Chapter 8

Left-sided vs. right-sided phonology of labial-velars

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Labial-velars are shown to be phonologically single units by diagnostics such as duration and their patterning in syllable structure. However, they also exhibit processes in which the active feature is [dorsal] on their left side, but [labial] on their right. This is shown by partial nasal assimilation as ŋKP and KPm, as well as other processes. Several phonological models are found to be inadequate to explain the range of these behaviors. Standard or enhanced versions of Feature Geometry and Articulatory Phonology can account for the phonological sidedness behaviors noted here, but not with other behaviors, and issues still remain in combining the phonology with the phonetics.

1 Introduction

The term "labial-velars" refers to k͡p, g͡b, ŋ͡m (and modifications thereof such as ᵑg͡b) with approximately simultaneous labial and velar articulations. In this paper, unless referring to a specific type of labial-velar, these will be generalized under the label KP.

The "approximately simultaneous" label for the labial and velar articulations is an appropriate designation in many contexts – they largely overlap. But there is additional systematic, cross-linguistic detail that is foundational to this paper. In every case in which this issue has been examined, the velar articulation slightly precedes the labial, and the labial persists slightly longer. For example, this large but partial overlap is clearly seen in the electromagnetic articulography measurements in Figure 1 for Ewe [ewe] (Maddieson 1993). In this study, metal pellets

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were glued to the lips and tongue dorsum, and a metal-detecting sensor produced the positional readouts. Note that the "k" articulation slightly precedes the "p" articulation, and the "p" articulation persists after the "k" has finished.

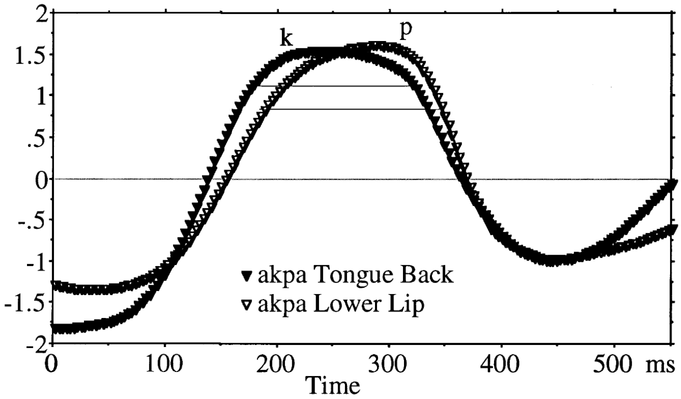


Figure 1: Coordination of lower lip and tongue back movements in the Ewe word *ákpá* 'too much'. Y-axis is vertical displacement, normalized scale, mean of ten tokens aligned at release; horizontal lines indicate the likely duration of actual contact of the articulator. (Figure 6 from Maddieson (1993))

Spectrographic evidence from Leggbo [agb] in Figure 2 also shows a velar onset and labial release (note the "velar pinch" of F2 and F3 going into the consonant). Spectrograms of intervocalic KP are also presented for Dedua ([ded]) and Efik ([efi]) in Ladefoged & Maddieson (1996: 336-37) and others in Connell (1994), showing a velar onset and a labial release. So, a KP largely, but not totally, overlaps velar and labial articulations.

Besides the phonetic evidence of gestural overlap, KPs exhibit a variety of patterns indicating they are units rather than sequences:

- They occur in languages which have only unambiguous single consonant syllable onsets (CV, CVN, CVV, CVVN). No consonant clusters occur word-initially in many of the languages cited in this paper, yet KP does occur word-initially.

- Their duration is much closer to single stops than to clusters. Consonant clusters typically have 1.5-2 times the durations of single segments (Ladefoged & Maddieson 1996: 333). The duration of labial-velars is slightly longer than simple stops (Yoruba gb/b = 132/128 ms), but does not approach

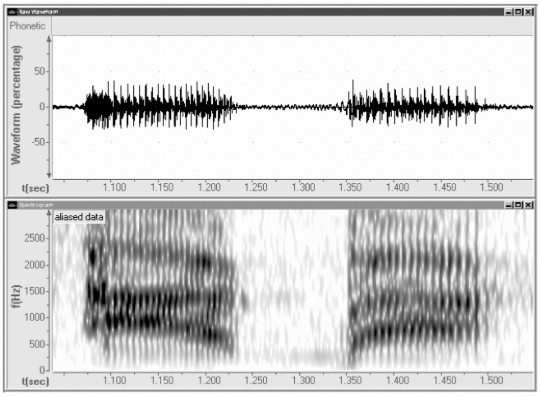


Figure 2: Spectrogram of [ag͡ba] from Leggbo (Nigeria) (recording courtesy of Julie Larson)

the duration of consonant clusters. They also report similar data for Ewe, as Connell (1994) does for Igbo, and Demolin (1991) for Mangbetu. In a direct comparison, Ladefoged and Maddieson also show by spectrographic evidence that Eggon's [kp] consonant *cluster* is longer than the [k͡p] *unit*, though no numerical measurements are given.[1]

- Turning to specific language data, in Ewe reduplication, KPs also act as single segments. A word with an initial consonant cluster has a reduplicant with only the first consonant, including KP, e.g. *fle* 'to buy', *fe-flee* 'bought' vs. *kplo* 'to lead', *kpo-kplo* 'leading' (Ansre 1963).
- In Kaanse [gna], /kp/ becomes totally (not partially) voiced after a nasal, e.g. *sànɪ kpógorò* 'sheep-shelter', *sṹŋ gbógorò* 'chicken-shelter' (Showalter pc).

[1]Gouskova & Stanton (2021: 183) "doubt a universal correlation between segmenthood and duration". However, the claim in this paper is limited to labial-velars, not the wider variety of sounds ("universal") they consider. More crucially, they do not consider the evidence here, and most particularly, they note that "the most straightforward evidence for a duration/segmenthood link would have to come from languages that contrast complex segments with same-phone clusters" (Gouskova & Stanton 2021: 184). This is precisely what the Eggon example above presents.

- In Mano [mev], /gb/ has an allophone [ŋm] before a nasalized vowel; that is, the voiced labial-velar is completely (not partially) nasalized (Welmers 1973: 47)[2]

This multiplicity of patterns indicates that KP are phonological units rather than sequences.[3] However, other processes are sensitive to edge effects, and the presence of both “unit phonology” and “edge phonology” indicates phonology operating on different levels. Nasal place assimilation, which can occur with nasals either preceding or following KP, is but one process that shows sensitivity to the edges of KP, not the whole segment.

2 Left-sided phonology

2.1 Nasal place assimilation

A nasal preceding KP, whether as prenasalization, a distinct morpheme, or within a morpheme, is reliably transcribed as *ŋKP* or ^{ŋ}*KP* as a product of assimilation or an independent phoneme in over 85 documented languages for which I have data (Appendices A-B), while a total assimilation as *ŋmKP* or ^{ŋm}*KP* is attested in at least 56 languages (Appendices C-D). There is sometimes uncertainty as to which of these two options is correct, but some investigators (e.g. Boyeldieu 2006) have differentiated *ŋKP* from *ŋmKP* in different languages (Bagiru and Ngiti), so these researchers, at least, are not only aware of the difference, but deliberately record these as different.

As Clements & Rialland (2008: 42) note:

> …in homorganic nasal–stop sequences, it is the dorsal feature that typically spreads to the preceding nasal, yielding [ŋmgb] or [ŋgb].

[2] A reviewer points out that the Kaanse and Mano examples have an alternate explanation, that the KP could be a cluster, not a unitary segment. As noted on the previous page, syllable structure inventories in these languages make this alternative untenable; /kp/ and /gb/ occur word-initially, but no unambiguous consonant clusters do. Also for these languages, Kaanse has codas only of nasal and glottal stop (Showalter 1997), and Mano does not have any stop consonant clusters (Khachaturyan 2015, 2018).

[3] Because of the inherent contradiction in the features associated with labial and velar articulations at the time, Jacobsen et al. (1953) claimed that labial-velars were an extreme form of consonant *cluster*. As Anderson (1976: 20) notes, such a claim is “counter to all previous treatments and (what is more to the point) quite at variance with the phonetic and phonological properties” of labial-velars, such as those noted here.

I regard the few transcriptions recorded as *mKP* as dubious, which I address in this section.

The two types of well-documented nasal place assimilation are thus limited to a total place assimilation *ŋmKP*, or a partial place assimilation *ŋKP*. It is the latter, illustrating sensitivity to the left edge of KP, that we are primarily concerned with here.

Ryder (1987) cites several languages in which a nasal segment assimilates to KP as [ŋ] (as well as languages assimilating as [ŋm]). Partial nasal place assimilation is exemplified below for a few languages. See Appendix A for a fuller list of 20 languages illustrating this phonological process.

(1) Gã [gaa] (Ryder 1987)
  a. ŋgbek ‘my child’
  b. ŋkpai ‘my cheeks’
  c. taaŋkpee ‘sisal’

(2) Dagaari [dga] (Kennedy 1966, personal data)
  a. kpàŋkpàŋ ‘upper arm’
  b. gbáŋgbáŋ ‘noon’

(3) Vagla [vag] (Crouch & Smiles 1966)
  a. tʃaŋkpalŋa ‘antelope’
  b. sʌŋgbo ‘baboon’

(4) Mono [mnh] (Olson 2005)
  a. ŋgba ‘be many’
  b. kéŋgbā ‘alone’

Olson (2005: 33) notes the pronunciation as [ŋg͡b], though written orthographically as <ngb>

(5) Gonja [gjn] (Painter 1970)
  gbìŋgbìŋ ‘big’

Painter (1970: 36) notes that “when /gb/ is preceded by a syllabic nasal this nasal has a velar, not a bilabial or labial-velar articulation”.

Many languages also exhibit a prenasalized KP. Similar to the pattern across syllables above, this is often realized as ^{ŋm}KP, but also occurs as ^{ŋ}KP, as in (6) from Bongo. Kilpatrick (1985: 8) notes, “The prenasalization just has velar closure, rather than both labial and velar closure”.

(6) Bongo [bot] (Kilpatrick 1985)
/^{ŋ}gb/: ^{ŋ}gbáyá ‘corn’

The dozens of languages which have ^{ŋ}KP as a phoneme include Ambele [ael] (Nganganu Kenfac 2001), Kako [kkj] (Ernst 1996), Yango [yng] (Bostoen & Donzo 2013), Mündü [muh] (Jeffrey & Polley 1981), Avokaya [avu] (Callinan 1981), Logo [log] (Goyvaerts 1983). See Appendix B for a list of 66 such languages.

The patterns [ŋKP] and [ŋ͡mKP] are well-documented (see Appendix C for 10 languages showing assimilation as [ŋ͡mKP], and Appendix D for 46 languages showing /ŋmKP/ as a phoneme). In contrast, the actual likelihood of an [mKP] can be uncertain, for several reasons.

First, the literature that reports assimilation as [m] does so in a way that indicates the writer has never considered the possibility of [ŋm]. A labial closure is observed, and it is assumed that that is all there is to it.

Second, in some languages, the orthographic convention does not match phonetic or phonological reality. Yoruba uses orthographic <p> to represent /kp/ (Folarin 1987, inter alia) and orthographic <m> for [ŋm].

Third, the different nasals which are possible before KP are not always easy to distinguish by ear alone. Besides personal experience, we see that this issue was noted almost a century ago. Ward (1933) writes concerning Efik [efi]:

> It is, however, extremely difficult to *hear* which is being said without *seeing* the presence or absence of lip-articulation… There are some words in which *m* has been written and others in which *ŋ* occurs. *mkpa*, death; *ŋkpɔ*, thing. It is probable that both articulations are made at the same time, i.e. a labio-velar nasal consonant… (Ward 1933: 10)

Note that Ward indicates the probability of [ŋmkp], but never writes it as such. The difficulty of distinguishing [ŋmkp] and [ŋkp] is exacerbated by their word- and utterance-initial positions, as these positions have no vocalic transition into the nasal. For Efik more recently, (Welmers 1968: xii) observes that a nasal before /kp/ in Efik is pronounced “with simultaneous closure at the lips and with the back of the tongue”, i.e. [ŋm], but Welmers (1973: 47) comments that “For some unknown reason, in the usual orthography of Efik, *mkp* is written in some cases but *ŋkp* in others”. Both Cook (1969) and Ohala & Ohala (1993) elucidate this by noting that the nasal assimilating to /kp/ manifests itself as either [ŋ] or [ŋm] in Efik.

Another case of alleged [mkp] occurs in Bikele, also called Kol [biw], cited as having /mkp/ and /mgb/ in Begne (1980: 30-33). However, the more recent

Henson (2007) records every nasal before KP as [ŋ], and notes the possibility of them being [ŋm] (Henson, pc). Furthermore, Begne notes that the number of words with either labial-velar is very limited, around a dozen, and these are all borrowed, generally from Ewondo [ewo]. The cognate Ewondo words in two dialects are shown below (data courtesy of Steven Bird, pc).

(7)		**Bikele (Yaoundé)**	**Ewondo (Mbalmayo)**	**Ewondo**	gloss
	a.	mkpálá	ə́ŋ̀kpálá	ŋm̀kpálá	‘playful’
	b.	mkpámág	ə́ŋ̀kpámán	ŋm̀kpámáŋ	‘new’
	c.	mkpeg	ə́ŋ̀kpɔ̂k	ŋm̀kpâk	‘favorite co-wife’
	d.	mgba	ə́ŋ̀gbà	ŋm̀gbà	‘friendliness’

Interestingly, the Ewondo data, in which particular care was taken in the nasal transcription, shows [ŋkp] in one dialect and [ŋmkp] in the other. A borrowed word is typically changed to fit the receptor language’s phonology. But the fact that neither the source language nor any other languages clearly attest [mkp] makes the report of Bikele /mkp/ dubious.

Finally, some publications which record /mKP/ are corrected at a later time. For example, Boyd (1997) lists /mkp/ as a phoneme. Upon query, she responded (pc, 2023) “Yes, it is /ŋmkp/ or perhaps more correctly $^{\text{ŋm}}$kp. Sorry for the ‘shorthand’”.

As the above examples show, transcriptions of *mKP* are uncertain at best.

To sum up, a nasal preceding KP may be totally assimilated to the place of KP as *ŋmKP*, but it is also common to have a partial place assimilation, and if so, this yields *ŋkp*, not *mkp*. The nasal assimilates to the left edge of KP, the velar.

2.2 Other left-sided phonology

In Kɔnni [kma] (Cahill 2007a), vowel epenthesis occurs between segmental morphemes with differing place values (e.g. r-k, r-b, b-ŋ, and b-kp), but not between morphemes with the same place (e.g. r-t, b-b, n-r, and g-kp):

(8)	Kɔnni					
	a.	/b-kp/:	/kɔb-kpɪɪŋ/	→	kɔ̀b-ì-kpíꜝíŋ	‘big bone’
	b.	/g-kp/:	/hɔg-kpɪɪŋ/	→	hɔ̀k-kpíꜝíŋ	‘big woman’

Note that in (8a) the labial /b/ preceding the KP is treated as a different place than that KP, but in (8b) the velar /g/ preceding the KP is treated as the same place as the KP. This process, involving sounds relating to the left side of KP, treats KP as velar. This pattern would predict that for a KP-C sequence, a vowel would epenthesize if C is velar, but Kɔnni does not end morphemes with KP.

It is anticipated that more research will uncover more cases of “left-sided phonology”, but with KP often limited to morpheme-initial or word-initial positions, the required environment for these is not as common as for the right side, and many phonology sketches do not go into the detail needed to document either of these.

3 Right-sided phonology

3.1 Nasal place assimilation

Nasals occurring after KP are not nearly as common as those preceding KP, with even so well-informed a writer as Ohala (1993: 690), among others, not showing awareness that they exist. But the documented cases mirror those discussed in §2; i.e., *KPŋm* and *KPm* occur, but not *KPŋ*.

The *KPŋm* pattern has few documented cases, listed below and in Appendix F. For the Kuta dialect of Gwari [gbr], Hyman & Magaji (1970) cite phonetic syllables [p^{m}a], [t^{n}a], [k^{ŋ}a], [kp^{ŋm}a], but give no actual words which contain them.

Mada [mda] of Nigeria (Price 1989) has an unusual syllable type: a stop followed by a syllabic nasal, e.g. the middle syllable in [kpa.kŋ.ki] ‘tree stump’. When a nasal follows KP, there is total place assimilation as KPŋm (the posited underlying /m/ below is arbitrary, and could just as well be posited as /KPŋm/):

(9) Mada
  a. /kpm̀/ [kpŋm̀] ‘kapok tree’
  b. /gbm̄/ [gbŋm̄] ‘canoe’

Konabere [bbo] (Phil Davison, pc) also has a number of words with syllabic nasals as syllable peak (tone unmarked).

(10) Konabere
  a. g͡bŋ͡m ‘black’
  b. k͡pŋ͡m ‘war’

Other languages show partial nasal place assimilation on the right side of the labial-velar (Appendix E). Especially relevant to this discussion, the Tyebaara Senoufo language [sef], (Mills 1984: 94) shows partial nasal place assimilation as KPm:

(11) Tyebarra Senoufo

a. kpmɔ̃́: ‘to beat’
b. nì̃-gbmɔ̃́: ‘herb doctor’

Finally, the Gwari language [gbr] (Rosendall 1992) exhibits *both* patterns, with nasals on either side of a KP, in at least the Giri dialect. This shows that the partial nasal place assimilation is dependent on whether the nasal precedes or follows the KP. In (12c) particularly, we see both in a single word.[4]

(12) Gwari

a. tʃiŋkpè ‘stool’
b. kpmàmí ‘okra’
c. w^{j}édʒíŋgbmà ‘dark’

3.2 Other right-sided phonology

Nafaanra [nfr] (Jordan 1980) has not only syllabic and plain nasals (13a-b), but also post-oralized nasals (13c-d), a relatively rare phenomenon. The post-oralized labial-velar releases into a labial (ŋm^{b}), not a velar (13d). This process, involving sounds *following* KP, treats KP as labial.

(13) Nafaanra

a.	nthó:sì	‘tomato’	c.	n^{d}ú:	‘to climb’
b.	mãnã	‘nose’	d.	ŋm^{b}a	‘him’

Parallel to the two possibilities of nasal place assimilation (ŋg͡b and ŋ͡mg͡b), one would predict that there would be cases in which a post-oralized nasal labial-velar releases into a full labial-velar, that is, not only ŋm^{b} as above, but also ŋm$^{g͡b}$. At this point, I am not aware of such cases, probably because post-oralized nasals are rare in the world’s languages,[5] and the intersection of this probability with that of the frequency of labial-velars results in a lower probability still.

In Ejagham [etu], Watters 1981, /i/ becomes [ɨ] following either a labial OR labial-velar when the vowel precedes a velar (14a,b). Here, the right side of labial-velars patterns with labials. Note that if the /i/ precedes a velar but follows “any

[4] At least some non-African languages also illustrate some of these same patterns. The Yeletnye language of Papua New Guinea [yle] also illustrates nasals both before and after a KP, e.g. [ŋ͡mg͡ba:] ‘constrict’, [k͡pŋ͡mĩ:] ‘coconut’. However, these are total nasal place assimilation, not partial (Henderson 1995: 8). The Nambo [ncm] language, also of Papua New Guinea, has a phonemic prenasalized KP, which shows up as the partial assimilation ^{ŋ}g͡b, as in /jɐ^{ŋ}g͡b/ ‘bag’ (Kashima 2021).

[5] See Wetzels & Nevins (2018) for a discussion of post-oralized nasals vs. prenasalized stops.

consonant other than a labial or labial-velar” (Watters 1981: 39), the /i/ is realized as [ɪ], as in (14c-e).

(14) Ejagham

a.	/é-bîg/	→	[éβɪ̂k]	‘it is enough’
b.	/ɔ̀-kpígì/	→	[òkpɨ́ɣì]	‘you turned’
c.	/à-ríg/	→	[àrɪ́k]	‘ropes’
d.	/ɔ̀-síŋ/	→	[òsɪ́ŋ]	‘mangoes’
e.	/ɔ̀-kîg/	→	[òk^{h}ɪ̂k]	‘cheek’ (Watters, pc)

In the Mande language Dan (Santa) [daf], it is reported that before nasalized vowels, the labial components of both /kp/ and /gb/ “tend to be realized as [m]” (Bearth & Zemp 1967). They give the examples in (15) (the “1” superscripts mark high tone). The nasality of the vowel spreads only to the labial portion, the right side, of KP:

(15) Dan

a.	/gbã^{1}/	[gmã^{1}]	‘leg’
b.	/kpã^{1}/	[kmã^{1}]	‘basement’

Since labiality is often (but not always) associated with rounding, one might predict the possibility of a process rounding a vowel following a KP. If so, this would also occur following a plain labial. I am not aware of any such processes, but in a somewhat related process in some languages, KP is consistently labialized, e.g. Williamson (1965: 19) notes that in the Kolokuma dialect of Ijo, kp and gb are “both produced with rounded lips”.

In summary, we see that labial-velars exhibit a mixture of identities. For some processes, they act as units with no discernable internal phonological structure. But with other phonological processes, they exhibit a sensitivity to the left and right edges of KP, with the left edge acting as velar, and the right edge acting as labial. How can these left- vs. right-sided processes be formalized, with KPs composed of both [dorsal] and [labial] features? The challenge of how to account for this bifurcate nature is the topic of the remainder of this paper.

4 Phonological approaches

How a few major relevant phonological theories have interacted with labial-velars is summarized in this section. As we shall see, while some models explain some phenomena quite well, no theory covers all the phonological patterns of labial-velars that have been presented in the previous two sections.

4.1 SPE

Chomsky & Halle (1968)'s *Sound Pattern of English* (SPE) has largely been superseded, but it did specifically address labial-velars. In this framework, features were unordered and binary. The pertinent question became whether labial-velars "are labials with extreme velarization or velars with extreme rounding" (Chomsky & Halle 1968: 311). Anderson (1976: 21) expands on this concept, noting that the two articulations have opposite values of the [anterior] feature, which is impossible for a single segment. Consequently, labial-velars were required to have either one place or the other as primary, and the other as secondary. Even with phonetically identical exponents, it was a language-specific matter which place was primary.

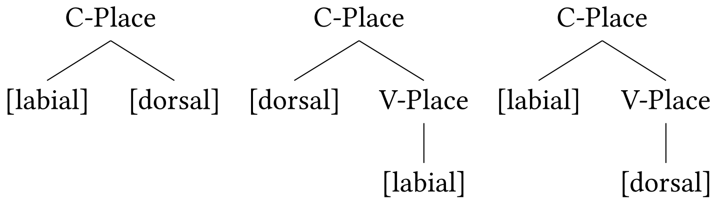
The partial nasal place assimilation as ŋKP discussed in §2.1 was the evidence that led Chomsky & Halle (1968) and Anderson (1976), though not as strongly in Anderson (1981), to propose velar as the primary place of articulation for KP in some languages. But we have seen that this is a consequence of the left-sided phonology of KP. They do not discuss the existence of [ŋmKP], which, by the same reasoning, should show a labial-velar as having *both* places of articulation as primary. Also, the previously cited case of Gwari in (12), in which a nasal assimilates as velar to the left of KP and labial to the right (*w^{j}édʒíŋgbmà* 'dark'), shows that nasal assimilation cannot be the defining factor in determining primary place.

Besides leaning on nasal place assimilation as evidence, the SPE approach was supported by Anderson (1976) largely on distributional grounds, nicknamed the "filling the gaps" criterion. For example, Limba has /k/ and /gb/, but has no /g/, so /gb/ "fills the gap" as a velar, with secondary labialization. If another language has /k^w/ but no /p/, then /kp/ fills the gap as a labial, with secondary velarization. This criterion thus wholly depended on criteria external to the segment itself, rather than phonetic nor phonological characteristics inherent to the segment. Applying the two criteria for a language also can give opposing results. Efik is a language for which Anderson (1976) posits labial-velars as labial as primary because of distributional patterns, but notes later (Anderson 1981: 499) that the nasal assimilation pattern points to velar as primary.

4.2 Feature Geometry

The standard Feature Geometry model (FG, Clements & Hume 1995) accounts for some labial-velar phonology, but not the left- and right-sided phonology described above. A specific modification to FG developed below would be consistent with these directional patterns, but then becomes problematic for other labial-velar phonology.

In Feature Geometry, the [dorsal] and [labial] features are in separate tiers, and thus are specifically unordered (Clements & Hume 1995: 249, 253), since only features or elements in the same tier are ordered (unlike the elements in syntactic trees). This unordering means that features in separate tiers are simultaneous, and such features overlap phonetically. The configuration in Figure 3a below accounts nicely for the phonological unity of KP. However, because the features are unordered, the partial nasal place assimilation to one feature but not the other is purely arbitrary, and thus the predominance of ŋKP and KPm is not predicted.



(a) [kp] (b) [kp] or [kʷ] (c) [kp] or [pɣ]

Figure 3: Possible labial-velar geometries (partial representation)

Alternative representations are Figure 3b,c and these correspond somewhat conceptually to the SPE model in that either [dorsal] or [labial] is the primary feature. Since the existence of a particular feature does not imply the degree of closure of that feature, Figure 3b,c are ambiguous in the phonetic segment they represent. Cahill (1998) proposed Figure 3c as a universal configuration for labial-velars, with rules of assimilation to V-Place to account for ŋKP, and assimilation to C-Place to account for ŋmKP. This also accounts for the unusual Dagbani pattern in which a labial-velar becomes a labial-coronal before a front vowel (Cahill 2007b):

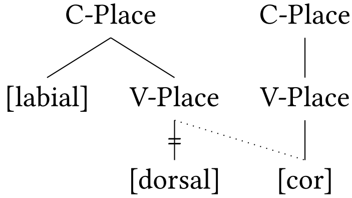


Figure 4: Dagbani assimilation rule: K͡PI →T͡PI

But though there are several phonological processes, such as co-occurrence restrictions and neutralization patterns, that indicate the phonological prominence of [labial] for KP (cf. Cahill 2006), the configuration in Figure 3c does not account for KPm, or the other edge effects in (1–15). Connell (1998-1999) specifically asserts that labial-velars are problematic for Feature Geometry, largely because of the type of asymmetries discussed here.

The central issue of this study is the fact that labial-velars act both as single units and as complex sounds, with significant differences in processes sensitive to their left side and right side. Other classes of segments – contours – have somewhat of the same issue, but we will see that labial-velars have significant differences from these. Contours include prenasalized and postnasalized stops, which contain both [+nasal] and [-nasal] in the same segment, and affricates, which contain both [+continuant] and [-continuant] in the same segment. For affricates, the ordering of the [continuant] features is predictable, with [-continuant] always preceding [+continuant]. Partly for this reason, Lombardi (1990) proposes "that affricates are composed of [-cont] and [+cont] specifications which are unordered at underlying representation and throughout the phonological derivation, although they are ordered phonetically". See similar discussion of this lack of underlying ordering of [±cont] in van de Weijer (1996).

Prenasalised and postnasalized stops are unlike affricates in that their parts are phonologically ordered, shown by the existence of contrast between prenasalized segments with the [+nas][-nas] order and postnasalized segments with a crucial [-nas][+nas] order. See further discussion of these in an aperture model, but with [nasal] as privative in Steriade (1993).

To deal with the directionality issues, van de Weijer (1996) proposes a two-root analysis in the Dependency Phonology framework (as in Figure 5 for clicks, as well as prenasalized stops, postnasalized stops, affricates, and labial-coronals, though without a specific application to labial-velars). For all these, the two root nodes are connected to a single timing position.

The pre-/postnasalized stops and affricates have only partial relevance to labial-velars, since articulations of these do not overlap, as those of labial-velars do. Ulfsbjorninn (2021) has a similar proposal within Element Theory, with ordered root nodes for labial-velars, linked to a single timing position. This differs from Van de Weijer's proposal, which deals with contour segments, not complex segments.

However, the basic idea of a segment that can be represented both as a unit and also with different featural structure on the left and right sides in FG is worth a closer examination, though we will ultimately see it has critical weaknesses. van de Weijer (1996: 65) notes:

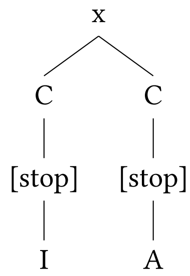


Figure 5: Representation of click reproduced from van de Weijer (1996: 199)

> In Clements & Keyser (1983), a case is made for representing long consonants and vowels with two positions on the timing tier, both connected to the same root node on the melodic tier. The opposite situation, two root nodes connected to a single timing position, is also predicted to be a well-formed phonological representation.

This connection of two featural nodes to a single timing position also has a parallel in tone systems of the world. Yip (1989) solved the problem of contour tones spreading as units by proposing another node in the autosegmental representation. To represent a contour tone, at least in the Asian languages, Yip proposed the configuration in Figure 6.

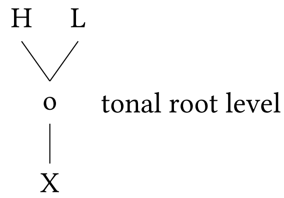
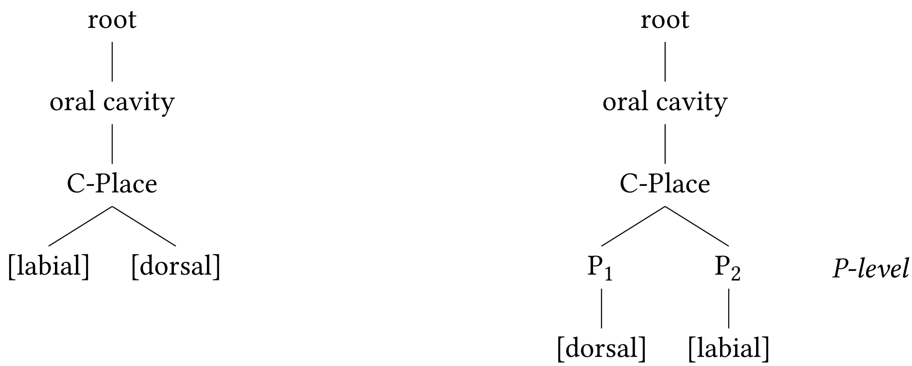


Figure 6: Contour tone representation from Yip (1989)

The rule for spreading a HL contour tone as a contour spreads the "tonal root level" node intermediate between the TBU and the H and L tones, and carries them both along. Could it be possible that the same type of reasoning could be applied to the unitary nature yet differing phonologies of the left and right sides of labial-velars? As Clements & Hume (1995: 259) wrote, "…any feature or feature set that assimilates as a unit must constitute a node on an independent tier of its own".



(a) One C-Place node (b) Two C-Place nodes

Figure 7: One vs. two C-Place nodes for labial-velars

In Figure 7a, the figure represents a somewhat fuller representation of Figure 3a, a common way that KP has been presented in Feature Geometry, with the [labial] and [dorsal] features attached to the same timing unit, overlapping, but unordered. The representation in Figure 7b depicts a new node level, provisionally labeled "P", between the C-Place node and the terminal features. The [dorsal] and [labial] attached to two separate P nodes. The nodes P_1 and P_2 are crucially ordered, with [dorsal] preceding [labial] here.

This ordered configuration of Figure 7b can now account for both the unitary nature of KP and its phonological edge effects. Total nasal assimilation will assimilate the place of a nasal on either side of the KP to the C-place node, yielding ŋmKP or KPŋm. Partial nasal place assimilation on the left will yield the correct ŋKP by associating the place of the nasal to the P_1 node, and partial nasal place assimilation on the right will yield the correct KPm by associating the place of the nasal to the P_2 node.

A significant drawback of the configuration in Figure 7b is that how to interpret this is not obvious, in light of the relative phonetic timing of the [dorsal] and [labial] features, as gestures. In Figure 7a, the features are attached to a single C-Place and this to a single timing unit, implying simultaneous articulations, which largely agrees with the phonetics presented in Figure 1. However, in Figure 7b the P_1 and P_2 nodes are sequential and non-overlapping, just as the H and L tones were sequential in Figure 6. Thus, the configuration in Figure 7b, though consistent with the left-and right-sided phonological patterns of KP discussed here, is not consistent with the articulatory phonetics of KP.

However, while prenasalization displays a relatively sharp boundary between [+nas] and [-nas], the phonological falling tone HL does not consist of a level H that drops instantaneously to a level L. Rather, it moves smoothly from one articulation to the next. So, might the sequential features [dorsal] [labial] be interpreted phonetically as 1) moving from one place to the other, with 2) significant overlap in articulation? These are two separate issues. Both tone and KP shift from one place to the other. But while the [labial] and [velar] places overlap, the H and L tones do not overlap, but have a brief transition that is neither H nor L. The overlap problem remains for KP.

While the issue of phonetic overlap is problematic, the Dagbani process in Figure 4 KP → TP / _front vowels, repeated below as Figure 8 and expressed in terms of the configuration in Figure 7, is actually incompatible with this.

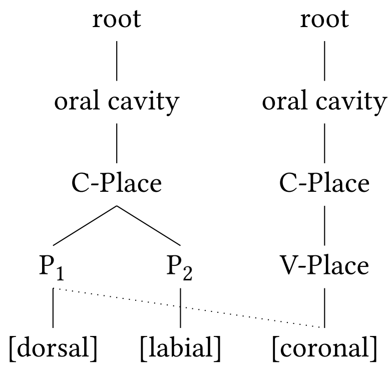


Figure 8: Dagbani assimilation rule: K͡PI →T͡PI (modified)

This is firstly because the [coronal] feature of the vowel displaces and delinks the [dorsal] feature of KP. But the ordering of features in Figure 7b means the KP [dorsal] is not adjacent to the vocalic [coronal]; the [coronal] would have to cross lines to associate to the mother node of [dorsal] which it displaces. Secondly, unlike the well-formed rule in Figure 4, [coronal] above is shared by two unlike nodes, and it is not at all clear how this ill-formedness could be repaired.

At this point, it appears that while different KP phenomena can be captured quite neatly by different versions of FG, no version of FG can be proposed as universal to account for all the phonology of labial-velars.

4.3 Feature Class Theory

Constraints in various instantiations of Optimality Theory can be formulated to describe the phenomena above and other KP phenomena, but would describe surface patterns without providing a principled and non-arbitrary account.

The Feature Class Theory (FCT) variety of Optimality Theory described in (Padgett 1995, 2002) does away with the nodes and organization of FG in favor of direct reference to the features. With respect to labial-velars, Padgett has dealt specifically with both partial and total nasal assimilation on the left side of KP. He accounts for ŋKP as in Figure 9, with the nasal ([+son]) linking directly to the [dorsal] feature rather than a C-Place node.

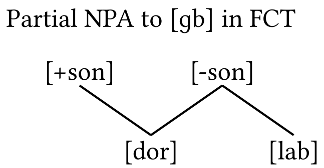


Figure 9: Partial place assimilation, yielding [ŋɡb] Padgett (1995: 153)

However, since the [dor] and [lab] features are unordered, they could just as easily be represented as [lab] [dor]. In that case, the result would yield the undesirable mKP. Also, this approach, exactly like the basic Feature Geometry discussed above, does not and cannot distinguish between this and the mirror image right-sided nasal place assimilation of KPm.

4.4 Articulatory Phonology

Nasal place assimilation and the other directional phenomena cited above may be more amenable to a phonetically-sensitive approach rather than to an abstract phonological one. Articulatory Phonology (AP, Browman & Goldstein 1986, 1989, 1990, 1992) makes reference to primitive units of gestures and their temporal coordination as speech proceeds, as represented in the “gestural score” of Figure 10, with each gesture having both a location and degree of closure.

Such a gestural score makes reference to timing in a more fine-grained degree than to models discussed above. The coordination of gestures is expressed as degree of temporal overlap. The differing nasal assimilation patterns can be represented straightforwardly, as in the scores below, using the “box notation” of Browman & Goldstein (1989, 1990, 1992).

Here, the relevant articulators start with VELUM, with a “wide” articulation indicating it is open, i.e. there is airflow through the nose – the nasal part of the utterance. The T.BODY articulator, as “closed velar”, indicates the tongue dorsum is firmly against the roof of the mouth, and lasts for the entire pronunciation except for a small portion at the end. The timing of these two gestures agrees with Maddieson's electromagnetic articulography graph in Figure 1. The LIPS are closed for the latter part of the pronunciation. Note that when the velum closes, that is when the lips close, thus providing a demarcation between the nasal *ŋ* and the KP: partial nasal place assimilation.

The difference between *ŋK* and *ŋmKP* is simply that the LIPS gesture is extended into the VELUM gesture, as in Figure 11. The difference between Figure 10 and Figure 11 is more gradient than categorical, and thus may exhibit variability due to presently unknown factors. If so, this may help explain why Efik speakers are observed to pronounce both *ŋKP* and *ŋmKP*, as previously noted in §2.1 by Cook (1969) and by Ohala & Ohala (1993).

Similar representations can be generated for *KPm* and *KPŋm*, being basically mirror images of the above.

Interestingly, AP representation may give a clue as to what is problematic about the unattested [mKP]. If [mKP] represents the phonetics, then first a labial nasal is articulated, then the labiality ceases in favor of a velar articulation, but then returns again later in the articulation. It is represented as follows.

In Figure 12, we see that the labial gesture would be interrupted briefly in the articulation which is first [m], then becomes non-labial for the velar part of [KP], then immediately returns to labial for the bulk of [KP]. This rapid on/off/on setting of *bilabial* is a complex gesture and less likely to occur than a simpler one.

Note that if the gap between the two bilabial gestures was erased, producing one bilabial gesture, then we would have [**m**KP], but with the velar gesture K completely hidden.

I will not attempt a gestural score for all of the phenomena in §2 and §3. Some should be straightforward in a gestural account, as with the Nafaanra labial-velar nasal's oral release [ŋm^{b}a] in (13).

However, it is not at all clear from previous AP literature how interaction of the consonant KP and vowels is to be handled. Vocalic epenthesis in the Kɔnni /kɔb-kpɪɪŋ/ ⟶ kɔ̀b-ì-kpí$^{!}$íŋ in (8) seems like it should be amenable to a gestural account, but probably additional machinery would be required within the Browman & Goldstein (1989, 1990, 1992) approach. More challenging yet is the centralization of a high vowel when between a labial and a velar in Ejagham in (14). It is possible that a version of AP could describe it, but it is not obvious how. A more in-depth exploration will have to wait for another occasion.

5 Q-theory

Q-theory, as expounded by Inkelas & Shih (2017) and Shih & Inkelas (2019), offers a quantized extension of Articulatory Phonology, with each segment Q com-

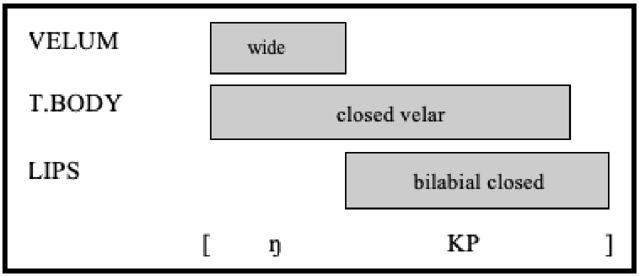


Figure 10: Gestural score for *ŋKP*

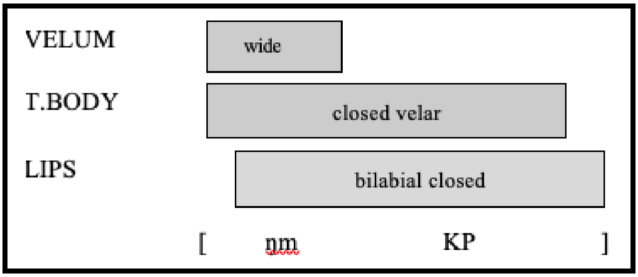


Figure 11: Gestural score for *ŋmKP*

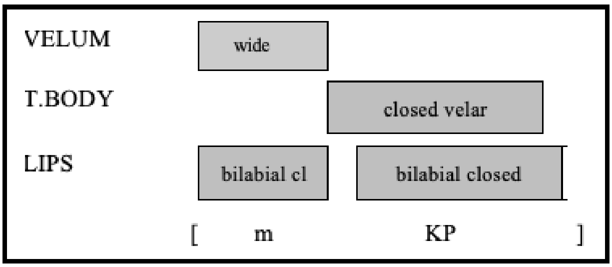


Figure 12: Gestural score for unattested *mKP*

posed of subsegments q_1, q_2, q_3. These correspond to the onset transition, main target, and release of a segment. Crucially for this discussion, each subsegment is *featurally uniform*, with no further internal structure or divisions. This representation has generally been paired with the Agreement by Correspondence framework of Rose & Walker (2004) *inter alia*, but here we focus only on the representational aspects of Q-theory.

It might be thought that q_1 and q_3, being at the edges of a segment, offer a promising approach to the left- and right-sided labial-velar phonology noted in this paper. The left-hand phonology would be a q to q_1 correspondence, and the right-hand phonology would be a q_3 to q correspondence.

However, Inkelas & Shih (2017: 1) specifically note:

> "Contour segments possess *distinct phases sequenced in time*; this crucial sequencing differentiates them from doubly articulated segments, such as labiovelars, in which distinct gestures are (nearly) simultaneous" (my added emphasis).

Q-theory excels at addressing such true contour segments, such as affricates and prenasalized stops, which have clear boundaries between their sub-parts. In Inkelas & Shih (2017), they give cases of the Kiyaka prenasalized unit stop [ŋg] being represented by the q subunits (ŋ g g), and the tone on the Changzhi vowel vowel ə in [təʔ$_{213}$] is represented by the q subunits (ə$_2$ ə$_1$ ə$_3$). Each of these q subunits has features which do not overlap with an adjacent q. Labial-velars differ from these by having a majority of their articulatory target consist of *two* distinct major features overlapping: [labial] and [dorsal]. This would be represented in Q-theory by KP (k kp p), with the subsegment q_2 being the two-unit "kp". This two-unit overlap is not allowed in Q-theory, though it was in Articulatory Phonology.

Thus the problem for Q-theory applying here is not at the edges, but in the putative central q_2 subsegment of a labial-velar. This reinforces the notion that labial-velars cannot be treated as contour segments, but that their nature as *complex* segments requires a different approach.

6 Conclusions and further research

The examples of left-sided and right-sided phonology across languages are not numerous, but do illustrate a clear pattern. Differential nasal assimilation is the most often reported phenomenon, possibly because it is the most easily observable one. Phenomena such as the Kɔnni and Ejagham vowel patterns require detailed investigation, which is not available for many of the languages listed in the Appendices. But the cross-linguistic pattern is that labial-velars do reveal phonological processes sensitive to a velar configuration on the left, and a labial one on the right, but never the reverse.

At this point, we see that no current phonological model is able to capture the totality of labial-velar phonology. Not all models have even attempted to include labial-velars, and those which have done, have generally only referred to the bare existence of KP, not to the phonological patterns noted in this and other works. Labial-velars are complex segments, neither simple nor contours, and details of their phonology have been largely unexplored. It remains to be seen if, in fact, it is possible to incorporate the totality of the phonetic and phonological facts of labial-velars into a single model.

Acknowledgements

I am grateful for researchers who responded to my queries and provided data beyond what they had published (Steven Bird, Ginger Boyd, Phil Davison, Bonnie Henson, Stuart Showalter, and John Watters), for input from the audience at ACAL 53, and especially the editors of this volume for their suggestions and pushing some of my generalities into specifics.

Appendix A Assimilation as [ŋKP]

	Language [ISO]	Sample	Gloss	Reference
1.	Adioukrou [adj]	tóŋkpó	'daba'	Kaul (2006)
2.	Aizi, Tiagbamrin [ahi]	atɪŋgbra	'bouteille'	Herault (1971)
3.	Anufo (Chakosi) [cko]	ŋgbɛ̃	'empty'	Stanford & Stanford (1970)
4.	Birifor [biv]	kpaŋkpan	'upper arm'	Kuch (1993)
5.	Bongo [bot]	ᵑgbáyá	'corn'	Kilpatrick (1985)
6.	Chumburung [ncu]	ŋ̀kpìnɔ̀	'chests'	Price (1975)
7.	Dagaari [dga]	gbáŋgbáŋ	'noon'	Kennedy (1966)
8.	Dɛg [mzw]	dàŋgbàlá	'walking stick'	Crouch & Herbert (2003)
9.	Gã [gaa]	taaŋkpee	'sisal'	Ryder (1987)
10.	Gangam [gng]	ūsɛ̀ŋ̀gbɛ́ń	'dog'	Reimer (2022)
11.	Gonja [gjn]	gbìŋgbìŋ	'big'	Painter (1970)
12.	Gwari [gbr]	tʃiŋkpè	'stool'	Rosendall (1992)
13.	Gbaya-Mbodomo [gmm]	líŋkpòŋ	'vine for swinging'	Boyd (1997)
14.	Konkomba [xon]	ŋ̄gbéèm	'full'	Steele & Weed (1966)
15.	Kɔnni [kma]	tìŋgbáŋ	'floor'	Cahill (2007a)
16.	Kusaal [kus]	nɪŋgbɔŋ	'skin'	Spratt & Spratt (1968)
17.	Mbembe, Cross River [mfn]	kpenaŋkpen	'every, each'	Barnwell (1969)
18.	Mono [mnh]	kéŋgbā	'alone'	Olson (2005)
19.	Ncam (Bassar)[bud]	ŋ́-gbàn̄	'skin'	Cox (1998)
20.	Vagla [vag]	tʃaŋkpalŋa	'antelope'	Crouch & Smiles (1966)

Appendix B /ŋKP/ as independent phoneme

	Language [ISO]	Reference
1.	Ambele [ael]	Nganganu Kenfac (2001)
2.	Avokaya [avu]	Callinan (1981)
3.	Bagiro (Furu) [fuu]	Boyeldieu (2006)
4.	Baka [bkc]	Léonard (2009)
5.	Balanta-Ganja (Fjaa, Fca) [bit]	N'Diaye-Corréard (1970)
6.	Bali [bcp]	Grégoire (2003)
7.	Banda, Mid-Southern (Yakpa) [bjo]	Cloarec-Heiss (1978)
8.	Banda, South Central (Ngbugu) [lnl]	Cloarec-Heiss (1978)
9.	Banda, West Central [bbp]	Cloarec-Heiss (1978)
10.	Banda-Bambari (Linda) [liy]	Cloarec-Heiss (1978)
11.	Banda-Yangere [yaj]	Moñino (1988)
12.	Bangando [bgf]	Baron (1995)
13.	Bangba [bbe]	Boone (1995)
14.	Bekwel (Bekwil) [bkw]	Phillips (2009)
15.	Birri [bvq]	Santandrea (1966)
16.	Bofi [bff]	Moñino (1995)
17.	Bulu [bum]	Yanes & Moise (1987)
18.	Digo (Chidigo) [dig]	Nicolle (2013)
19.	Ding [diz]	Muluwa & Bostoen (2015)
20.	Dongo ('Dongo-ko) [doo]	Moñino (1988)
21.	Esimbi [ags]	Stallcup (1980)
22.	Fang [fan]	Medjo Mvé (1997)
23.	Gbanu [gbv]	Moñino (1995)
24.	Gbanziri (Gbanzili) [gbg]	Bostoen & Donzo (2013)
25.	Gbaya (Kresh, Kreish) [krs]	Boyeldieu (2006)
26.	Gbaya Southwest [gso]	Moñino (1995)
27.	Gbaya-Mbodomo [gmm]	Boyd (1997)
28.	Gobu (Gubu, Gabu) [gox]	Cloarec-Heiss (1978)
29.	Gola [gol]	Koroma (1994)
30.	Indri [idr]	Santandrea (1969)
31.	Jula, Odienne (Wojenaka) [jod]	Derive (1983)
32.	Kako [kkj]	Ernst (1996)
33.	Kare (Kali) [kbn]	Elders (2006)
34.	Kol (Bikele) [biw]	Henson (2007)

	Language [ISO]	Reference
35.	Kpagua [kuw]	Cloarec-Heiss (1978)
36.	Kpatiri (Kpatili, Gbayi) [kym]	Boyd (1988)
37.	Kuo [xuo]	Elders (2006)
38.	Kyoli (Chori, Cori) [cry]	Dihoff (1976)
39.	Lele [lln]	Frajzyngier (2001)
40.	Lendu [led]	Boyeldieu (2006)
41.	Logo [log]	Goyvaerts (1983)
42.	Lutos [ndy]	Olson (2013)
43.	Mangbetu [mdj]	Larochette (1958)
44.	Mayogo [mdm]	McCord (1989)
45.	Mbandja (Mbanza) [zmz]	Cloarec-Heiss (1978)
46.	Mbum [mdd]	Elders (2006)
47.	Mono [mnh]	Olson (2005)
48.	Mono [mru]	Elders (2006)
49.	Mündü [muh]	Jeffrey & Polley (1981)
50.	Ndai (Galke, Pormi) [gke]	Elders (2006)
51.	Ngbaka Ma’bo [nbm]	Thomas (1963)
52.	Ngbaka Manza [ngg]	Selezilo (2006)
53.	Ngbandi, Northern [ngb]	Bostoen & Donzo (2013)
54.	Ngbandi, Southern [nbw]	Bostoen & Donzo (2013)
55.	Ngombe [ngc]	Grégoire (2003)
56.	Ngundu [nue]	Cloarec-Heiss (1978)
57.	Nzakara [nzk]	Santandrea (1965)
58.	Pagibete [pae]	Reeder (1998)
59.	Pande [bkj]	Murrell (2022)
60.	Sango [sag]	Samarin (1967)
61.	Sere [swf]	Moñino (1988)
62.	Togoyo [tgy]	Santandrea (1969)
63.	Wumboko (Mboko) [bqm]	Mutaka & Ebobissé (1996/7)
64.	Yakoma [yky]	Moñino (1988)
65.	Yango [yng]	Bostoen & Donzo (2013)
66.	Zande [zne]	Bostoen & Donzo (2013)

Appendix C Assimilation as [ŋ͡mKP]

	Language [ISO]	Sample	Gloss	Reference
1.	Agni [any]	ŋ̀mgbàfwɛ̰̂	‘jeune homme’	Ouattara (2006)
2.	Dan [daf]	ŋm gbe	‘my arm’	Bearth & Zemp (1967)
3.	Efutop [ofu]	ŋm̀-kpìb	‘ant, tailor’	Crabb (1965)
4.	Ejagham [etu]	ŋ̀m-gbɛ̀	‘leopard’	Watters (1981)
5.	Eton [eto]	ŋ́mkpôŋ	‘pumpkin leaves’	Van de Velde (2008)
6.	Gɪdɪrɛ (Adele) [ade]	ŋm̀-kpá	‘life’	Kleiner (1989)
7.	Kpelle [xpe]	ŋm-gbiŋ	‘myself’	Welmers (1962)
8.	Nkonya [nko]	ŋ̀m-kpàà	‘paths’	Peacock (2011)
9.	Samue [wbf]	kpɛŋmgba	‘gall bladder’	Ouattara (2015)
10.	Yoruba [yor]	o ŋm gbo	‘he is hearing’	Bamgbose (1969)

Appendix D /ŋ͡mɡ͡b/ as independent phoneme

(Bangolan alone also has /ŋ͡mk͡p/)

	Language [ISO]	Reference
1.	Baka [bdh]	Persson (2004)
2.	Banda-Ndele (Banda-Tangbago) [bfl]	Moñino (1988)
3.	Bangolan [bgj]	Mbah (2003)
4.	Belanda Bor [bxb]	Gilley (2004)
5.	Belanda Viri (Viri) [bvi]	Bilal (2004)
6.	Beli (Jur Beli) [blm]	Stirtz (2014)
7.	Bhogoto [bdt]	Boyd (2015)
8.	Bila [bip]	Kutsch Lojenga (2003)
9.	Bongo [bot]	Persson (2004)
10.	Buwal [bhs]	Viljoen (2009)
11.	Bwa (Benge, Bua-Yewu) [bww]	De Wit (2020)
12.	Cuvok [cuv]	Dadak (2021)
13.	Daba [dbq]	Lienhard & Giger (2009)
14.	Eloyi [afo]	Armstrong (1969)
15.	Etulo [utr]	Armstrong (1969)
16.	Gavar [gou]	Viljoen (2009)

	Language [ISO]	Reference
17.	Gbaya-Bossangoa (Gbeya) [gbp]	Samarin (1966)
18.	Iceve-Maci (Icheve) [bec]	Cox (2013)
18.	Ipulo [ass]	Tuinstra (2015)
20.	Jur Modo (Mödö) [bex]	Persson (2004)
21.	Kakwa [keo]	Onziga & Gilley (2012)
22.	Keliko [kbo]	Kilpatrick (2004)
23.	Kisi, Southern [kss]	Childs (1992)
24.	Komo [kmw]	Thomas (1982)
25.	Kuwaa [blh]	Marchese (1984)
26.	Kwakum (Bakoum) [kwu]	Hare (2018)
27.	Langbashe (Langbasi) [lna]	Cloarec-Heiss (1978)
28.	Lika (Liko) [lik]	De Wit (2008)
29.	Lulubo (Olu'bo) [lul]	Kilpatrick (2004)
30.	Ma'di [mhi]	Kilpatrick (2004)
31.	Mambila [mcu]	Connell (1998-1999)
32.	Mbo [zmw]	Rasmussen (2015)
33.	Mbudum [xmd]	Dadak (2014)
34.	Morokodo [mgc]	Persson (2004)
35.	Moru [mgd]	Kilpatrick (2004)
36.	Ndogo [ndz]	Bilal (2004)
37.	Ngbaka [nga]	Maes (1959)
38.	Ngiti [niy]	Boyeldieu (2006)
39.	Nzakambay (Touboro) [nzy]	Mbanji (1996)
40.	Omi (Kaliko-Omi, Omiti) [omi]	Bradley (2004)
41.	Suga (Nizaa) [sgi]	Kjelsvik (2002)
42.	Suma [sqm]	Bradshaw (1995)
43.	Tiv [tiv]	Kropp Dakubu (1980)
44.	Tuki [bag]	Clements & Rialland (2008)
45.	Twendi (Cambap) [twn]	Connell (2002)
46.	Yaka (Aka) [axk]	Duke (2001)

Appendix E [KPm]

	Language [ISO]	Sample	Gloss	Reference
1.	Gwari [gbr]	kpmàmí	‘okra’	Rosendall (1992)
2.	Tyebaara Senufo [sef]	kpmɔ̃́:	‘to beat’	Mills (1984)

Appendix F [KPŋ͡m]

	Language [ISO]	Sample	Gloss	Reference
1.	Konabere [bbo]	g͡bŋ͡m	‘black’	P. Davison (pc)
2.	Mada [mda]	kpŋm̀	‘kapok tree’	Price (1989)
3.	Kuta Gwari [gbr]	kpᵑᵐ	no specific words given	Hyman & Magaji (1970)

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