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ON THE DYNAMICS OF VELARIZATION AND LABIALIZATION: SOME BANTU EVIDENCE[1]

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1. Introduction

In the literature the term 'secondary articulation' is used in two senses:

(i) It frequently serves as a descriptive, classificatory tag, denoting the structure of segments such as k^w and p^y ; cf. Abercrombie [1967:61]: "...there are occasions when it is necessary to draw attention to aspects of the vocal tract other than place and manner of the stricture, and when this is so, we do it in terms of secondary articulations...We have here...another dimension of classification for segments...." Compare also Ladefoged [1971:59]: "Sounds can also be modified by secondary articulations which occur at the same time as the primary articulations."

(ii) Chomsky and Halle [1968:307 ff.] account for sense (i) but point out that (i) is the result of a PROCESS, viz. regressive assimilation (cf. for instance [1968:308]). We shall be attending primarily to sense (ii) in respect to labialization and velarization.

The strict sense of velarization (labialization) is: regressive assimilation of a consonant to the velarity (labiality) of the following sonorant. The regressive assimilation triggers a whole train of processes, and velarization (labialization) will frequently be used in this sense: a whole set of processes resulting from velarization proper (labialization proper). The main factors of velarization and

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labialization viewed as functionally unified sets of different processes are regressive assimilation (velarization and labialization proper) and narrowing (also called hardening):

(1) Velarization

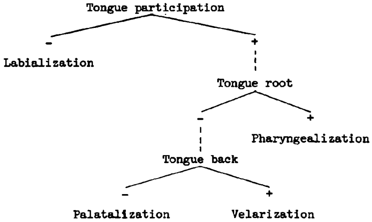
p	
$p^{ɯ}$	Velarization proper
pf	Narrowing (Fricativization)

Labialization

k	
k^{w}	Labialization proper
kp	Narrowing (Closure)

In terms of tongue body participation the secondary articulations may be classified as follows:

(2)



This classification is formally reflected as follows [Chomsky and Halle 1968:306, 310]:

(3)

Labialization:	[+ round]	i.e. [k^{w}]
Pharyngealization:	[+ low, + back]	i.e. [$p^{ɒ}$]
Velarization:	[+ high, + back]	i.e. [$p^{ɯ}$]
Palatalization:	[+ high, − back]	i.e. [p^{y}]

Such a classification is not an adequate reflexion of the similarity and complementarity of labialization and velarization:

(4) (i) Both are [+ grave] superimpositions.
(ii) Labialization is initiated with velars and velarization with labials.
(iii) Labialization may result in velar segments and velarization in labials.

The ambivalence of [+ round] seems to be part of the problem. This feature is characteristic of vowels and is related to [+ anterior, - coronal], i.e. [+ labial] in consonants. The problem is explored in Vennemann and Ladefoged [1972] and in Reighard [1972].

A secondary articulation is a type of regressive assimilation. This has been substantiated for labialization, velarization and palatalization, but not, as far as I know, for pharyngealization. Palatalization and pharyngealization are excluded from further consideration.

I shall try to account for the following main features of labialization and velarization:

(5) Labialization: gwa > gba > ɓa (gʘa)
Velarization: bwa > bga > ga

Labialization is initiated with velars and velarization with labials. In both processes the secondary articulation is hardened, i.e. develops (maximally) into a closure. Finally, the processes may result in single segments, velars in the case of velarization and labials (implosives and, rather peripherally, clicks) under labialization.

2. Shona Velarization

2.1. Velarization as regressive assimilation. Velarization is a process of regressive assimilation under which a consonant takes on the velarity of a following [+ grave] sonorant. The process progresses dimensionally along the axes of place and manner of articulation: (i) labials are affected before linguals, (ii) glides are converted to obstruent glides, then to fricatives and finally to stops.

My data are drawn almost exclusively from Doke [1931], the extensive pioneering study of the process. In Bantu velarization manifests itself most clearly in Shona, especially the Zezuru dialect of Central Shona, but is attested also in Venda, Rundi, Nyiha, Tumbuka and Mang'anja. Its occurrence in Sotho and Nguni is subject to debate, but cf. Ponelis [1973].

The fact that velarization is phonologically a process of regressive assimilation is obscured in much of the literature, since on the one hand the w causing velarization is considered extraneous and on the other hand Doke's statement of the process seems to be at variance with its regressive assimilatory nature.

2.1.1. <u>The status of w</u>. Chomsky and Halle [1968:310] state that "Labialization combines quite commonly with velarization...." Trubetzkoy [1969:137-8] distinguishes between the correlation of full gutturalization (i.e. extreme velarization) and the correlation of labiovelarization. Trubetzkoy and Chomsky and Halle obviously follow Doke [1931:109 ff.], who distinguished between 'plain velarization', and 'velarization with semi-vowel', as in (6) below. The latter process is viewed by Trubetzkoy and Chomsky and Halle to be a product of velarization combined with labialization.

(6) a. <u>Plain</u>[2]

pkere	'child'	rambɏe	'buffalo'
pkisa	'absorb'	semŋa	'be hated'
kupkera	'to suckle'	mŋene	'owner'
bɏaɲa	'crush'	mŋara	'flint'
rušambga	'accident'		

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[2] These are all Zezuru forms. ɏ is a voiced palatal fricative. Other graphs used elsewhere in the text are φ , a voiceless palatal fricative (the congener of ɏ); ŵ , ŷ and w̃ are used to indicate extremely narrow glides, respectively voiced, voiceless and nasalized. The term 'obstruent glide' will be used to characterize this set of segments collectively.

(6) b. With semi-vowel

tkwana	'little children'	taŋwa	'be picked'
utkwu	'these'	rɣwa	'fight'
tkwaenda	'they travelled'	rɣwadza	'pain'
dɣwe	'drip, of rain'	biskwa	'be removed'
tandɣwa	'be driven away'	skwera	'spend the time'
kuŋwa	'to drink'	izɣwi	'word'
muŋwe	'finger'		

Clearly pk and tkw do not illustrate two distinct processes, viz. velarization as opposed to 'labiovelarization' but merely belong to different steps in the same velarization processes. Velarization affects labials first, hence they would be first to undergo a subsequent step, i.e. dropping of w . Doke gives very few examples[3] of velarized labials in combination with w , whereas all his examples of 'velarization with semi-vowel' contain dental and alveolar segments.

2.1.2. Doke's statement of the process. "Velarization is brought about by an abnormal raising of the back of the tongue towards the soft palate ..., instead of the usual slight raising effected in pronouncing the velar semi-vowel w "[Doke 1931:109]. A phonological explanation of this abnormal raising of the back of the tongue would necessarily entail assimilation to the preceding obstruent or nasal. This seems to be extremely plausible but conflicts with the conception of velarization as a regressive assimilatory process. The matter may be cleared up if Doke's definition is taken to apply to a later step in the process. First a consonant takes on the velarity of a following sonorant: $C \rightarrow C^{ɯ}$; then $C^{ɯ} \rightarrow Cw$ by other rules and $Cw \rightarrow C\c{ɸ}$ by Glide Narrowing.

On the surface Doke's Narrowing (= abnormal raising) analysis seems to handle the facts quite elegantly. This would derive the Tavara form -pɕa 'dry up' in the following way: -pwa 'dry up' → -pɕa (by Narrowing). The glide /w/ is narrowed ultimately to a voiceless palatal fricative ɕ .

[3]These examples involve nasals. Their significance is discussed below.

This analysis, however, does not predict the Korekore form -ɸwa , where the glide is retained ; hence ɸ requires a different explanation. The derivation of this particular form is given at the end of the section on velarization (sec. 4). It briefly amounts to the following: -pwa 'dry up' → -pɸwa (by Velarization, etc.) → -ɸwa (Cluster Initial Deletion).

The velarization analysis proposed in this paper also accounts for forms such as the following (where nonlabial segments precede the glide) -batwa 'hold' → -batɸwa , twana 'little children' → tkwana (cf. (6) for more examples). The Narrowing analysis cannot explain the 'extraneous' ɸ and k .

2.2. Initial domain and spread of velarization. Velarization in Shona is induced by w , arising from Proto Bantu *uV becoming wV : *bua > bwa .[4]

(7)	-pú-	'dry up'[5]	>	-pɸa , -pka
	-búa-	'dog'	>	-bwa , -bɣa , -bga
	-dúád-	'become ill'	>	-rwara , -rɣwara

2.2.1. The affected segments. The data allow only a few suggestions.

(8) a. $\begin{bmatrix}+\text{ ant}\\-\text{ cor}\end{bmatrix}$ precedes $\begin{bmatrix}+\text{ ant}\\+\text{ cor}\end{bmatrix}$

Labials precede alveolars.

b. [- son] precedes [+ son]

[p , b] precede [m].

[t , s , r , z] precede [n].

c. [- voice] precedes [+ voice]

[p] precedes [b].

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[4]Proto Bantu *ų induces labialization, a rule that precedes velarization in time.

[5]The Bantu proto citations are taken from Guthrie [1967, 1970, 1971]. Guthrie lists his starred forms by a C.S. (= Comparative Series) number; these are not indicated here since the items are arranged alphabetically and can be easily located.

That labials precede alveolars has already been pointed out in sec. 2.2. above. It follows from an inventory such as Stevick's [1964:59] for Manyika:

(9)	bɣ	dw	gw
	px	tw	kw
	mŋ	nw	

The labial series has already reached an advanced stage of velarization, fricativization and closure, whereas the other series still have w .

The evidence for the primacy of obstruents (8b) is rather scant and consists of two sets of free variants which have not undergone w - Absorption: Korekore: -yamwa ~ -yamŋwa 'suck'; ŋwana ~ mŋwana 'child'. Doke notes furthermore that -yamŋwa is "unique in its occurrence" [Doke 1931:113].

Closure (8c) seems to be lagging with the voiced labial b so that there are more fricativized forms than with p [Doke 1931:110-11]. Thi might indicate that velarization is initiated later in voiced segments.

2.2.2. The following vowel. Lanham [1955:46] points out that velarization (in Tonga) is favored before a , fluctuating before e and nonexistent before i . Hence there is a clear preference for the lower vowel. Doke's data confirm this: the vast majority of velarized clusters occur before a . This state of affairs might be ascribed to the process of gliding preceding velarization: vowels become glides first before low vowels.

2.3. The processes of velarization. The following rules are hypothesized: Velarization, Segmentation, Glide Narrowing, Fricativization, Backing, and Closure. Rules such as w -Absorption and Cluster Initial Deletion interact with those in the Velarization block but do not form part of it.

Doke [1931:110] gives the following steps, which are correct, minor details aside:

(10)	pwa	bwa	mwa
	pŵ̥a	bŵa	mw̃a
	pɸa	bɣa	
	pka	bga	mŋa

2.3.1. <u>Velarization</u>. Underlying the account in 2.2. is the concept of precedence central to implicational spread. The velarization rule below (cf. 11) reflects the spirit of Chomsky and Halle [1968]: it is static and discrete. The rule is static in the sense of merely giving a picture of the outcome instead of the dynamics of the process (i.e. where it starts and in which direction it is heading). The discreteness of the formalized rule is above all a function of the way place of articulation is handled within the system of Chomsky and Halle. This might be remedied by the introduction of scalar features [Vennemann 1972] and a return to the traditional place of articulation continuum [Chen 1971:30-1].

Be that as it may the theory should allow for a precedence statement such as: Under velarization an obstruent with maximum (= maximally available) frontness takes on the color of the maximally back and high vowel following. Other precedence relations in this process include [- voice] >> [+ voice], [- son] >> [+ son];

(11) Velarization

$$[+\text{ant}] \rightarrow \begin{bmatrix} +\text{high} \\ +\text{back} \end{bmatrix} / \_\_ \begin{bmatrix} +\text{son} \\ +\text{high} \\ +\text{back} \end{bmatrix}$$

$$\begin{matrix} \text{p} & & \text{p}^{\text{ɯ}} & & \\ \text{b} & & \text{b}^{\text{ɯ}} & & \\ \text{m} & \rightarrow & \text{m}^{\text{ɯ}} & / \_\_ & \text{w} \\ \text{r} & & \text{r}^{\text{ɯ}} & & \\ \text{t} & & \text{t}^{\text{ɯ}} & & \end{matrix}$$

The vagaries of the velarization inducing glide w will be left aside. The justification for its occurrence has been given in sec. 2.1. above. Compare 2.3.4. below for some remarks on w -Absorption.

2.3.2. Segmentation. The non-simultaneity of [+ high, + back], i.e. the velarization, is abundantly clear from more advanced stages, where the velarization is manifested as a segment following the velarized segment, cf. forms such as tkwana , utkwu , etc. in (6) above, where k is the reflex of earlier velarization. Doke [1931:111, fn. 13] remarks that bg may even be realized as [bᵊg]. Evidently a rule such as (12) is necessary:

$$(12)\quad \begin{bmatrix} + \text{ant} \\ + \text{high} \\ + \text{back} \end{bmatrix} \rightarrow [+ \text{ant}] \begin{bmatrix} + \text{high} \\ + \text{back} \end{bmatrix}$$

The forms Nambzya pɰ̥a 'dry up', Unyama mbŵa 'dog', Zezuru mw̃ana 'child', and Njanja nw̃a 'drink', contain obstruent glides which are rounded. The change in rounding, i.e. ɯ becoming w , is probably attributable to the same universal marking convention concerning Round in vowels that are [+ high, + back]. In sum, then, $C^{ɯ}$ becomes Cw by Segmentation and Rounding Adjustment.

2.3.3. Hardening. Glide Narrowing, Fricativization, Backing and Closure are all aspects of Hardening.[6] These rules are obviously well spaced in time, hence it is tempting to assume an 'inner teleology' or global process within the development. Assimilation alone does not explain it all, since w becomes k even after s . Greenberg [1971:344] has noted that Saussure cannot account for the linguistic counterpart of the Sicilian Defense in chess. This may be interpreted as an implicit plea for the introduction of teleological considerations. The elements of the Sicilian Defense metaphor are to me the following: (a) It is not only states, but also processes that matter. (b) The Gestalt of a given process is not revealed in a specific state or even succession of states. A process is a dynamic entity. (c) Processes are not blind (like Neogrammarian sound laws) but operate in a specific way and in a specific direction (asymmetrically, cf. Chen [1971]).

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[6] It is not at all unreasonable to assume that the problems concerning the functional unity of Hardening might be solved by a dimensional (and nondiscrete) interpretation of phonological categories. The matter will not be pursued any further here.

Chomsky and Halle [1968:308] state that "...the degree of narrowing is determinable from other features of a particular sound." This is correct, with the exception of the obstruent glides; cf. sec. 2.3.3.1. below. However, this statement may also be taken to mean that the degree of narrowing is a high order feature determining the sound type. The fact that there is a change in sound class, then, follows from a change in stricture. There is no way to reflect this directly in the current formalism. Progression within a dimension (stricture/manner of articulation) rather than discrete change of category seems to be involved (cf. also sec. 2.3.3.1. below).

Another question is whether the degree of narrowing is predictable from the preceding segment (which induces the narrowing). There is no such regularity in the Shona data--suggesting that narrowing progresses on its own along the stricture dimension--but Chomsky and Halle [1968: 310-11] discuss a few cases where narrowing is indeed predictable in this way.

2.3.3.1. <u>Glide Narrowing</u>. This is ostensibly a rule assimilating voicing and nasality:

(13) Glide Assimilation

$$[+\text{ son}] \rightarrow \begin{bmatrix}\alpha\text{ voice}\\ \beta\text{ nasal}\end{bmatrix} \;/\; \begin{bmatrix}\alpha\text{ voice}\\ \beta\text{ nasal}\end{bmatrix} \;\_\_$$

However, the actual result is an extremely narrow obstruent glide w̑ or w̥̑ . Within the current formalism the glides in question may be represented as follows:

(14)

	w	w̑	w̥̑	w̃	x	ç
high	+	+	+	+	+	+
back	+	+	+	+	+	-
son	+	+	+	+	-	-
nasal	-	-	-	+	-	-
voice	+	+	-	+	-	-

This is unsatisfactory on the following counts: (i) w and w̑ are not distinguished. (ii) It fails to bring out the relatedness of w̑ , w̥̑ , w̃ as opposed to w .

Doke [1931:109] notes the narrowness of these segments on account of "an abnormal raising of the back of the tongue". It is not possible to express this in a rule such as the following:

(15) Glide Narrowing

$$\begin{bmatrix} + \text{son} \\ + \text{round} \end{bmatrix} \rightarrow [-\ \text{son}]$$

This has the effect of changing w to x^w or γ^w instead of yielding the required outputs ŵ , ŵ̥ and w̃ . It is not at all clear to me how the formalism could be modified to accommodate obstruent glides and capture the correct generalization.

2.3.3.2. <u>Fricativization</u>. This rule turns the voiceless and voiced obstruent glides ŵ̥ and ŵ into fricatives, i.e. ç and ɣ̶ :

(16) Fricativization

[ŵ̥] → [ç]

[ŵ] → [ɣ̶]

Notice that the resulting fricative is a palatal and not a velar.[7] A possible explanation is fronting of w under Narrowing.

2.3.3.3. <u>Backing and Closure</u>. These are necessary to account for k , g h , ɦ < ç , ɣ̶ ; cf. Karanga pça : Zezuru ipka 'sweet reed'; Zezuru imbɣ̶a : Hera imbga 'dog'; Korekore içwa ~ ihwa 'sweet reed'; Korekore -ɦwa 'fight' < -rɣ̶wa . [h , ɦ] arise from the weakening of [x , ɣ]. The rules for these processes are stated as (17) and (18) respectively:

(17) Backing

$$[-\ \text{back}] \rightarrow [+\ \text{back}]\ /\ \begin{bmatrix} \overline{+ \text{cont}} \\ + \text{high} \end{bmatrix}$$

i.e. ç → x , ɣ̶ → ɣ

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[7] In Ladefoged [1968:32] a palatal fricative is attested under labialization.

(18) Closure

$$[+\text{ cont}] \rightarrow \begin{bmatrix} -\text{ cont} \\ -\text{ round} \end{bmatrix}$$

i.e. x → k , ɣ → g , w̃ → ŋ

2.3.4. Other rules. There are a number of rules interacting with the velarization process, including w -Absorption, Stop Assimilation, Cluster Initial Deletion, Palatalization, and Weakening. These fall beyond our scope. w -Absorption has been mentioned in sec. 2.1. It depends on a number of factors, including the following:

(i) The nature of the cluster initial segment: w drops more readily (sooner) when this is a labial: Manyika pɸwiza > pɕiza 'giraffe'; Zezuru mŋwara > mŋara 'flint'. In this, the initial form of w -Absorption, the labial glide is absorbed into the labiality of the cluster initial, hence the name of the rule.

(ii) The operation of Cluster Initial Deletion hinders w -Absorption: Korekore iɸwa < ipwa 'sweet reed', cf. Zezuru ipka ; Korekore [-ɦwara] < -rwara 'be ill', cf. Budya -rwara . In these cases p and r respectively have been deleted and the glide has been retained.

However, the following Chopi and Venda forms have undergone both w -Absorption and Cluster Initial Deletion: Chopi: -gela < *-bʊ́éd- 'tell'; Venda: ɦalwa < bwalwa 'beer', ɦatsi < bwatsi 'grass', ɦana < bwana 'childhood'.

Further examples and derivations illustrating these processes are given in Appendix I.

3. Labialization

3.1. Introduction. Under velarization labial obstruents may become doubly articulated labiovelars and ultimately simple velars. It is hypothesized that labiovelar (and labial) obstruents in a variety of languages may be explained by the complementary processes of labialization, cf. *kua , *gua > k͡pa , g͡ba in a number of nonBantu Niger-Congo languages; *kʷa , *gʷa > pa , ba in some Indo-European languages; and *kua , *gua etc. fa , va over an extensive part of the Bantu field.

3.2. The steps in labialization. The various steps in labialization are not instantiated as profusely as those in velarization. Analogous to velarization the following intermediate stages are assumed.

(19)

A	B[8]		
gwa	gwa		
$g^{w}wa$	$g^{w}wa$	1.	Labialization
$g^{w}a$	$g^{w}a$	2.	Glide Absorption
gwa	gwa	3.	Segmentation
gŵa	gŵa	4.	Glide Narrowing
gβa	gβa	5.	Fricativization
-	gva	5a.	Fricative Adjustment
gba	-	6.	Closure
^{g}ba	^{g}va , ^{b}va	7.	Subordination of inner closure
ba	va	8.	Elimination of inner closure

3.2.1. Step 1: Labialization proper. The skeletal formalization of this process is:

(20) $C \rightarrow [+\text{ round}] \; / \; \_\_ \begin{bmatrix} +\text{ son} \\ +\text{ round} \end{bmatrix}$

(a) The conditioning environment. Proto Niger-Congo items with the canonical form *Cua are reflected as labiovelar stops in a number of daughter languages, whereas *Cu never is (cf. Westermann [1927:197 ff.] and sec. 3.2.6. below). Hence I take it that gliding converts *Cua to *Cwa before labialization sets in and that glides precede vowels in the hierarchy of this rule. In Bantu (cf. sec. 4. below) labialization operates before glides as well as vowels but the reflexes give no indication of the early precedence relations.

(b) The domain affected. The prime focus of labialization is on velars. Ladefoged [1968:5-13] almost exclusively cites labiovelars such as kp and gb . Westermann's reconstructions [1927] indicate that only

[8] Column B represents the typical development in Bantu, cf. sec. 4. below.

*k and *g are affected. The incipient labialization documented in Doke [1931:124] is confined to the velar segment h (cf. Korekore hwunl < hunl 'firewood' and sec. 3.2.3. below). The development of the Proto Indo-European labiovelars in languages such as Greek, Old Irish and Old Cymric is so typical of the full labialization process that an early PRIE labialization rule can be hypothesized without too much wishful thinking, cf. *k^wok^w- 'bake' > Proto Old Cymric *popl , and *g^wen- 'wife' > Old Irish ben . The point is now that the PRIE labiovelars *k^w , g^w , g^wh are labialized <u>velars</u>: "Der idg. Phonemtyp wird...allgemein als ein Velar mit gleichzeitiger Lippenrundung definiert..." [Szemerényi 1970:55].

Part of the Wichita stop system [Hockett 1955:102] is:

(21) t k
k^w

It appears that the labial hole in the stop pattern is on the verge of being filled by a labialized velar.

The comparative Bantu evidence indicates the full extent of the process, all points of articulation being affected, but allows no conclusions regarding the implicational spread due to the great age of the process (cf. sec. 4. below).

(c) The labialization. It is not easy to decide the precise status of the [+ round] feature in the structural change of the rule. The rounding presumably extends through the whole of the consonant. This is clearly demonstrable in Sotho, where all linguals are rounded before rounded sonorants. The labialization is manifested as an extreme rounding affecting a given segment from beginning to end; cf. the following Northern Sotho forms where the rounding is signified by a raised ɣ :

(22)	[tšhɣukɣudɣu]	tšhukudu	'rhinoceros'
	[-rɣoka]	-roka	'sew'
	[-lɣoma]	-loma	'bite'

It seems, however, that the rounding may--and usually does--develop into an offglide. Hence:

(23) $\underset{[+\text{ round}]}{C} \rightarrow [C^w]$

$[C^w]$ is a segmental polyphthong (cf. sec.3.2.6. for discussion). The PRIE labiovelars instantiate this stage. In Sotho original clusters of lingual consonant and w are converted to C^w via labialization:

(24)	C	w	a	
	C^w	w	a	Labialization
	C^w		a	Glide Absorption

The $[^w]$ offglide is not by any means a separate glide but a rounded transition to the following nonround vowel, cf. Northern Sotho [-š^{w}ɛu] -šweu 'white', [-r^{w}ala] -rwala 'carry'. Kunene [1961:120] notes the following:

> The element w, when occurring immediately after a consonant or consonant combination, is anticipated in the articulation of this sequence, imparting labial characteristics, in the form of lip-rounding, to this consonant or consonant combination, and itself persisting after the articulation of such consonant or consonant combination, and being released by the movement of the lips towards the position of the following vowel.

Kunene interprets the rounding as a glide following the rounded segment, a conclusion which does not necessarily follow, but we shall leave the matter at that.

3.2.2. Step 2 : Glide Absorption. Nothing much need be said about this: the glide is absorbed into the rounding of the labialized segment.

3.2.3. Step 3: Segmentation. Like Glide Absorption this is a prerequisite to later stages. No function is claimed for this rule other than the development of a rounded element following the consonant affected by labialization. In other words, this distinct element may be a full glide or even the rounded offglide mentioned above. The following Korekore forms attest to Segmentation [Doke 1931:124]: ɦuni > hwuni 'firewood', ɦope > hwope 'sleep', ɦono > hwono 'mole'.

3.2.4. Step 4: Glide Narrowing. Glide Narrowing is hypothesized but not instantiated.

3.2.5. Step 5: Fricativization. In Bantu, Narrowing is terminated at this point. Step 5a: Fricative Adjustment is a 'natural segment' rule: the most natural labial fricatives are labiodental.

3.2.6. Step 6: Closure and double articulation. Compare the reflexes of the following "Western Sudanic" (i.e. Proto Niger-Congo) forms [Westermann 1927:197 ff.]:

(25)	*guà	'zerbrechen'	:	Ewe gbà, gbã; Ga gba
	*guà	'viel'	:	Ewe gbàgbàgbà 'sehr viel'; Nupe gbãgba
	*-guí-	'Leopard'	:	Dē gbí; Akassele -gbé; Bulom -gbe
	*-guò	'Widder'	:	Ewe -gbò; Nupe -gbo
	*-kua-	'Weg'	:	Beri -kpa; Nupe -kpa
	*-kuì	'gross, viel'	:	Ewe kpì; Santrokofi kpi

Compare also Greenberg [1966:16, 20, 21]: no. 14 'die', no. 30 'leopard', and no. 40 'skin'. Westermann [1930:21] points out that Dahomey Ewe has gw and kw in the place of Ewe gb and kp .

Ladefoged [1968:5-13] has given detailed descriptions of Step 6. The facts are complex and involve the timing of closures and releases, the direction of the airflow and the airstream mechanisms used (cf. sec. 3.2.7. below). The phonological interpretation of double articulations in Chomsky and Halle [1968] is singled out for closer scrutiny.

SPE phonology equates segment with monophthong--especially in phonological representations. For example, diphthongs are analysed as realizations of underlying tense vowels (cf. Chomsky and Halle [1968:183]). The rule there does not reveal the exact nature of a diphthong, i.e. that it is a unitary vocalic segment with an acoustic structure that varies in time. The output of the SPE Diphthongization Rule is: [ī] [y], [ū] [w], i.e. sequences of two separate segments. Naturally this has the highly satisfying effect of constraining the theory in such a way as to preclude different (not to say contradictory) feature specifications within a single segment. In the cases above the opposite specifications [+ voc] and [- voc] are assigned to two distinct segments:

(26) $\overset{\text{T}}{[+\text{ voc}]}\ \overset{\text{y}}{[-\text{ voc}]}$, $\overset{\bar{\text{u}}}{[+\text{ voc}]}\ \overset{\text{w}}{[-\text{ voc}]}$

A monosegmental interpretation is forced to assign these opposite values to one and the same segment:

(27) $\left[\overset{\text{T}}{[+\text{ voc}]}\ \ \overset{\text{y}}{[-\text{ voc}]}\right]_{\text{Seg}}$

Evidently, the unconstrained use of opposite features within a single segment may so seriously weaken a phonetic theory as to neutralize every theoretical claim it has to make. I should, however, like to plead the case of the constrained use of non-homogeneous feature specifications in a small range of cases, the segmental polyphthongs. Andersen [1972] has explicated the usefulness of such a concept in a wider context. His <u>segmental diphthong</u> is equivalent to <u>segmental polyphthong</u> as used in this study. Compare Andersen's definition [1972:18]: "...a single segment whose central phase is acoustically heterogeneous in its temporal development, rather than presenting a steady state".

A diphthong is a kind of vocalic polyphthong. Other polyphthongs include secondary articulated consonants, i.e. consonants with offglides: k^y , k^w , p^w ; affricates: ts , kx ; doubly articulated sounds such as $\widehat{gb}$, $\widehat{kp}$, and clicks. Only secondary and doubly articulated obstruents fall within our purview.

Notice that the alphabetic phonetic notation used here represents the relevant segments as polyphthongs. This, the binary feature system does not do:

(28) $\overset{k^w}{\begin{bmatrix} -\text{ cont} \\ -\text{ voice} \\ +\text{ high} \\ +\text{ back} \\ +\text{ round} \end{bmatrix}}$ $\overset{\widehat{gb}}{\begin{bmatrix} -\text{ cont} \\ +\text{ voice} \\ +\text{ high} \\ +\text{ back} \\ +\text{ round} \end{bmatrix}}$

This essentially timeless, monophthongal interpretation of all segments fails in the Nupe case reviewed in Chomsky and Halle [1968:311].

Historically, the Nupe labiovelars $\widehat{kp}$ and $\widehat{gb}$ are extremely labialized velars developing from *kwV and *gwV , cf. the beginning of this subsection and Westermann [1927:197 ff.]. Being doubly articulated segments--and the only two in the Nupe system--they are phonologically opaque from a synchronic point of view and could be either extremely labialized velars or extremely velarized labials.

Chomsky and Halle [1968] invoke the Nupe phonological system in order to decide the issue. They interpret $\widehat{kp}$ and $\widehat{gb}$ as extremely velarized labials. Consider the following. The phonological system of Nupe contains segments such as k and $\widehat{kp}$ and rules such as exemplified in (29):

(29) $/k\ ,\ \widehat{kp}/ \rightarrow [k^w\ ,\ \widehat{kp}^w]$

and palatalization:

(30) $/k\ ,\ \widehat{kp}/ \rightarrow [k^y\ ,\ \widehat{kp}^y]$

cf. [Smith 1967; Hyman 1970].

Specifying $\widehat{kp}$ as a velar with (extreme) rounding would fail to distinguish $\widehat{kp}$ from $\widehat{kp}^w$ (and $[k^w]$), since the only feature configuration available would be:

(31) $\begin{bmatrix} -\text{ ant} \\ -\text{ cor} \\ +\text{ high} \\ +\text{ back} \\ +\text{ round} \end{bmatrix}$

The $\widehat{kp}$ x $\widehat{kp}^w$ distinction might be salvaged by rejecting the principle that "...the particular degree of rounding...can be determined by the phonological rules of the language..." [Chomsky and Halle 1968:311] and by specifying degree of rounding: p of $\widehat{kp}$ being, say [+4 round] and ^{w} of k^w and $\widehat{kp}^w$ [+1 round]. Nevertheless, no amount of juggling will save the $\widehat{kp}$ x $\widehat{kp}^w$ distinction since the feature [+ round] is reserved for the p portion.

By regarding $\widehat{kp}$ as a labial with extreme velarization, i.e.

(32) $\begin{bmatrix} + \text{ant} \\ - \text{cor} \\ + \text{high} \\ + \text{back} \end{bmatrix}$

the k^w x $\widehat{kp}$ x $\widehat{kp}^w$ contrast is easily captured. However, the problem now is $\widehat{kp}^y$, the palatalized extremely velarized labial, since, as Professor Hyman (personal communication) points out, the velarization [+ high, + back] is incompatible with the palatalization [+ high, - back] in the same segment.

I submit that this particular dilemma is the result of an exaggerated insistence on the monophthongal nature of segments. Once this requirement is relaxed to allow a polyphthongal interpretation of double articulation the whole problem concerning the phonological opacity (are the segments velarized labials or labialized velars?) and the phonological representation of $\widehat{kp}$ and $\widehat{gb}$ in Nupe vanishes: synchronically they are neither labials with extreme velarization nor velars with extreme labialization but labiovelars: doubly articulated polyphthongs.

The processes of extreme labialization of k and extreme velarization of p may have precisely the same outcome: a labiovelar stop, written $\widehat{kp}$, which can only be:

(33) $\left[\begin{bmatrix} - \text{cont} \\ - \text{voice} \\ + \text{high} \\ + \text{back} \end{bmatrix} \begin{bmatrix} - \text{cont} \\ - \text{voice} \\ + \text{ant} \\ - \text{cor} \end{bmatrix} \right]_{\text{Seg}}$

Furthermore, the existence of kp^y forces the acceptance of a hierarchical arrangement of polyphthongs with $\widehat{kp}$ as one unit and ^{y} as another:

(34) $[\ [\widehat{kp}]\ ^y\ ]_{\text{Seg}}$

3.2.7. <u>Step 7: Inner release and double articulation</u>. In regard to the timing of releases in doubly articulated segments Chomsky and Halle [1968: 324] state:

> The order of release of the different closures is governed by a simple rule. In sounds without supplementary motions, the releases are simultaneous. In sounds produced with supplementary motions, closures are released in the order of increasing distance from the lips. The reason for this ordering is that only in this manner will clear auditory effects be produced, for acoustic effects produced inside the vocal tract will be effectively suppressed if the vocal tract is closed.

Compare the following remarks of Ladefoged on Kalabai g͡b [1968:10]: "...the velar closure must have been completely released <u>while the lips remained closed for a further 50 msec</u>...." [Emphasis mine, FP].

This contravention of the Chomsky-Halle release principle accomplishes a subordination of one stricture to another: the g -stricture could eventually become a modification of b . The Chomsky-Halle principle could be extended in the following way to account for this: primary release of inner closures result in their subordination.

For Yoruba ɓ the following development may be hypothesized: g͡b > ^{g}b > ɓ .

(i) g͡b is a doubly articulated, extremely labialized g .

(ii) ^{g}b is a b with velaric action: when the inner stricture is released first it becomes secondary in terms of the extended Chomsky-Halle release principle.

(iii) ɓ is an implosive. Velaric action induces lowering of pressure in the mouth so that air flows into the mouth on release of the labial closure (cf. Ladefoged [1968:9]).

This conclusion is supported by the following considerations:

(i) Ladefoged [1968:6-7] has found that implosive ɓ in Igbo is not always implosive, the stable mark distinguishing it from b being velaric action (heightening of the back of the tongue). This may be a result of the transition from Step 2 to 3 above.

(ii) The large formant transitions of implosive ɓ are similar to those of $\widehat{gb}$ [Ladefoged 1968:13, and Plate 4B].

(iii) In Soso, Ladefoged informs us [1968:14] that "...there is also a fully voiced $\widehat{gb}$ which verges on the implosive".

(iv) Igbo has $\widehat{kp}$ and ɓ but no $\widehat{gb}$ [Ladefoged 1968:59]. It seems plausible that ɓ derives from $\widehat{gb}$ if due consideration is taken of (i) above.

(v) If ɗ occurs, so does ɓ but not vice versa. A possible explanation is that ɓ arises from labialization of g , which, being a velar, leads the labialization process.

Greenberg [1970] gives three ways in which implosives arise, this being his second (1970:28-30).

The extended Chomsky-Halle release principle also accounts neatly for the development of the bilabial nasal click in Idoma [Ladefoged 1968:12] from an extremely labialized velar nasal:

(35)	$ŋ^w$	Labialization
	ŋm	Closure and double articulation
	ᵑm	Subordination of inner closure
	ŋʘ	Modification of primary (labial) closure

We may assume a similar development via double articulation and the subordination of inner closure for the Greek, Old Irish and Old Cymric labials from PRIE labiovelars, whereas Wichita k^w is evidently on its way to [p] (cf. sec. 3.2.1(b)).

But a teleological explanation seems to be called for in view of the following symmetry:

(i) Velarized labials may result in velars. Compare the Chopi and Venda examples in sec. 2.3.4. above.

(ii) Labialized velars may yield labials, as implosive ɓ in Igbo.

Such changes could be described in terms of normal and extended versions of the Chomsky-Halle release principle, but in the end, the timing of releases itself requires explanation. Could it not be that the 'velar' part of a velarized segment and the 'labial' part of a labialized segment bear some kind of 'focus'?

3.3. Labio-alveolar fricatives. These doubly articulated fricatives arise from combinations of labial (labiodental) fricatives and spirants. In Sotho (and Shona) the cluster itself arises from palatalization: fɨ > fsɨ > f͡sɨ .

(36) Shona

*-pɨk-	>		-f͡sika	'arrive'
*-plɨp-	>	Zez.	-f͡sipa	'become black'
*-bįád-	>		-β͡zara	'bear child'
*bi- Class 8 IP	>		β͡zi-	

(37) Sotho

lefifi > lefsifsi > leswiswi	'darkness'
lefɨka > lefsika > leswika	'stone, rock'

This is progressive assimilation induced by a consonant and does not fall within the scope of the present account. Notice that Sotho goes one step further: the labio-alveolar fricative is changed to a rounded spirant: f͡s > s^w (cf. Ponelis [1973] for details).

4. Labialization in Bantu

4.1. Introduction. The earliness of this rule in Bantu is reflected by the following.

(i) Labialization is attested in a wide variety of Bantu languages, including Rundi, Nkoya, Manyika, Pende, Sagala, Zulu and Bemba.

(ii) It functions before the 7 > 5 neutralization in the vowel system, e.g. Zulu: *b → v /__ ų ; ɓ elsewhere: *-bųn- > -vun- 'harvest'; *-bumba > -ɓumba 'clay for pottery'.

(iii) Labialization precedes velarization in the languages where both rules are operative (e.g. Rundi). The interaction between these rules points to the following: (a) Velarization and labialization take place before the highest back sonorant (vowel) available. (b) Stops take precedence over fricatives. Together, (a)+(b) explain the fact that when labialization changes *p and *b to fricatives before *ṷ , velarization attacks the stops before *u (and not the fricatives before *ṷ); cf. Rundi: *-bṷ́n- > Rundi -vun- 'break'(tr.); *-búɪ́d- > Rundi -bɣir- 'tell'

(iv) There is extensive neutralization of obstruents before ṷ which is evident from the many cases of multivalence among Guthrie's reflexes. Generally:

(38) *p , t , k → f /__ ṷ
*b , d , g → v /__ ṷ

(v) The process covers a large and continuous area in the central to southern heartland of the Bantu field (cf. Topogram 14 in Guthrie [1967:79]).

4.2. Initial domain and spread of labialization. The assimilation determinant is the high back *ṷ , the highest back vowel in the Proto Bantu four height system. Labialization Proper conceivably preceded Gliding, since no difference as to Labialization could be established between the environments /__ṷ and /__ŵ , where ŵ developed from ṷ by Gliding. Note however, that the glide undergoes Absorption in a number of languages, cf. the reflexes of *-kṷ́a 'die':

(39)

No Glide Absorption (Bemba, Ila)	Glide Absorption (Nyoro, Zulu)	
k ṷ a	k ṷ a	
k^w ṷ a	k^w ṷ a	Labialization
k^w ŵ a	k^w ŵ a	Gliding
	k^w a	Glide Absorption
pf w a	pf a	Narrowing, etc.
f w a	f a	Cluster Simplification

The affected segments are voiced and voiceless plosives, nasals remaining unaffected. All three primary Proto Bantu series--velars, alveolars and labials--participate in the process.

4.3. The processes of labialization. Since it is an ancient rule the stages are poorly attested in Guthrie's data. The rules above generate derivations such as the following:

(40)					
	pɥ	tɥ	kɥ	dɥ	
	pʷu	tʷu	kʷu	dʷu	Labialization
	pwu	twu	kwu	dwu	Segmentation
	pŵu	tŵu	kŵu	dŵu	Glide Narrowing
	pfu	tfu	kfu	dvu	Fricativization
		pfu	pfu	bvu	Stop Assimilation
	ᵖfu	ᵖfu	ᵖfu	ᵇvu	Stop Subordination
	fu	fu	fu	vu	Stop Elision

The change *p , t , k → f and *b , d , g → v is not mere fricativization. Pure fricativization would have resulted in f θ x β ð γ .

Hardening goes no further than the fricative stage, hence pfu tfu kfu bvu dvu gvu do not develop further into *ppu tpu kpu bbu dbu gbu .

The Stop Assimilation and Fricativization stages are exemplified in Appendix II with forms from Guthrie [1967, etc.].

4.4. Rule interaction. Languages such as Nyekyosa [Guthrie 1971:56], Bemba [Guthrie 1971:57], Sagala [Guthrie 1971:47], Sango [Guthrie 1971: 51], and Zulu have reflex patterns such as the following:

(41)		-į	-ɥ[9]
*p	>	f	f
*t	>	s	f
*k	>	s	f

The fact that *p → f /__į might be explained by the following assumptions:

(a) Labialization and palatalization both spread from velars to labials, with palatalization trailing labialization (i.e. being initiated

[9] Details such as Bemba š for s are not reflected in (41).

after it).

(b) Labialization reaches the labial series first and spreads to labials before į by phonetic analogy.

However, these assumptions are not borne out by Mambwe [Guthrie 1971: 56]:

(42)

		-į	-ų
*p	>	f	f
*t	>	s	s
*k	>	s	f

The implicational spread explanation above might be salvaged in the following way. Palatalization is the earlier rule, which spreads first to the alveolar series. Labialization then jumps the alveolar series while palatalization is still 'busy' there to operate on the labial series.

However, the data seem to point to the existence of an intensity dimension within implicational spread to the effect that a given series is more susceptible to a given rule than another series. The processes in (42) illustrate that alveolars palatalize more readily, whereas (41) and (42) together exemplify the greater susceptibility of labials to labialization. The assumption of an intensity scale explains why phonetic analogy takes place before į making it unnecessary to state phonetic analogy as a separate principle.

4.4. Swazi labialization. In Swazi there is labialization of lax voiced and voiceless, aspirated alveolar stops: in both the release is slow. In (43) compare the following instances of this type of labialization, which occurs before back vowels and before the glide w .

(43) a. th > tf :

-itfu	'ours'	Zulu	-ethu
litfole	'calf'	Zulu	ithole
umtfolo	'acacia caffra'	Zulu	umtholo
butfongo	'sleepiness'	Zulu	ubuthongo
-tfwala	'carry'	Zulu	-thwala
-tsatfu	'three'	Zulu	-thathu

(43) b. d > dv :

indvodza	'man'	Zulu	indoda
lidvolo	'knee'	Zulu	idolo
-dvuma	'flavorless'	Zulu	-duma
indvuna	'headman'	Zulu	induna
-dvwa	'alone'	Zulu	-dwa

What is different about this kind of labialization is that it affects only alveolars.[10]

5. Conclusion

I have tried to put forward a unified explanation of a number of seemingly disparate phenomena in terms of processes of secondary articulation. It is argued that the secondarily articulated segments arising via Velarization and Labialization Proper undergo Hardening, become doubly articulated and are eventually simplified to labial and velar obstruents, respectively. The possibility strongly presents itself that the rule hierarchies (implicational spread phenomena) and the dimensional progression of rules (as under Hardening) may be accounted for adequately only within a nondiscrete phonology.

[10] Swazi and Lala (i.e. Tekela) palatalization before front vowels is constrained in exactly the same way.

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Appendix I

A. Examples

*-tapwa	>	-tapɸa	'be captured as spoil'
*-pwa	>	-pka	'smash'
*-pwira	>	-pɣ̑ira	'dry up'
*-bwe	>	-bɣe	'stone'
*-bwaira	>	-bgaira	'wink'
*mwana	>	mŋana , mw̃ana , mŋwana , ŋwana	'child'
*-nwa	>	-nŋwa , -ŋwa	'drink'
*-batwa	>	-batɸwa , -batkwa	'be held'
*-twa	>	-twa , -tɣ̑a , -tɸwa , -ɸwa , -tskwa , -tsɸwa	'pound'
*-pindwa	>	-pindɣwa	'be entered'
*-biswa	>	-biskwa	'be removed'
*-zuzwa	>	-zuzɣwa	'be shaken'
*-rwa	>	-rɣwa , -gwa	'fight'

B. Derivations

In these derivations different dialect forms are generated.

*-dúád- 'be ill'

Budya -rwara , Karanga -rɣwara , Korekore -ɦwara , Manyika -gwara

rwara	
rɯwara	Velarization
rwwara	Segmentation
rŵwara	Glide Narrowing
rɣwara	Fricativization
rɣwara	Backing
rgwara	Closure
gwara	Cluster Initial Deletion
ɣwara	Cluster Initial Deletion
ɦwara	Weakening

*-pú- 'dry up'
Korekore -ɸwa , Tavara -pɸa , Zezuru -pka , Nambzya -pw̥͡a

pwa	
p^{ɯ}wa	Velarization
pwwa	Segmentation
pw̥͡wa	Glide Narrowing
pɸwa	Fricativization
pxwa	Backing
pkwa	Closure
pka	w -Absorption

pɸwa

Cluster Initial Deletion / \ w -Absorption

ɸwa pɸa

pw̥͡wa > pw̥͡a by w -Absorption

The precise derivation of pɸa is opaque since w -Absorption may either precede or follow Fricativization.

*-búa 'dog'
Korekore -mbwa , Urungwe -ŋgwa , Budya -mbɣ̶a , Hera -mbga ,
Unyama -mbw͡a

mbwa	
mb^{ɯ}wa	Velarization
mbwwa	Segmentation
mbŵwa	Glide Narrowing
mbɣ̶wa	Fricativization
mbɣ̶a	w -Absorption
mbɣa	Backing
mbga	Closure
mbgwa	

mgwa   Cluster Initial Deletion

ŋgwa   Nasal-to-Stop Assimilation

mbw̑wa

mbw̑a   w -Absorption

*mu-ana 'child'

Korekore mwana , mŋwana ; Zezuru mw̃ana , mŋana ; Lilima ŋwana

mwana

$m^{ɯ}$wana   Velarization

mwwana   Segmentation

mw̃wana   Glide Narrowing

mŋwana   Closure

w -Absorption (→ mŋana)   Cluster Initial Deletion (→ ŋwana)

mŋana   ŋwana

mw̃wana

w -Absorption   mw̃ana

'To pound'

Guta -twa , Hungwe -tsɕwa , Jindwi -tw̥̑a , Garwe -tɕwa , Rozwi
-ɕwa , Zezuru -tskwa

twa

tɯwa   Velarization

twwa   Segmentation

tw̥wa   Glide Narrowing

tɕwa   Fricativization

tsɕwa   Palatalization

tsxwa   Backing

tskwa   Closure

tw̥̑wa

tw̥̑a   w -Absorption

tɕwa

ɕwa   Cluster Initial Deletion

Appendix II

A. Examples

*p > pf :

*-pụ- > Manganja -pfu 'stomach';

*-pụko > Venda pfuko 'mole'.

*t > pf :

*-tụ > Manyika -pfu 'flour';

*-tụ- > Venda -pfa 'spit';

*-tụd- > Manyika -pfur- 'forge'.

*k > kf :

*-kụ́ba > Ngom kfuba 'chicken'

*k > pf :

*-kụ́dû > West Kongo pfudu 'tortoise';

*-kụkam- > Ha -pfukam- 'kneel';

*-kụmbat- > Manyika -pfumbat- 'hold in arm or hand'.

*b > bv :

*-bụ́da > Tetela -bvula 'rain';

*-bụ́n- > Cewa -bvun- 'harvest'.

*d > bv :

*-dụ́ad- > Gogo -bvwal- 'wear'; Manganja -bval- ; Manyika -bvar-.

*g > bv :

*-gụ́i > Cewa -bvi 'arrow';

*-gụbú > Manganja -bvuu 'hippo';

*-gụ́n- > Chopi -bvun- 'help';

*-gụnd- > Manyika -bvund- 'become rotten'.

B. Further Examples

*b

*-bụn- 'harvest' > Zulu, Tumbuka, Unguja -vun- ; Cewa -bvun-

*d

*-dụkut- 'blow bellows' > Unguja, Luba-Katanga -vukut-' ;Bemba -fukut- ;[1] Manganja -bvukut-

*g

*-gụnd- 'become rotten' > Unguja, Zulu -vund- ; Manyika -bvund- ; Lenje -fund-

*p

*-pụk- 'dig up, fling up (earth)' > Kele -fụ- ; Shambala, Lwena, Bemba -fuk-

*t

*-tụ́d- 'forge' > Mvumbo -pfule- ; Tiene -tful ; Pfokomo -fuy- ; Unguja -fu- ; Central Kongo -ful- ; Manyika -pfur-

*k

*-kụkam- 'kneel' > Rundi, Central Kongo, Lwena, Luba-Katanga, Bemba, Ila -fukam- ; Ha -pfukam-

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[1] In some languages the voiced-voiceless contrast is neutralized under labialization: [+ voice] → [- voice]. This is a manifestation of a widespread strengthening rule functioning in the environment of high vowels and/or nasals.