of fricatives with glottalization lends further support to the analysis sketched above. Based on the presence in Kashaya of affricated allophones of /s'/, I assume that, when glottalization associates to any fricative, /s/ or /ʃ/, the segment acquires closure and becomes a postglottalized affricate:[40]

(82) Affrication of glottalized fricatives:

$$\begin{array}{ccc} A_f & \rightarrow & A_0\ A_f \\ | & & \quad\ | \\ ʔ & & \quad\ ʔ \end{array}$$

Several considerations support (82), quite aside from the need to characterize the affricated allophones of glottalized /s'/. This rule will neutralize the distinction between the glottalized fricative /ʃ'/ – which should exist but is not attested as such – and the postglottalized affricate /ʧ'/, which is amply documented. It will therefore account for an otherwise inexplicable contrast between /s/ and /ʃ/: the fact that /s/ is attested with glottalization, while /ʃ/ is not. Rule (82) will not have neutralizing effects in the case of /s'/, since Kashaya lacks an anterior affricate /ts/ or its underlying glottalized variant.

Suppose now that (82) is a pan-Pomo process. Then its effects should be recorded differently, depending on the phonemic inventory of affricates of each dialect: Pomo dialects which possess, unlike Kashaya, both underlying /ts/ and underlying /ʧ/ are predicted to be recorded as lacking surface glottalized /s'/ or /ʃ'/, since (82) will render these sounds indistinguishable

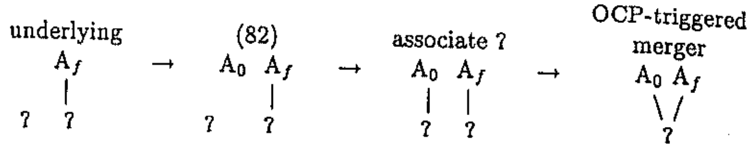
[40]More precisely, I am assuming that the glottalized fricatives are always phonologically represented as having the representations given in the output of (82), regardless of whether the affricated realization of /s'/ is invariant or not.

from the underlying glottalized affricates /ts'/ and /ʧ'/. For such dialects, it will appear that no fricatives can have glottalized variants. Glottalized fricatives should be recorded only in dialects where homorganic affricates do not exist.

A look at the comparative Pomo data gathered by McLendon (1973) indicates that this prediction is correct in every one of its aspects. First, all Pomo dialects which have the underlying palatoalveolar fricative /ʃ/ – i.e. all Pomo dialects except Central Pomo – also have the homorganic affricate /ʧ/, the latter appearing in plain, aspirated and glottalized form: as a result of (82), no dialect possesses a distinctive glottalized /ʃ'/. Wherever /ʃ/ occurs, /ʧ/ occurs as well: for glottalized /ʃ'/, (82) will neutralize the /ʃ/:/ʧ/ distinction in every relevant dialect. This explains the complete absence of surface /ʃ'/. Second, Southern, Northern and Eastern Pomo, dialects which possess plain as well as glottalized /ts/, are recorded by McLendon as lacking glottalized variants of /s/: this is, again, due to the effects of (82), which merges underlying /s'/ with the independently occurring /ts'/. In contrast, Southwestern Pomo (Kashaya) and Central Pomo, dialects which lack /ts/, are recorded as possessing glottalized /s'/: the affricated realization of /s'/ is not recorded as such, because, in these dialects, it is necessarily allophonic. The general conclusion then is that (82) applies across the board, in all Pomo dialects and explains the defective distribution of the glottalized fricatives.

The effect of (82) on underlying Kashaya /s'/ and /ʃ'/ is to create an additional aperture position, the A_0: this position may serve as anchor for a second /ʔ/. This will explain two additional facts: the absence of incremented /ʔs/ distinct from /s'/ and the possibility of glottalized and incremented /ʔs'/. Kashaya lacks /ʔs/ because /s/ – like all other continuants – can be only plain or glottalized: hence /ʔs/ is, under the present analysis of laryngeal incrementation, indistinguishable from /s'/. However, Kashaya possesses something which Buckley transcribes as /ʔs'/: our analysis identifies this as a pre-and-postglottalized affricate /ʔts'/, the result of applying (82**) to underlying /s'/ and then associating the increment /ʔ/ to its newly available closure. The synchronic genesis of this /ʔts'/ is outlined below: I make the assumption that all laryngeal increments originate as floating laryngeal features, lacking associated A positions.

(83) Deriving /ʔts'/ from floating /ʔ/ + /s'/

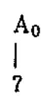


In addition to explaining why /s'/ and /ʔs/ are non-distinct, despite the apparent existence of /ʔs'/, this analysis explains why glottalization and aspiration function differently when incrementing fricatives: /ʔs'/ is possible but /hs^h/ is not, because /s^h/, whether or not it exists as distinct from /s/, does not trigger (82).

5.2.3 Conclusion on Kashaya and Comparison with Buckley's (1992) Analysis

We noted earlier that the /hC^h/ and /ʔC'/ incremented onsets are found only in onset position: this follows from the assumption that these segments possess both closure and release, and that release is unavailable in coda. Coda glottalized plosives are attested and transcribed as postglottalized, in forms such as /yahmot'/ 'it's a cougar' and /ʧahnoʧ' ba/ 'after speaking' but, given the lack of contrast between coda /C'/ and coda /ʔC/ or /ʔC'/, we may assume that these notations stand for structures in which the unreleased closure is associated to /ʔ/. The absence of release in coda explains the collapse of the four-way contrast into a binary one.

(84) Glottalized plosives in coda

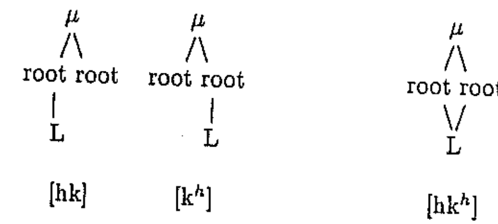


A last point to settle is the source of the difference between Kashaya and Huautla Mazateco. We observed only three-way contrasts among the Huautla plosives (/C/ vs. /C^h/ vs. /hC/ and /C/ vs. /C'/ vs. /ʔC/): the additional options of pre-and-postaspiration, pre-and-postglottalization, seen in Kashaya, are absent in Mazateco-Popolocan. A possible source for this difference is the strictness of OCP effects: Kashaya appears to tolerate intermediate OCP violations segment-internally (as in the next-to-last-step of the derivation in (83)). Mazateco does not: a second laryngeal feature,

identical or not to one already linked, cannot associate to the A positions of the same segment.

Buckley (1992), whose work on Kashaya has inspired this section, presents a very different analysis of the laryngeal increments. According to Buckley, the incremented consonants represent two distinct root nodes associated to a mora. (L = laryngeal node)

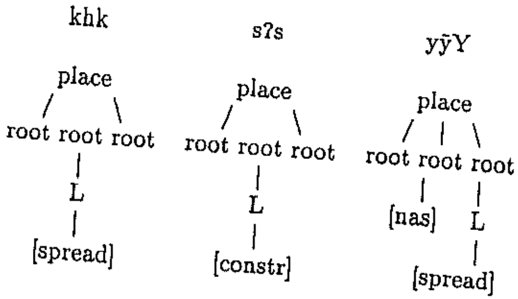
(85) Incremented consonants in Kashaya (after Buckley 1992)



As Buckley points out, such structures require a morification algorithm akin to Zec's (1989), in which an underlying sequence of consonantal mora plus vowel becomes a single light syllable, with the consonant in onset position.

To account for the impossibility of /h/ co-occurring with /ʔ/ within an incremented onset – i.e., the impossibility of two distinct laryngeal nodes within the mora – Buckley assumes that an OCP effect on feature geometry requires that "only one node of each type be permitted per segment". This is clearly the right idea, but Buckley's representations do not allow it to be correctly implemented. The problem is that the structures in (85) do not contain one segment each, but rather two: there are two root nodes in every one of the moras of (85). We are left then with a fundamental unanswered question: what counts as one segment? Surely moras *can* be polysegmental, if not in Kashaya, whose syllable structure is too constrained to illustrate this point, then at least in languages where CVCC(C) syllables are allowed. Moreover, if the structures in (85) are monosegmental simply by virtue of being linked to the same mora, what prevents structures like those in (86) from being associated to one mora and thus counting as monosegmental onsets in some other language?

(86)



The non-segments in (86) do obey the conditions invoked by Buckley: they are homorganic and thus contain, at most, one place node, one laryngeal node and one nasal value. What is then the reason why Kashaya /hk^h/ counts as a possible single segment, while the very similar /khk/ cannot? This question is answered in the framework of our analysis by the notion of single segment defined in (15): the sequence of A positions contained within one segment must be reducible – by reference to the release projection mechanisms – to one basic A node. The clusters in (86) cannot be so analyzed.

Buckley does not discuss explicitly the restrictions observed on the type of consonants allowing the interesting /C^h/, /hC/, /hC^h/ contrasts. I submit that the representations he employs are in principle unable to explain why such contrasts are attested in their full expansion with plosives but not with continuants.

6 Brief Conclusion

This study set out to support the idea that closure and release are formally represented in the phonology, by documenting the existence of the patterns of laryngeal association in (4). A second goal was to motivate the notion that single segments cannot be simply defined as bundles of features linked to one anchor, whether this anchor is a root node or a weight unit. Rather, monosegmental status is a function of two distinct criteria: the sequence of A positions contained within the segment and their global feature contents.

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