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THE ANALYSIS OF COMPLEX PHONETIC ELEMENTS IN BURA AND THE SYLLABLE*

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This paper examines those complex phonetic elements in Bura (and related languages such as Margi) which have been described by earlier scholars as unitary segments having a labial-alveolar double articulation. Several kinds of observations at the phonetic level show that this description is incorrect. Instead these segments are shown to be composed of a phonetic sequence of a labial articulation and an alveolar one. The analysis of the "labial-alveolars" as a sequence of phonological elements is also shown to be appropriate. If they are viewed as unitary segments represented by a single matrix of features there are problems with selecting correct feature values. If they are represented as two feature matrices linked to a single segmental position an invalid distinction is introduced between this representation and the same two matrices linked to separate segmental positions. On the other hand, representation as two independent segments accounts for vowel length adjustments and for resyllabification. Although unusual syllable-initial consonant clusters are posited in this analysis, these clusters are heterosyllabic when an appropriate environment occurs and violations of the universal syllable canon are minimized.

1. Introduction

The linguistic literature on Bura and closely related Chadic languages in the Bura-Margi cluster appears to maintain unanimously that certain types of word-initial complex phonetic elements[1] are monosegmental [Hoffmann n.d.,

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[1]In order to avoid prejudicing the discussion to follow, the term "element" will be used instead of talking about "segments" or "clusters". Digraphs and trigraphs are used to represent these elements, again, without prejudice to their eventual analysis.

1955a, 1955b, 1963; Ladefoged 1968; Newman 1977; Schuh 1982 ms.]. The elements concerned are those involving both a bilabial and an alveolar or palatal-alveolar articulation, as well as those elements which are prenasalized. The tradition of regarding these elements as single segments can be traced back to the work of Carl Hoffmann some 20 to 30 years ago. After completing a doctoral dissertation on Bura, he published a grammar of Margi in which he stated his views:

> A peculiar feature of Margi as well as the whole Bura-Margi group... are the labial-alveolars, which in this respect are comparable with the labio-velars of so many languages in the West Sudan. That these labio-alveolars (and the labio-alveopalatals) are simple phonemes and not casual juxtapositions of two separate phonemes can be concluded from their behaviour in reduplications [Hoffmann 1963:28].

Subsequent writers have accepted this phonological interpretation of Bura and Margi. For example Paul Newman, in his monograph on Chadic classification, echoes Hoffmann's opinion:

> The most striking phonological feature of the Bura group is the existence of simultaneously articulated labio-alveolar and labio-palatal consonants ... Although written as digraphs, these have to be treated as unit phonemes like the labio-velars kp and gb so common in West Africa [Newman 1977:17].

More recently, Russell Schuh, following first-hand work with a speaker of Bura during 1981/2, gave the opinion:

> These [the labial-alveolars] are phonetic and phonemic units, *not* word initial clusters [Schuh 1982].

Besides Chadic specialists, linguists interested in the range of phenomena found in natural languages have accepted that "labial-alveolars" are possible segments, e.g. Chomsky and Halle [1968] and Ladefoged [1971].[2]

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[2]Chomsky and Halle [1968:310-311] treat "labial-alveolars" in Margi as coronal segments with an extreme degree of rounding. (Labial-velars are classed as either labials with extreme velarization, e.g. in Nupe, or as velars with extreme rounding, e.g. Temne). The Stanford Phonology Archive, however, interprets all the complex elements in Margi as being composed of sequences. No explicit reasons are given for this reinterpretation of Hoffmann [1963].

A full list of the relevant complex phonetic elements is given in the appendix at the end of this article. The most straightforward examples are stops which have been written with the letters "pt" and "bd" in a way that is analogous to the use of /kp/ and /gb/ in transcriptions of labial-velars. In addition there are various elements involving fricative, nasal or lateral articulations which must also be considered. In particular, prenasalized elements in which both a labial and an alveolar or palato-alveolar articulation are involved also occur. Ladefoged, in his authoritative *Phonetic Study of West African Languages* [1968:xviii, 64-5], accepted Hoffmann's view that the two articulations in these elements accur simultaneously and provided phonetic descriptions and transcriptions of them such as those in (1) which directly express this view.

(1) p͡t voiceless labial-alveolar plosive
b͡d voiced labial-alveolar plosive
m͡np͡t prenasalized voiceless labial-alveolar plosive
m͡nb͡d prenasalized voiced labial-alveolar plosive
ʔ͡bd laryngealized voiced labial-alveolar plosive
p͡ts voiceless labial-alveolar affricate
p͡tʃ voiceless labial-palato-alveolar affricate

Naturally, prenasalized elements with only a single place of articulation, such as /nt/ , /mb/ , etc., have also been regarded as phonemic units.

Despite the unanimity with which it has been maintained, the monosegmental hypothesis bears re-examination. We will show phonetic evidence which demonstrates that the so-called labial-alveolars are in fact a simple sequence of a bilabial and an alveolar articulation, and we will argue that a sequential interpretation is the correct analysis from a phonological point of view as well. In short, we will show that these elements are *neither* phonetic nor phonemic units. The principal material on which this reanalysis is based comes from one speaker of Bura from the town of Garkida. This speaker is identified as speaker S . Extensive data was elicited by Schuh[3] who pre-

[3]The very generous assistance from Russell Schuh in making his data available and in introducing me to Elisha Shalangwa is very gratefully acknowl-

pared a selected wordlist for this study. Three readings of this wordlist were recorded in a sound-attenuated environment in the UCLA Phonetics Laboratory. This recording constitutes our primary data. Besides the material due to Schuh, tapes of speakers of Bura and Margi collected by Ladefoged in 1961 and 1962 have also been examined. Ladefoged's Bura speaker is identified as M . Unless specifically mentioned, the remainder of this paper focusses on the facts of Bura, but there is every reason to believe that the conclusions presented apply to Margi and the other languages involved.

2. Phonetic Analysis

The phonetic evidence for the sequential nature of the elements under discussion is of several different kinds. All of these elements involve a closure of the lips. We can show in several different ways that the bilabial closure is made before any alveolar closure is formed, and often we can show that the bilabial closure is released before the alveolar one is made. Bear in mind that the lips are further from the glottis than the alveolar ridge is and hence air flowing from the lungs will encounter an alveolar closure, if it is present, before it has a chance to encounter a labial one. Now, where stops and affricates such as /pt/ , /bd/ and /pts/ are concerned, separate release bursts can often be recognized for the labial and alveolar closures. The spectrograms shown in Figure 1 are examples of this kind of phenomenon. The spectrograms show readings of the words /bda/ 'gather honey' and /ptsa/ 'roast' by Bura speaker S . In order to produce a plosive burst, air pressure must be built up in the oral cavity behind the articulatory closure. For two separate bursts to be seen in these two tokens, the alveolar closure must not be formed until after the bilabial closure is released, since the presence of a simultaneous alveolar closure would prevent the air-flow from reaching the location of the bilabial closure.

Even when separate bursts cannot be seen, it can still be shown from an examination of the formant transitions in adjacent vowels that we are dealing with sequential articulation. Whenever a vowel precedes a bilabial closure there is typically a lowering in frequency of both the second and third for-

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edged. Without his assistance this paper would not have been possible.

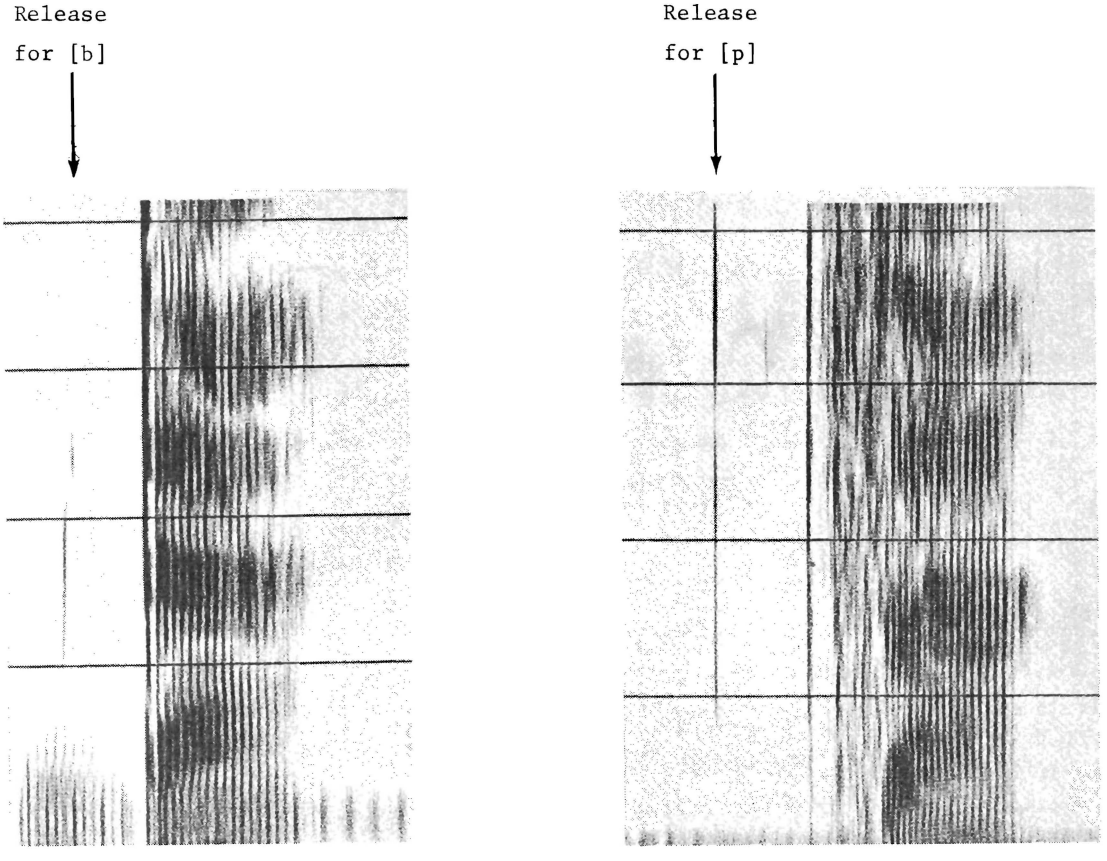


Figure 1. Separate releases in labial and alveolar clusters.

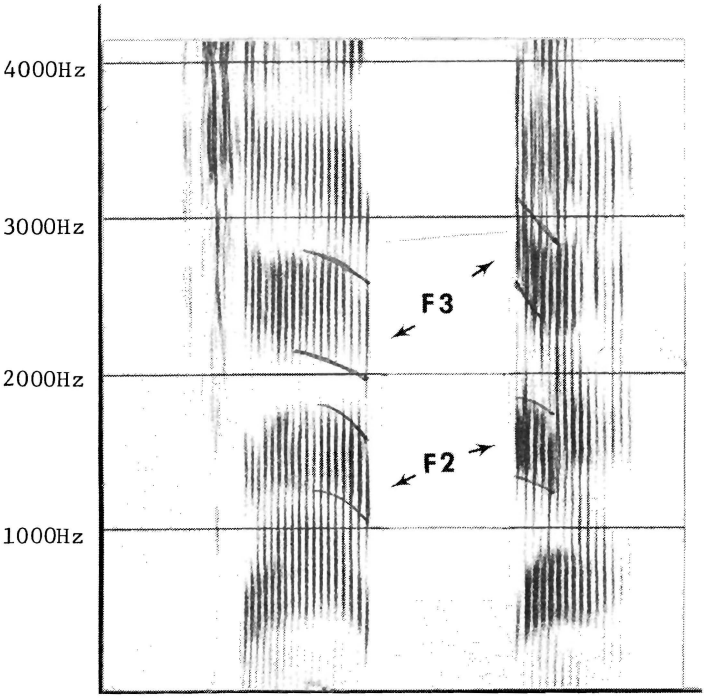
mants. This lowering can be seen in the preconsonantal vowels in *both* utterances in Figure 2, where the example on the right has a plain /b/ and the example on the left contains the complex element /bd͡/ . This confirms that a bilabial closure is found in both words. On the other hand, the postconsonantal transitions in these two examples differ. On the right, in /ba/ , the transitions are typical of a bilabial release. The transitions to and from the consonant are approximately symmetrical. On the left, in /bd͡a/ , the postconsonantal transition is typical of an alveolar release, and the pre- and post-consonantal patterns are not symmetrical. We can thus conclude that the bilabial articulation precedes the alveolar one in this case (although there may be a brief period of coarticulation during which both closures are maintained). The alveolar place of the second part of the complex elements is confirmed by the data in (2), showing mean values in Herz for F2 at the onset of the postconsonantal vowel in six tokens of the syllables /ba/ , /bda/ and /da/ spoken by speaker S .

(2)

	/ba/	/bda/	/da/
F2	1142	1614	1584

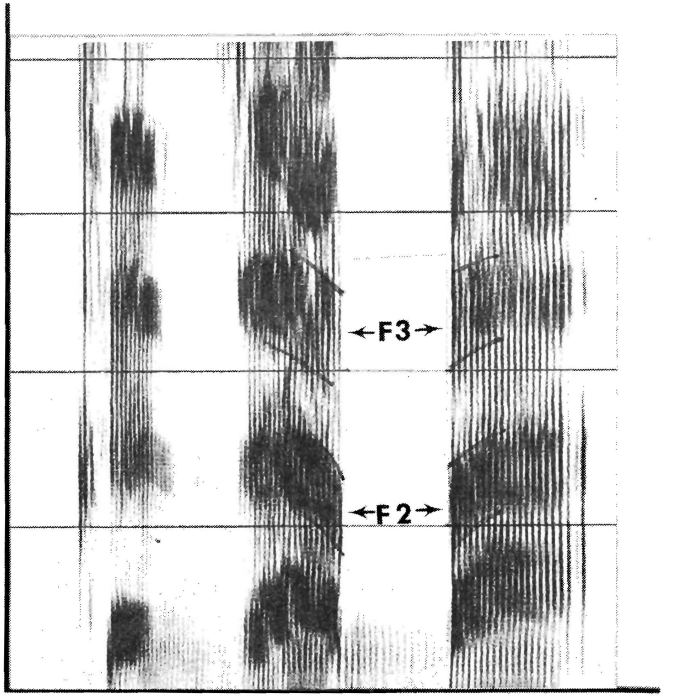
Note the similarity in the mean vowel-initial values of F2 for the /bda/ and /da/ syllables and the substantially different value for /ba/ .

As for the "doubly-articulated" prenasalized elements, explicitly transcribed by Ladefoged as having simultaneous bilabial and alveolar closures during both the nasal and stop portions, it can be shown that the nasal portion is simply bilabial; that is, it is not homorganic with the claimed double articulation of the stop. In this case it is not necessary to refer to evidence from the surrounding phonetic context such as formant transitions, since the nasal itself contains the information. There is a clear acoustic distinction between the nasals in words with the supposed double articulations like /m̥ta/ 'death' and words with a prenasalized alveolar segment such as /n̥ta/ 'tear'. Compare the spectral shapes of the nasal portions from tokens of these words in Figure 3. (Note that the nasal portions are voiceless in this context and the transcription is modified to reflect this fact.) The location of the second peak in the spectrum is distinctly higher



t s a b ɗ a

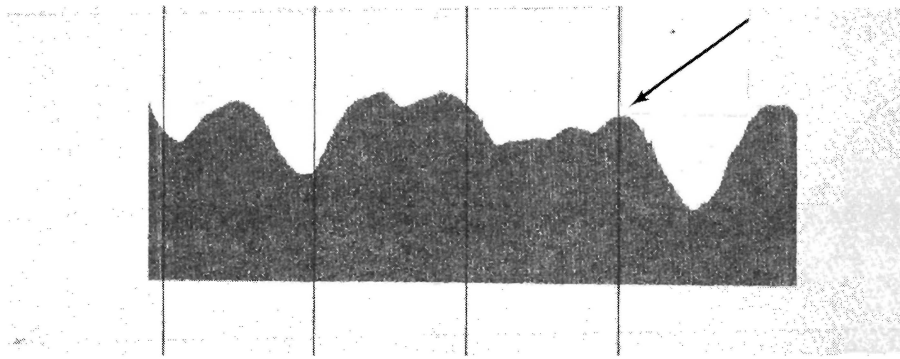
'he ate (meat)'



k ə d z a b a

'there is a granary cover'

Spectrum of /n̥/ in /n̥ta/ 'tear'



4000 Hz 3000 Hz 2000 Hz 1000 Hz

Spectrum of /m̥/ in /m̥ta/ 'death'

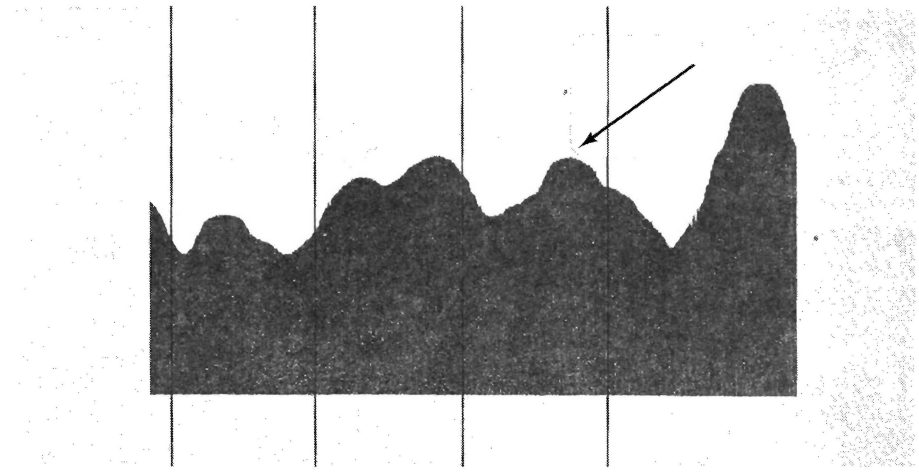
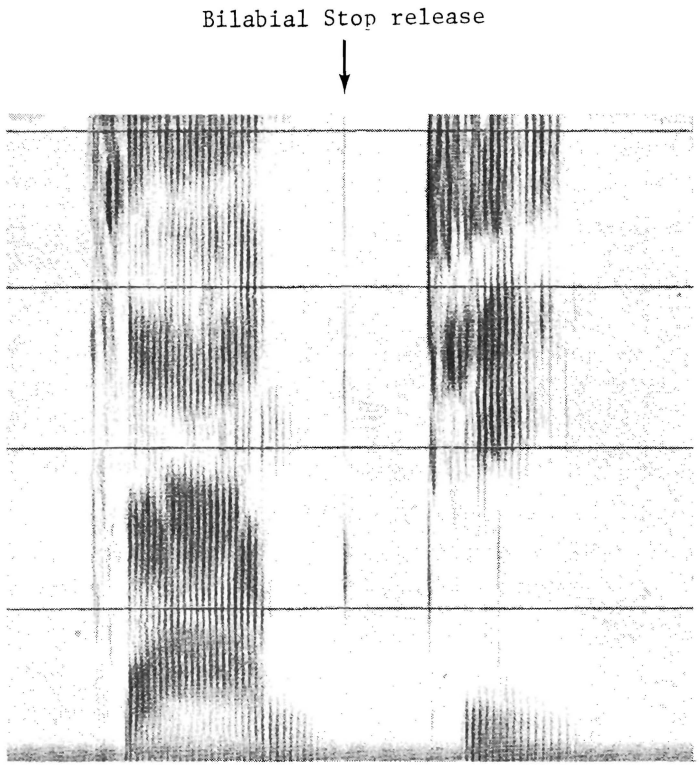


Figure 3. Spectra of contrasting voiceless nasals before /t/

in frequency for /m̥/ than for /n̥/ . Simply watching the speaker's mouth as he produces /m̥ta/ shows that there is a bilabial articulation. However, if an alveolar articulation coincided with it, then the effective oral cavity shape would be the same as in the alveolar nasal in /n̥ta/ 'tear'. A closure at the lips makes no acoustic contribution if the oral cavity is already closed off behind the lips. Since the nasals are not the same acoustically, we may assume that there is *only* a bilabial closure at the beginning of a word like /m̥ta/ 'death'.

Equally, just as the nasal portion of these prenasalized elements is not doubly articulated, neither is the stop portion. In most instances /m̥ta/ and similar words contain a straightforward alveolar stop. However, on occasion, the velum is raised early for the stop /t/ before the bilabial articulation for the nasal is ended, producing a brief bilabial stop segment with a separate release, i.e. phonetic [mpt] . (This phenomenon is similar to the introduction of the "epenthetic" [p] in English words such as "dreamt".) An example is shown in the spectrogram in Figure 4. (Note that the nasal is voiced in this case.) The auditory impression given by this variant pronunciation is probably responsible for the perception of the stop portion as a doubly articulated "labial-alveolar". But in fact it provides further evidence that the bilabial and alveolar articulations are not simultaneous, since again there could be no intra-oral pressure build up behind the bilabial closure if an alveolar closure had already been formed behind it. If the bilabial release is audible, it must precede any alveolar articulation and not overlap with it. The transcription /mt/ is thus a more phonetically appropriate one, rather than /m͡n͡p͡t/ .

In addition to the phonetic evidence of an articulatory sequence, examination of the relative timing of utterances indicates that there are in fact two segments to be recognized at the phonetic level in the places where the alleged labial-alveolars occur. In intervocalic position, for example, when preceded by a vowel-final morpheme, such as the person/tense marker /tsa:/ , the consonantal duration for /pt/ is considerably longer than the duration for a single /t/ or /p/ . In Figure 5 we compare this with the situation in a language with genuinely doubly-articulated stops, such as Yoruba with



t s a m (p) t i

'he will die' Speaker S

Figure 4. "Epenthetic" [p] in /mt/ sequence.

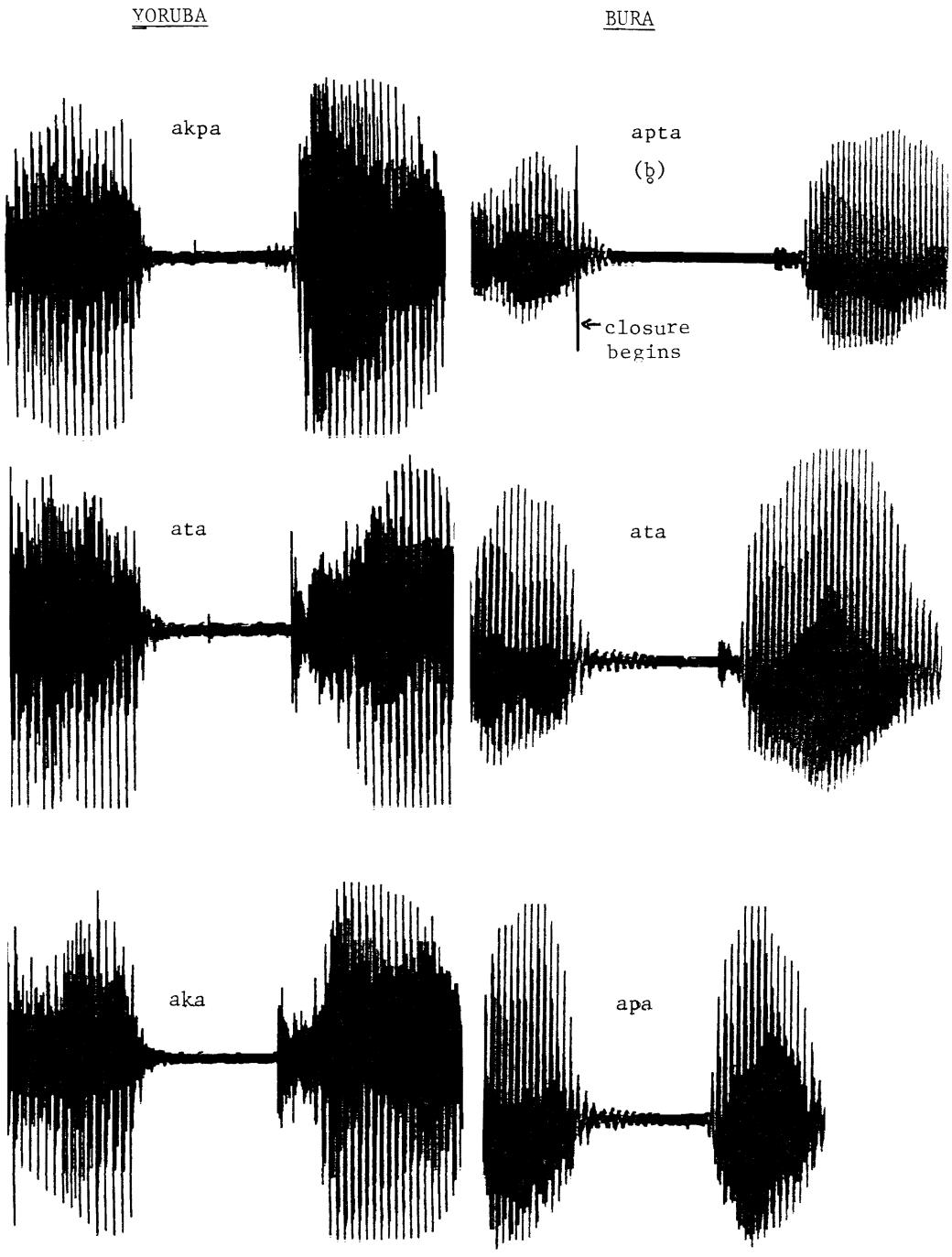


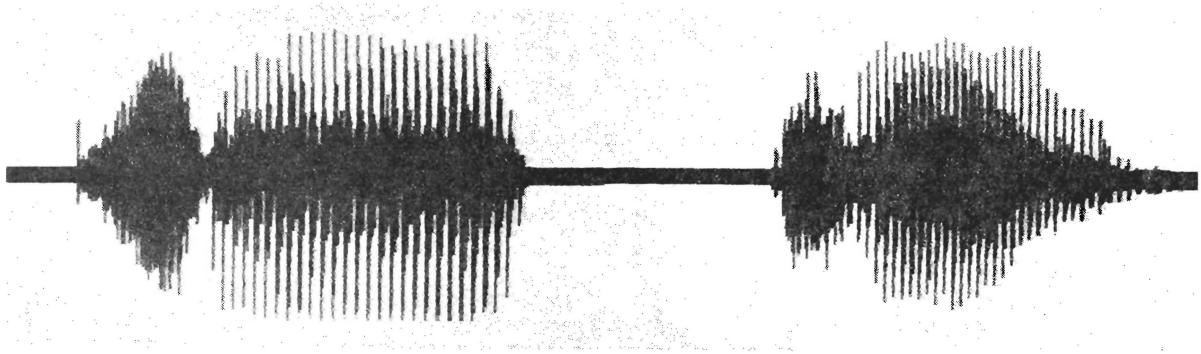
Figure 5. Comparison of stop closure durations in Yoruba and Bura.

its labial-velars. In Yoruba, the duration of a doubly-articulated stop closure is about the same as the closure duration of a stop with a single articulation. Figure 5 shows waveforms illustrating closure durations of intervocalic /pt/ , /p/ , and /t/ from speaker M of Bura and intervocalic /kp/ , /k/ , and /t/ from one speaker of Yoruba. Whereas all the Yoruba closures are of approximately equal duration (about 130 msec) regardless of whether they have single or double articulation, the closure for the complex element /pt/ in Bura is about 180 msec whereas that for a simple /p/ and /t/ is only about 130 msec long. This longer duration, while not conclusive by itself, is an indication that there may be more than one segment between the two vowels in the phrase containing /pt/ .

Another important phonetic fact concerning the "doubly-articulated" elements becomes apparent as soon as one examines them in an intervocalic context. This is a voicing change. The labial first portion in all the cases we are discussing is voiceless when the second (alveolar or palato-alveolar) portion is voiceless, at least as far as initial position in citation forms goes and our transcriptions have generally reflected this voiceless pronunciation (as /m̥t/ and /pt/). However, when a voiced segment, such as a vowel, precedes, the bilabial portion is voiced. The waveform for /-pt-/ in Figure 5 shows greater perseveration of voicing into the closure than for simple /p/ or /t/ , and in Figure 4 voicing can be seen throughout the nasal /m/ in intervocalic /mt/ , whereas this nasal would be a voiceless utterance initially. This alternation in voicing does not directly bear on the phonetic unity or otherwise of these elements—after all, segments which are phonetically speaking partially voiced are quite commonly found in languages—but it has an importance for the phonological analysis we will discuss below.

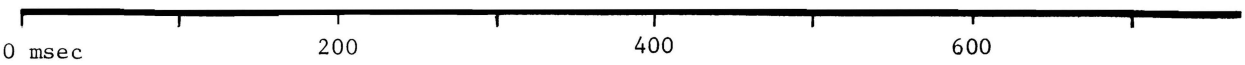
There is also another durational effect to notice. A vowel before a "doubly-articulated" stop is shorter than one before a simple following stop. A representative illustration of this is shown in Figure 6. In these examples the vowel before simple /p/ is about 180 msec long, whereas that before the complex element /pts/ is about 150 msec long. In many languages vowels are typically shorter in a closed syllable than in an open syllable.

Before a simple consonant:

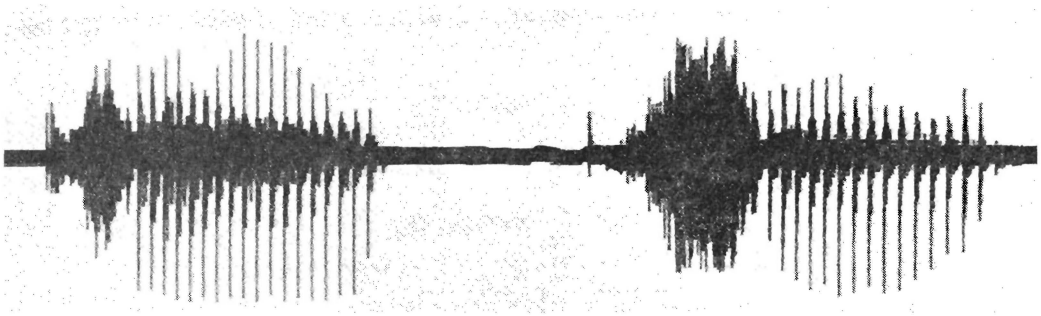


t s a: p i

'he will spend the night'



Before a complex consonant:



t s a: p t s i
(ᵇ)

'he will roast'

Figure 6. Vowel Shortening.

For example, in Tamil lexically long vowels are about 50 msec longer in CV syllables than in CVC syllables [Balasubramanian 1981]. Such length variations have been readily phonologized in numerous languages, for example in rules requiring short vowels in closed syllables in Hausa and Arabic or before geminate consonants in Finnish, Italian, etc., and in the Middle English sound change known to historical linguists as "lengthening in open syllables". If there is other evidence to support an analysis which treats the phonetic sequences such as /pt/ in Bura as heterosyllabic consonant clusters in intervocalic positions, then these durational facts would be accounted for also. We will return to the issue of syllabification below.

3. Phonological Analysis

Now, even if there are not simultaneous bilabial and alveolar articulations in the kinds of elements under discussion here, and, hence they are not phonetically speaking labial-alveolars, it could still be the case that from a phonological point of view these elements should be regarded as single entities. However, whatever phonological account is given must be consistent with the phonetic facts as we have shown them to be. In view of this, it seems that a stronger case can be made for an analysis of these elements in precisely the fashion that Hoffman rejected, namely, as a juxtaposition (albeit not casual) of two phonemes. In other words we will argue that they are phonologically a sequence of a bilabial and an alveolar (or palato-alveolar) consonant.

First let us dispose of two possible counter-arguments to the sequential analysis. Recall Hoffmann's remark about the "labial-alveolars" in Margi to the effect that "their behaviour in reduplication" demonstrates their unity. Hoffmann does not explain this remark, but refers the reader to a list of reduplicated forms for support. I presume that he would have intended the reader to note that when a form like /bd͡ə/ is reduplicated, all of the prevocalic material is replicated, i.e. the form is /bd͡əbd͡ə/ , rather than /bəbd͡ə/ .[4] However, if this is to serve as an argument for the unity of the

[4]An unnecessary distinction between allophones of /ə/ in open and closed syllables has been eliminated from Hoffmann's transcription.

initial elements, then it is necessary to show that a sequence would have been reduplicated in some different fashion. Let us suppose that Margi had a form /tku/ , with the reduplicated form /tətku/ . We would require an explanation for the fact that on the one hand the whole of the /bd͡ʃ/ element is repeated in the reduplicated form but that on the other only the initial portion of the /tk/ element. A logical account of these facts would be to posit that /bd͡ʃ/ is a unit, whereas /tk/ is a cluster, and the rule of reduplication is to repeat the initial consonant. But Margi has no forms such as the hypothetical /tku/ by which to demonstrate that elements such as /bd͡ʃ/ are treated differently from "real" clusters.[5] Invariably in Margi, and in Bura, either complete roots are reduplicated or entire initial syllables. These processes provide no evidence one way or the other for the analysis of word-initial complex elements as units or sequences.

Equally the sequence analysis cannot be ruled out by pattern conformity. There is no basis for arguing that Bura (or Margi for that matter) disallows consonant sequences in general. Beside the elements whose analysis in initial position is in dispute, various lateral + obstruent clusters, e.g. /kilfa/ 'fish', /kəldəfu/ 'anger', and additional nasal + obstruent clusters occur medially, e.g. /mɮ/ in /umɮa/ 'nine'; /mɬ/ does occur initially. Consonant sequences are also generated by reduplication, both productively and in frozen forms like /warwar/ 'throat'.

On the other hand, a unitary phonological analysis of the "labial-alveolars" raises some difficult problems concerning feature assignments with respect to prenasalized and affricated types. It is self-evident that these types of elements contain a *phonetic* sequence of events, and other authors have argued for representing such elements as complexes of one kind or another, because, for example, they have different assimilatory effects on segments which precede them than they do on those which follow, e.g. Anderson

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[5]There is one misleading example in Hoffmann [1963]. The form /tskwar/ 'to touch' is given (p. 160) with a reduplicated derivative /tsətskwari/ 'to touch many things'. Forms cited elsewhere in the book, e.g. /ts(u)kwari/ 'to touch' (p. 120), suggest that there is an underlying vowel between the alveolar affricate /ts/ and the velar stop /k/ in this word.

[1976], Feinstein [1979]. But, beyond these considerations, because two places of articulation are involved, unique problems arise if the prenasalized and affricated elements with bilabial and alveolar components in Bura are regarded as doubly-articulated units, i.e. as a single matrix of features. Given the existence of prenasalized alveolars and bilabials, e.g. /nt/ and /mp/ , and the evidence above that the nasal in the "labial-alveolar" /mt/ is bilabial, no simple feature marking all these "segments" as prenasalized will correctly indicate the place of articulation of the nasal, since it is not necessarily homorganic with the stop portion.[6] In a similar fashion, simply marking "doubly articulated" affricates such as /pts/ , /pt∫/ , etc. with a familiar feature, such as [+ delayed release] would imply that the fricative portion of these "segments" is both labial and alveolar (or palatal-alveolar as the case may be). This is not so. Such false predictions could be avoided by creation of features which specify which of the two articulations is being prenasalized or affricated, but it seems more appropriate to recognize simply that there is a place contrast in nasal segments preceding alveolars (and palato-alveolars) and a place contrast in affricates (and fricatives) following labials.

A similar situation applies with respect to the voicing changes in the first element of the prenasalized elements and the "labial-alveolars". Recall that before voiceless stop portions the nasal portion of the prenasalized elements is itself voiceless under certain conditions, e.g. initially in citation forms. However, when preceded by, for example, a vowel the nasal portion is voiced: thus [n̥ta] 'tear' but [tsa: nta] 'he will tear'. If /nt/ is regarded as a prenasalized unit which is underlyingly voiceless throughout, then the voicing assimilation rule must apply only to the nasal portion of this segment which, in such an analysis, has no separate status. Alternatively, if the nasal portion is taken to be normally voiced even in such "voiceless" prenasalized elements (which we would prefer to do on universalist grounds), then an initial devoicing rule must be stated which applies only to

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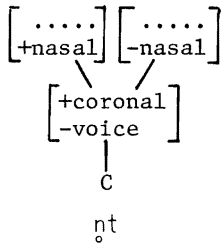
[6]Note that whatever feature representation of unitary prenasalized segments is preferred there would be no such problem if the "labial-alveolars" were actually doubly-articulated.

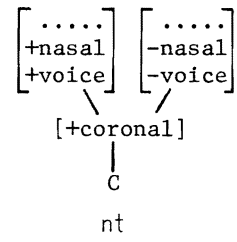
the nasal portion. No conventional feature is available which will enable such a rule to be formulated. Naturally, if the nasal is recognized as a separate segment, no such problem arises. Similarly with the voiceless labial + alveolar stop elements. If /pt/ is a unit, then the voicing of the labial portion when this element is in an intervocalic position is difficult to specify. If it is recognized as a cluster then there is no difficulty in the way of having voicing apply to the first segment in the sequence.

The above objections to an analysis in which these complex elements are represented by a single feature matrix might be met by proposing that the correct representation is by means of two feature matrices linked to a single consonantal slot. This is the complement of analyses of geminate segments as single feature matrices linked to two slots in the CV skeleton, e.g. McCarthy [1979], Schein [1981]; cf. also Halle & Vergnaud [1980]. In this account, features whose values are shared by both portions of a complex consonant would appear in a matrix directly linked to the C slot, thus expressing the extent to which the portions of a complex consonant are similar to each other. Features which differ in the two portions appear in separate matrices. By such an analysis, /nt/ would receive the representations shown in (3), with (3) representing the variant with the devoiced nasal, (3b) the variant with the voiced nasal.

(3) a.

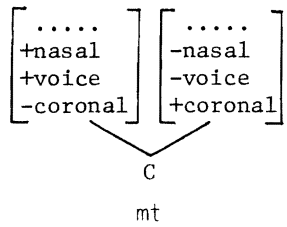


b.



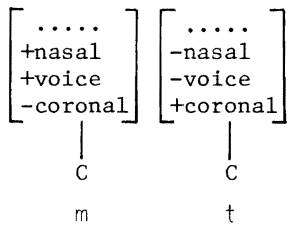
As we will argue more fully below, there is good reason to take the voiced variant as the underlying form. In terms of the proposal being evaluated let us just state that (3a) represents in some sense a simplification of (3b) and is more easily derived from it than vice-versa. If this is the case, then note that in a prenasalized "labial-alveolar" segment such as /mt/ there are no shared features; the two matrices are entirely distinct as in (4).

(4)



The lack of any unifying feature value shared by the two matrices in (4) removes the most obvious motivation for this analysis. In its place we would need to show that there was theoretical justification for the distinction between (4) and (5), where the same matrices are linked to two different consonantal slots.

(5)



The evidence for this distinction is not forthcoming in Bura. Where we might have expected to see it, e.g. in reduplication, there is no reason to posit a difference between single complex consonants and consonant clusters.

Since representation of /nt/ as (3b) can be justified on the basis of shared features, but representation of /mt/ as (4) cannot, we are left with the question of whether representing /nt/ as (3b) and /mt/ as (5) has any merit. Applying this strategy to all of the relevant elements in Bura (see the appendix) would result in a division into two groups. One group, with shared features, would include the prenasalized homorganic stops (/nt, nd, mp, mb, nk, ng/ etc.) and elements with two articulations but shared manner features (including [±voice]) such as /pt, bd, bd͡ʃ, bdz, bƀ, mɲ, bw/ etc. The other group would contain voiceless coronals with bilabial prenasalization such as /mt, mts, mɬ/ etc. plus cases where palatal or labial-velar glides follow consonants with which they share no features, e.g. /fy/ . However, aside from the fact of shared features values on which the grouping is based, these groups have no functional distinction in Bura phonology that we

are aware of. All of the rules we know of (reduplication, voicing assimilation, vowel shortening) do not distinguish between these groups. Whereas, within both groups, it is necessary to distinguish between the elements in which the second portion is a glide (/y/ or /w/) which have no tendency to shorten a preceding vowel, and the rest, which do. Since introduction of a formal distinction between complex single consonants (with shared features) and consonant clusters is antagonistic to a clear account of Bura phonology, we are left with the simplest remaining assumption—that all of the complex elements are consonant sequences.

The hesitancy of earlier scholars to adopt the sequential analysis may have been due to the rather large number of word-initial clusters of a highly unusual type which are created by this analysis, implying many unusual types of CCV syllables. Many of these violate normal conceptions of the sonority hierarchy governing acceptable syllable formation (for discussion of this old-established idea in recent linguistic literature see, for example, Hooper [1972], Lowenstamm [1981], Cairns and Feinstein [1982], Steriade [1982]). These clusters have adjacent segments of equal rank in sonority, e.g. two voiced stops such as b + d/ , or a more sonorous segment, i.e. a nasal, preceding a less sonorous one, i.e. a stop or a fricative. However, recent proposals concerning the analysis of the syllable within a metrical framework, originating with Kiparsky [1981] and elaborated by Steriade [1982] and others, have provided a framework within which these clusters can receive a natural account. They recognize that consonants in an initial or final cluster, particularly at the margins of a word may not be part of the syllable onset or coda.

The phonetic evidence on vowel length suggests that the unusual word-initial sequences in Bura are resyllabified where this becomes possible, so that /tsa + bda/ becomes /tsab.da/ , /tsa + mta/ becomes /tsam.ta/ and so on. As noted earlier, the vowel preceding the cluster is shortened in such circumstances, as in an originally closed syllable. Note that in these contexts there is no violation of normal syllable structure. Let it be assumed that syllables are constructed in the first instance in strict conformity with the universal syllable template [Lowenstamm 1981], given in (6).

(6) In a string of segments, a syllable is a maximal substring such that:

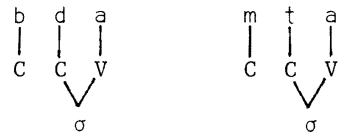
a. (i) no segment is of lower sonority than both its immediate neighbours

(ii) no two segments of equal ranking on the hierarchy are adjacent.

b. the onset is maximal within the limits of (a).[7]

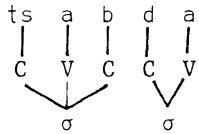
Sonority hierarchy violations are disallowed by the conditions in (a), hence marginal consonants with a segment of equal or greater sonority between them and the nearest candidate to be a syllable peak will not be incorporated into any syllable. This would be the output of the lexical component (cf. discussion by Mohanan [1982], Pulleyblank [1983], and especially Harris [1983:71-80]). Thus items such as /bda/ and /mta/ will initially be syllabified as in (7),

(7)

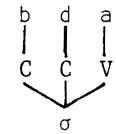


leaving a stray initial consonant in the segmental skeleton. Postlexically, if the context permits this to be done in conformity with the sonority principles, this stray consonant is adjoined to the preceding syllable, as in (8a). If there is no preceding syllable or it cannot be adjoined to the preceding syllable without violating (6), a postlexical rule incorporates it into the onset of the following syllable, as in (8b). (Stray consonants are never erased in Bura.)

(8) a.



b.



This incorporation, creating surface violations of the universal syllable canon, can be explained if Bura is subject to a language-specific constraint

[7]The more elaborate proposals of Cairns and Feinstein for syllable construction seem unnecessary—certainly for Bura and probably elsewhere. See Steriade [1982] for discussion.

that all syllables must contain a lexically supplied vowel. If no such condition governs syllable-formation in Bura, it would be expected that the isolated initial consonant would form a syllable by itself, i.e. become syllabic. This does not happen, even with segment types such as nasals, which readily become syllabic. Neither does Bura eliminate the violations by insertion of a non-lexical vowel (a "schwa-insertion" process). Compare the situation in Bade, a geographically not-so-distant Chadic language which underwent a somewhat similar historical process to the one in Bura, converting word-initial CVC syllables into CC sequences. The historical process in Bade, illustrated in (9), deleted a short high low-toned vowel between many pairs of consonants, especially non-homorganic obstruents. The details are discussed in Schuh [1978]. In general the damage to canonical syllable structure is "repaired" by insertion of a prothetic vowel if the cluster consists of two obstruents, or by making the initial consonant of the sequence syllabic if it is a liquid or nasal (9c).

(9)	a. Proto-Bade		b. Underlying		c. Surface	
	*bə̀d(ú)	→	bdú	→	ə̀bdú	'he asked'
	*mə̀tú	→	mtú	→	m̀tú	'he died'

Having motivated a sequential analysis of the "labial-alveolars", it now becomes clearer that the labial + alveolar consonant clusters in Bura should be regarded as having a *voiced* labial segment in first position, even though in citation forms the labial is voiceless before a voiceless second element. This argument hinges mostly on what happens with the nasals. Although both voiceless and voiced nasals occur phonetically in Bura, there is no contrast between them. Voiced nasals are found in a wider range of environments—everywhere except word-initially between a pause and a voiceless obstruent. Hence one would mark nasal segments in Bura as underlyingly voiced. This is also consistent with the universally unmarked status of voiced nasals [Maddieson, to appear]. Since the initial bilabial stop segments in what we have been writing as /pt/ , /pts/ , etc. take part in the same voicing alternation as the nasals, we would want to posit an underlying /b/ in these sequences and account for the voicing change by the same rule of devoicing.

This direction for the voicing assimilation rule is also motivated by an understanding of universal preferences concerning syllable structure. The degree to which the universal syllable canon is violated is reduced by devoicing the bilabial segments. In other words Bura takes a small step towards repairing the violations of the sonority hierarchy by making the adjoined nasals or stops before voiceless obstruents in a syllable onset into their less sonorous voiceless counterparts. An onset containing two voiceless obstruents is a less severe violation of the sonority hierarchy than one which contains a voiced one before a voiceless one. Similarly with the nasals.

4. Conclusion

In conclusion, we have shown that the elements previously analyzed as doubly-articulated labial-alveolars in Bura are phonetic sequences of a labial and an alveolar. We have also shown that phonetic and phonological arguments converge in favor of proposing that those sequences are present in underlying forms. This may mean that there are no human languages in which underlying labial-alveolar segments occur.[8] Moreover, we have also shown that universal patterns of syllable construction play an important role in explaining the phonological status of these elements as sequences.

[8]The remaining cases in which labial-alveolars have been claimed to occur seem to be allophonic, e.g. Dagbani, or dubious (Nzema).

APPENDIX

A. A consolidated list of Bura labial + alveolar or palato-alveolar/palatal elements

This list is based principally on the data collected by Russell Schuh, but is supplemented by data from Hoffmann (n.d.). The four columns contain the following:

1. A transcription of the element in the style usually used by Hoffmann and other Chadicists.
2. A transcription which represents the phonetic assumptions implicit in Ladefoged [1968] concerning the realization of these elements. Many of the elements are not given by Ladefoged in his Bura phonemic inventory (even though the inventory was supplied by Hoffmann, who insists on the phonemic unity of many more elements than Ladefoged includes), but I have extended his transcriptional conventions on the basis of the elements he does include and on the basis of those he gives for Margi.
3. A transcription representing what I would propose as the underlying forms of these elements in my analysis of Bura.
4. A word exemplifying the element in question, accompanied by an English gloss. In five instances, this column has a question mark as its entry. This indicates a strong presumption that this element exists given the general patterns of formation, but that no examples are known in available sources. There are further elements which would seem in principle to be possible but are also unattested.

(a) Stop-initial elements

1 (Hoffmann)	2 (Ladefoged)	3 (Maddieson)	4 (example + gloss)	
pt	p͡t	bt	btà	(an animal)
bd	b͡d	bd	bdà	'to collect honey'
bd᷈	ʔb͡d	bd᷈	bd᷈à	'to eat meat, chew'
ps	ps	bs	bsà	'to mix mud'
bz	bz	bz	bzə̀r	'child'
pts	p͡ts	bts	btsà	'roast'

1 (Hoffmann)	2 (Ladefoged)	3 (Maddieson)	4 (example + gloss)	
bdz	b͡dz	bdz	bdzà	'to patch'
pš	pʃ	bʃ	bʃàrì	'to spread a net'
bž	bʒ	bʒ	?	
pč	p͡tʃ	btʃ	btʃì	'sun'
bj	b͡dʒ	bdʒ	?	
p↓	p↓	b↓	b↓à	(an insect)
bƀ	bƀ	bƀ	bƀà	'to forge'

(b) Nasal initial elements

mt	m͡np͡t	mt	mtà	'death'
md	m͡nb͡d	md	mdâ	'person'
md	m͡n?b͡d	md	?	
ms	ms	ms	msə́kâ	'maternal uncle'
mz	mz	mz	?	
mš	mʃ	mʃ	mʃǐ	'corpse'
mž	mʒ	mʒ	mʒá	'be enough'
mč	m͡np͡tʃ	mtʃ	?	
mj	m͡nb͡dʒ	mdʒ	mdzǐ	'people'
m↓	m↓	m↓	m↓ì	'ferment'
mny	mɲ	mɲ	mɲà	'mouth'
mhy	mç	mç	mçì	'sorghum'

B. Homorganic prenasalized elements in Bura

These elements differ less in their transcription than the "labial-alveolar" since there is no basic disagreement on their phonetic nature. Hence only one column of transcription is given, together with an example. Two elements strongly presumed to exist are included in the list, and there are others which might reasonably be expected to occur.

mp	mpà	'to fight'
mb	mbà	'to burn'
mʃf	mfwà	'tree'
mʃv	mvwà	'Kanuri person'

nt	ntà	'to tear'
nd	ndà	'to cook'
nts	ntsàrà	'to step on'
ndz	?	
nt∫	nt∫à	'eye'
ndʒ	ndʒà	'to sting'
ns	?	
nz	nzì	'to sit'
nɬ	nɬì	'to cut'
nɮ	nɮì	'to be sated'
ŋk	ŋkà	'to come back'
ŋg	ŋgá	'big'
ŋɣ	ŋɣí	'to be full'

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