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The Lubukusu Syllable Structure in Optimality Theory

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Abstract:
*The syllable has been a central linguistic construct in phonological theory ever since its 'acceptance' by neo-generativists as an indispensable phonological unit in delimiting recurrent phonological processes cross-linguistically. It is considered a vital source of phonotactic statements and the building block of the prosodic hierarchy. However, not everything pertaining to its structure has been explained. In Generative phonology, its status was questioned while in Non-Linear phonology approaches, it was conceived merely as a hierarchical structure with little information on the preference of the CV structure and the sonorant sounds as syllabic consonants. The role of sonority has been questioned and upheld with the same measure of passion. In this paper, couched in Optimality Theory and based on Lubukusu language of Kenya, it is argued that the preference of the CV structure arises through constraint interaction in which markedness constraints that demand syllable well-formedness dominate faithfulness constraints. In addition, markedness constraints against onset clusters allows the CG (Consonant Glide) onset because it satisfies the sonority sequencing constraint; SSP. This constraint bans a sequence of two nasals in the onset and in concert with *NN/OCP, rules out such marked onset clusters. It is further argued that in an OT grammar, constraints are violable hence the restriction of consonants in heading syllables can be violated if the consonants are positively specified as [+sonorant].*

Keywords: *Constraints, markedness, faithfulness, optimal, sonority*

1. Introduction

The concept of the syllable has been a central construct in phonological theory long after it was 'acceptable' and its ontology acknowledged as real by the neo-generativist in the late 1970s and early 1980s. In spite of its chequered history and lack of a clear phonetic correlate, the syllable has emerged as an indispensable phonological unit in constraining attested phonological processes across languages. Besides being a vital source of phonotactic statements, it is also viewed as the building block of the prosodic hierarchy and the domain for the assignment of key prosodic features such as tone and stress, among others. Literature on the syllable is replete in relation with its centrality and role in prosodic phonology especially as the foundation for the organization of higher level prosodic categories such as the foot, prosodic word, phonological phrase and intonation sentence (Kahn, 1976; Selkirk, 1984; Blevins, 1995). The syllable structure has, therefore, been a major focus in phonological theory, description and analysis. In terms of its structure, there is a general consensus that it is divided into three main parts; on one hand the Onset (O) and on the other, the Nucleus (N) and Coda (Co). The latter two form the Rhyme. Depending on constraints operating in specific languages, either all or the obligatory nucleus is filled by some sound segment. Generally, the onset and coda positions are occupied by consonant sounds while the nucleus is occupied by a vowel (or a syllabic consonant). There are constraints on syllabification based on inherent sonority of segmental sounds; however, these constraints are relative rather than absolute across languages explained in OT as violable constraints.

A number of languages ban consonant clusters and may employ various strategies such as vowel epenthesis and consonant deletion to break up or eliminate unacceptable consonant clusters. In languages allowing onset and coda clusters, they may be constrained by sonority in that such clusters have a rising sonority from the onset to the nucleus and a falling sonority towards the coda. This is encoded in the Sonority Sequencing Principle (SSP) of Kahn (1976). However, this requirement is not categorical as we often note in English words beginning with the fricative [s] such as 'string' [strɪŋ] whose onset cluster violates the SSP constraint. In spite of this apparent violation, we still observe that every language has canonical syllable structure and phonological process invariably adhere to the syllable structure of the language. This argument is central in the examination of processes such as assimilation and reduplication in which the emerging syllables cannot deviate from the canonical syllable structure of the language.

The syllable structure thus remains a central issue and its importance has been more apparent in Optimality Theory (OT). Following the exposition of this theory (Prince & Smolensky, 19993/2004; McCarthy & Prince, 1993b; Kager, 1999; McCarthy, 2002, 2004), the role of the syllable in understanding various phonological phenomena has been tremendous. OT has been particularly strong in its typological predictive power arising from ranking permutations and its ability to account for different aspects of syllabification. On the other hand, through OT, the syllable has been better understood as a structure arising from constraint interaction. At the same time, the syllable helps reveal some problems in OT analytic approach. However, not all has been explained in OT as pertains to syllables across languages. Some linguists have argued that neither sonority nor phonotactics are crucial in accounting for the well-formedness of syllabic clusters in the margins (Steriade, 1999; Blevins, 2003; Green, 2003). Although sonority and markedness have been vital in explaining preference for CV syllables and the core clusters in some languages, there is little consensus on their role and the very concept of ‘markedness’.

In some cases, unacceptable consonant clusters have been explained as being extra-syllabic. Consequently, they can only be syllabified through vowel epenthesis, deletion via stray erasure or syllabified at the edges of higher prosodic categories such as the foot, prosodic word or the phonological phrase (Clements & Keyser, 1983; Fery, 2003; Green, 2003; among others). There seems to be specific markedness associated with specific cluster types. In Icelandic, steep rising clusters are tautosyllabic while shallow rising ones are heterosyllabic word internally and reference to sonority alone may not be sufficient without the steepness of the sonority climb. Equally, in Attic Greek (Steriade; 1982, Green, 2003), extrasyllabic consonants are allowed at edges of prosodic word while inadmissible as onset clusters contrary to the EXHAUSTIVITY constraints. The same is observed in Munster Irish, a dialect of Irish Gaelic (Green, 2003) in which there is a three-way contrast at word initial, internal stressed syllable and internal unstressed syllable in terms of what are considered licit clusters.

In the mentioned languages, there are onset well-formedness constraints that operate from the syllable to the higher prosodic categories. For example, while stop + liquid cluster is not allowed at syllable level, it is allowed at word initial and foot level. Consequently, fricative + liquid and obstruent + nasal is only allowed at word level. In fact, when a rising sonority occurs before stressed syllables in Munster Irish (Green, 2003) an epenthetic schwa is inserted to break the cluster contrary to the Sonority Sequencing Principle). This must be due to Syllable Contact Law that demands reasonable sonority distance for onset clusters hence no rising clusters are allowed across syllable breaks. Word internal unstressed syllables do not allow clusters at all because such syllables are on the left edge which does not correspond to either a foot or a prosodic word hence epenthetic schwa is used. More marked consonant cluster may be banned from the onsets of syllables but be acceptable at higher prosodic levels of the foot and prosodic word.

While obstruents, universally make better onsets, this is relative and a violable constraint. Morelli (2003) reports that a fricative-stop onset is the unmarked syllable onset cluster based on languages examined other than African languages. Her contention is that sonority cannot be the explanation due to its obvious violation but the unmarked status is based on the feature [continuant] and the least marked on the place dimension. Sonority is thus not relevant to obstruent clusters. A study on the syllabic phonology of Lubukusu should be vital in this debate especially because only one type of onset cluster is permitted; the CG. In this study we investigate these claims in OT by examining data in Lubukusu (Bantu, Kenya) to evaluate their veracity and how OT as a phonological theory can account for the syllable structure of the language. This paper is organized as follows; section 2 provides the background to Lubukusu, especially its phonemic inventory and the syllable structure. Section 3 examines the typology of the Lubukusu syllable structure in turn providing an OT analysis for each type of structure. Section 4 offers a summary, conclusion and some outstanding issues that require further probing.

2. Lubukusu phonemic Inventory and Syllable Structure

Lubukusu is a Bantu language spoken in western part of Kenya (Mutonyi, 2000; Nandelenga, 2013, 14). Its phonemic inventory consists of ten vowels as follows; five short vowels, [a, e, i, o, u] and five long counterparts [a:, e:, i:, o:, u:],and twenty consonant phonemes represented in the consonantal table (1) that follows.

(1) The Lubukusu consonant inventory (Mutonyi, 2000; Nandelenga, 2013, 2014)

	Bilabial	Labial-dental	Alveolar	Palatal	Velar
Plosives	p		t	c	k
Fricatives	β	f	s		x
Nasals	m		n	ɲ	ŋ
Liquids			l,r		
Glides				j	w
Pre-nasal stops	ᵐb		ⁿd	ᶮɟ	ᵑg

Table 1

All syllables in Lubukusu are open, a cross-linguistic tendency among Bantu languages. Lubukusu syllable structure can be divided into four basic types; CCV, CV, V and Ṇ. (Ṇ = syllabic nasal). The syllable structure of the language is explained via the following typology taking into consideration the long vowels that are part of Lubukusu sounds.

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(2) The syllable structure of Lubukusu I

(a) CV (V): The Consonant + Vowel type (the canonical and unmarked type)
(b) CCV (V): The Consonant + Glide + Vowel type (the only cluster allowed)
(c) V (V): The Onsetless syllable type
(d)Ṇ: The Syllabic nasal type (the only syllabic consonant allowed).

The CCV is strictly CGV= Consonant, Glide and Vowel. No other onset clusters may occur and whenever two consonants follow each other, a number of phonological repair mechanisms are triggered such as consonant coalescence or deletion. If two nasals follow each other, the first nasal is transformed into a syllabic nasal. The above syllable structure partly accounts for the various constraints on *NC effects that are observed in the language (Nandelenga, 2014). There is no nasal-consonant sequence except nasal-glide and the language does not have pure voiced obstruents. Instead, there are voiced prenasalized stops considered as one segment (contour segment) with a complex internal structure. These prenasalized stops are phonemic and not allophonic in the language.

3. The Typology of Lubukusu Syllable Structure

The four syllable types are exemplified in (3) below; the relevant syllable is word initial in the examples. Throughout this study, a period is used to indicate syllable boundary while the slanting lines // enclose the underlying phonological representation (un-syllabified phonemes). The square brackets [ ] enclose the surface phonetic representation (the level where syllabification takes place) while the dash (-) indicate morpheme boundary.

(3) The syllable structure of Lubukusu II.

σ type	Underlying		Surface form	English gloss
(a) CCV =	/lwana/	→	[lwa.na]	‘struggle’
	/fwara/	→	[fwa.ra]	‘dress up’
	/pje/	→	[pje]	‘very hot’
	/N-lja/	→	[^{n}dja]	‘I eat’
(b)CV =	/kaβa/	→	[ka.βa]	‘distribute’
	/tima/	→	[ti.ma]	‘run’
	/nanu/	→	[na.nu]	‘who?’
	/cexa/	→	[ce.xa]	‘laugh’
(c) V =	/ano/	→	[a.no]	‘here’
	/ima/	→	[i.ma]	‘stand up’
	/ona/	→	[o.na]	‘heal’
	/uja/	→	[u.ja]	‘migrate’
(d) N̩ =	/N-mala/	→	[m̩.ma.la]	‘I complete’
	/N-nula/	→	[n̩.nu.la]	‘I grab’
	/N-ɲala/	→	[ɲ̩.ɲa.la]	‘I am able’
	/N-ŋona/	→	[ŋ̩.ŋo.na]	‘I make’

In the following section, each type of the syllable structure is discussed in turn. We start by describing the structure, how it is represented and the constraints operating in the syllabification process of the language. In each analysis, an account of the syllable structure is done through language-particular ranking using universal constraints.

3.1. The CV (CV:) Syllable Structure

The CV syllable type is the most common in Lubukusu language; this is because it is considered the most unmarked of all syllable types (Clements & Keyser, 1983; Blevins, 1995; Cairns & Reimy, 2011; Goldsmith, 2011). In Lubukusu, all consonants can occupy the onset position in this structure (CV(CV:)) as exemplified in data (4) below. All the six manner of articulation classes (plosives, fricatives, nasals, prenasals, liquids and glides) are used with two examples from each class in the following CV syllable types. The relevant CVs are word initial in the examples.

(4) The CV syllable structure

Manner type	Input	Output	Gloss
(a) Plosives;	(i)/kana/	[ka.na]	‘desire(V)’
	(ii) /tima/	[ti.ma]	‘run’
(b) Fricatives;	(i) /soka/	[so.ka]	‘swim’
	(ii) /funa/	[fu.na]	‘break’
(c) Nasals;	(i) /nala/	[na.la]	‘get used to’
	(ii) /mala/	[ma.la]	‘complete (V)’
(d) Prenasals;	(i) /mbea/	[^{m}be.a]	‘I lie’
	(ii) /ndola/	[^{n}do.la]	‘I look’
(e) Liquids;	(i) /lila/	[li.la]	‘cry’
	(ii) /rura/	[ru.ra]	‘leave!’
(f) Glides;	(i) juja/	[ju.ja]	‘hurry up’
	(ii) /wica/	[wi.ca]	‘you come’

We could represent the above CV structure in terms of the traditional syllable structure which is viewed as a hierarchical structure divided into an onset and rhyme. The rhyme is further divided into the nucleus and coda. In Lubukusu, the onset and nucleus positions are occupied by a consonant and vowel respectively, but the coda position is empty (Ø). This is true of the native Bantu syllable structure that is invariably open. The CV syllable structure can be represented as follows (note, σ = syllable node, O= Onset, R= Rhyme, N= Nucleus and Co= Coda);

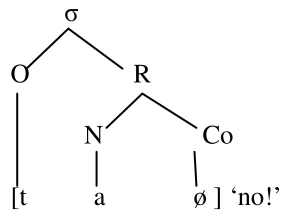

Figure 1: The CV syllable structure for Lubukusu prosodic word [ta] 'no!'

In OT, the emergence of syllables and the entire process of syllabification arise from constraint interaction. This study is meant to determine which constraints are relevant in the process and their ranking. To arrive at the CV syllable structure, we observe that there is a requirement that the syllable must have an onset implying the universal constraint; ONSET, is relevant in this case. Also, we note that the nucleus is occupied by a vowel, hence the anti-consonantal peak constraint *PEAK-C is required. Finally, the coda position is empty; the language does not allow coda consonants due to the anti-coda constraint *CODA. These constraints are defined as follows; ONSET, demands that syllables have onsets, *CODA states that syllables are open, and finally, *PEAK-C, states that syllable peak may not be occupied by a consonant (Prince & Smolensky, 1993/2004; Kager, 1999; McCarthy, 2002, 2004).
The following is the Lubukusu-particular ranking of these constraints. It is proposed that *CODA is undominated because it is never violated in the language as observed in the entire syllable typology of Lubukusu (see (2) above). It is further proposed that the two constraints: ONSET and PEAK-C, are ranked below *CODA because there are syllables without onsets and other syllables with syllabic nasals in the nucleus position. The ranking proposed is as follows: *CODA ≫ ONSET, *PEAK-C. There is no evidence of crucial ranking between the latter two constraints at this stage in the analysis. We represent the prosodic word /ta/ → [ta] 'no!'

(5a) /ta/→ [ta]'no!'

/ta/	*CODA	ONSET	*PEAK-C
a. ☞[ta]			
b. [at]	*!	*	
c. [t.a]		*!	*
d. [a]		*	

Table 2

From the above tableau, candidate (a) is the optimal candidate; it satisfies all the constraints while the rest of the candidates violate at least one constraint. Candidate (b) is the most disharmonic candidate in violating the undominated *CODA constraint thus incurring a fatal violation mark by having the voiceless alveolar stop [t] in the coda position. In addition, this causes a gratuitous violation of ONSET because the syllable begins with the vowel [a]. Candidate (c) performs no better than candidate (b) although it violates low ranked constraints. Candidate (d) harmonically bounds candidate (c) in having a subset of the latter's violation.
All the above constraints are responsible for the emergence of the CV structure based on these markedness constraints. This is crucial because the CV is the unmarked syllable type hence the decisive determination of the markedness constraints is in agreement with the view that markedness constraints are pivotal in determining CV syllables. However, the non-optimal candidates could not emerge as optimal because they violate other universal constraints whose language-specific ranking can be determined as well. It is expected that input segments must have output segments, therefore, candidate (d) violates some faithfulness constraints because there is disparity between the input-output mappings contrary to the anti-deletion faithfulness constraints: MAX-IO (Kager, 1999; McCarthy, 2002, 2004), which demands that input segment must have output correspondents (no deletion). If we incorporate this constraint, the result is a ranking in which it is dominated by *CODA because the general MAX-IO is violated in hiatus and *NC resolutions involving deletion (Nandelenga, 2013). The ranking of MAX-IO vis-à-vis ONSET and *PEAK is indeterminate subject to further analysis as follows; *CODA ≫ MAX-IO, ONSET, *PEAK-C.

(5b) /ta/→ [ta]'no!'

/ta/	*CODA	MAX-IO	ONSET	PEAK-IO
a. ☞[ta]				
b. [at]	*!		*	
c. [a]		*!	*	
d. [t]		*!		*

Table 3

Candidate (c) and (d) have the extra violations for the deleted segments (segments in the input not parsed in the output) contrary to the demands of MAX-IO. These violations are in addition to the violation of ONSET and PEAK-C, respectively. In the theory of alignment of morphological and prosodic categories (McCarthy & Prince, 1993a; Kager, 1999) adopted in this study, it is argued that the CV syllables are constrained by the requirement that the syllabic edges align with some morphological edge, for example, stem edges. In our example, 'ta' is a morphological word/stem, and also a prosodic word, [ta]. The relevant constraint that would evaluate this alignment requirement is; ALIGN (σ , R, Stem, R), which requires that for every syllable, there must be some stem such that the right edge of the syllable matches the right edge of the stem. This constraint is violated by any syllable whose right edge fails to coincide with the right edge of some stem. Considering that all Lubukusu syllables are open, any segment after the vowel is outside the alignment restrictions such as a coda consonant.

Conversely, if the input stem/word has a consonant, then we have a left edge alignment requirement which requires it to match with the syllable as required by the constraint; ALIGN (σ , L, Stem, L). This constraint states that for every syllable, there must be some stem such that the left edge of the syllable matches the left edge of the stem. The foregoing constraint is often simplified to ALIGN-L (Kager, 1999:111) and it states that the left edge of the grammatical word (GrWd) coincides with the left edge of a prosodic word (PrWd). This constraint is violated by any syllable whose left edge fails to coincide with the left edge of some grammatical word, given that a Lubukusu syllable can either have an onset or be onsetless. The constraint ALIGN-L evaluates harmony with respect to the input word whether it has an onset or not. If the input has no onset, insertion of a consonant will misalign the left edge between the stem and syllable of the prosodic word. Similarly, deleting the onset consonant present in the input violates this constraint. This latter violation is similar in effect to the ONSET constraint that punishes candidates without onsets. In this analysis, ALIGN-R replaces *CODA, ONSET is replaced by the ALIGN-L respectively.

(5c) /ta/ →[ta]'no!'

/ta/	ALIGN-R	ALIGN-L	PEAK-C	MAX-IO
a. ☞ [ta]				
b.[at]	*!	*		
c.[a]		*!		*
d. [t]	*!		*	*

Table 4

The optimal candidate (a) remains the same and the violations incurred by each of the candidates is similar to what we observed in tableau (5b), because ALIGN-L has the same effect as ONSET in demanding that input onset consonant is matched in the output. However, unlike ONSET, this constraint does not demand that the syllable has an onset, rather, that the input word is matched with the syllable on the left edge. Consequently, if the grammatical word begins with a vowel, it must be the same in the prosodic word or syllable. The same is true of ALIGN-R which prohibits the occurrence of coda consonant in the syllable but not in the grammatical word or input because the canonical Bantu word has what is referred to as stem final [a]; that is, it ends in a vowel.

(6a) /mala/→[ma.la]'complete'

/mala/	ALIGN-R	ALIGN-L	PEAK-C	MAX-IO
a.☞ [ma.la]				
b.[am.la]	*!	*		
c.[a.la]		*!		*
d.[m̩.la]	*!		*	*

Table 5

Candidate (a) is optimal in the tableau because it does not violate any of the constraints posited. Note that the alignment constraints are able to assess violations and provide the attested form (candidate, a) while ruling out the rest. Candidate (b) fails because it has a coda consonant, a fatal violation; in alignment terms, it is misaligned in having the bilabial nasal consonant in the final (the right) position. The same is true of candidate (c) which violates ALIGN-L constraint; it has no onset consonant that is present in the input, as a result, it also incurs violation marks for the deleted segment. Candidate (d), like (b), it is misaligned on the right margin with the grammatical word because of the missing vowel. Although syllabic nasals are attested in the language, the context under which they are legitimate is not satisfied in the current situation. Candidate (b) could also be ruled out by a constraint demanding that the linear or precedence relation between the segments in the input is maintained in the output. There is a reversal of precedence relation between the vowel [a] and the nasal [m]. The constraint LINEARITY-IO (Kager, 1999; McCarthy, 2002, 2004) would rule out this candidate as optimal. This is an anti-metathesis constraint which states that the precedence relation of the input is consistent with that of the output and vice versa (no metathesis). In the following, we replace the alignment constraints with LINEARITY-IO.

(6b) /mala/→ [ma.la]'complete'

/mala/	LINEARITY-IO	*PEAK-C	MAX-IO
a.☞[ma.la]			
b. [am.la]	*!		
c. [a.la]			*!
d. [m.la]		*!	*

Table 6

Only candidate (b) violates the linearity constraint, the rest of the candidates obey this constraint. But, as the previous evaluation in tableau (6a) indicates, candidate (a) remains the optimal candidate. However, we note that the language has long vowels as well (CV:). How do the constraints account for this inventory as the true reflection of the Lubukusu phonemic system? The following pairs of words indicate that length is contrastive in Lubukusu.

(7)Short and Long Vowels of Lubukusu

Short vowels	Vowel type	Long vowels	Vowel type
(i) [ta]'no!'	[a] low central	[ta:] 'draw (water)'	[a:] low central
[ma.la] 'complete'	[a] low central	[ma:.la] 'smear mud'	[a:] low central
(ii) [li.la] 'cry'	[i] high front	[li:.la] 'eat with'	[i:] high front
[ti.ma] 'run'	[i] high front	[ti:.ma] 'get lost'	[i:] high front
(iii)[xu.la] 'grow up'	[u] high back	[xu:.la] 'uproot'	[u:] high back
[ru.ra] 'get out'	[u] high back	[ru:.ra] 'unload'	[u:] high back
(iv) [βe.la]'forgive'	[e] mid front	[βe:.la] 'cheat for'	[e:] mid front
[me.la] 'germinate'	[e] mid front	[me:.la] 'get drunk'	[e:] mid front
(v)[bo.la]'rot (v)'	[o] mid back	[bo:.la] 'speak up'	[o:] mid back
[no.sja] 'make fine'	[o] mid back	[no:.sja] 'have delivered'	[o:] mid back

Apart from the fact that length is distinctive in Lubukusu vowels in signalling lexical distinctions and thus word contrast, long vowels have two moras (Mutonyi, 2000). Therefore, moras contrast the two types of syllables in terms of weight: short vowels have one mora and as a result, such syllables are light, while long vowels have two moras and consequently, the syllables are heavy. This difference is often shown with a branching rhyme/nucleus in heavy syllables as opposed to the light ones which do not have a branching nucleus. Because vowel length is contrastive in the phonology of Lubukusu language, shortening or lengthening of vowels is not allowed because of change in the lexical meaning of the prosodic word. This restriction is encoded in the relevant constraints that ensure lexical contrasts between the inputs are maintained in the output words.

Long vowels have two moras; therefore, if they are realized as short, they will violate a constraint that bans deletion of a mora; MAX-IO (mora) or change in the vowel feature of length: [length]; IDENT-V_{LENGTH}. These constraints demand that the mora count in the input is the same as those in the output, and that the length in the inputs is maintained in the outputs. Because length is contrastive, any change from either a short to a long vowel and vice versa will violate a constraint demanding contrast among the surface forms, this constraint is CONTRAST. It is possible to have IDENT- V_{LENGTH} violated independent of MAX-IO (μ) and also, it is possible to violate the two constraints without causing any violation of CONTRAST. These three constraints are relevant in this analysis. MAX-IO(μ)or MAX-μ –IO (Kager, 1999; McCarthy, 2002, 2004) requires input moras to have output correspondents (no deletion of moras). IDENT-IO_{LENGTH} (Kager, 1999; McCarthy, 2002, 2004) requires input segments to have an identical length feature with the output segment (no featural changes). Finally, CONTRAST, (Lubowicz, 2003), requires that the contrast in the input form is maintained in the outputs.

The following ranking is proposed: CONTRAST ≫ IDENT-IO_{LENGHT}, MAX- IO(μ). Contrast is consistently enforced and is never violated in any pair of Lubukusu words hence undominated in the hierarchy. There is no evidence of crucial ranking between IDENT-IO_{LENGHT} and MAX- IO(μ). However, the two are often violated in Lubukusu (Mutonyi, 2000) during hiatus resolution using deletion and glide formation.

(8)/taa/→[ta:]'draw (some water)'

/taa/	CONTRAST	IDENT-IO_{LENGHT}	MAX- IO(μ)
a. ☞[ta:]			
b. [ta]	*!	*	*

Table 7

The optimal candidate (a) does not violate any of the posited constraints; however, the losing candidate violates all the constraints. The looser violates the undominated constraint CONTRAST because mapping the long /ta:/ on to a short [ta] neutralizes the contrast between the two forms. In violating IDENT-IO (length), the feature of length between the input and output is not identical (one is [+long], the other [-long]). The violation of MAX- IO(μ) is a result of two moras present in the input being mapped on to one in the output; there is deletion of one mora contrary to the demands of MAX- IO(μ) and the universal mora preservation principle (Mutonyi, 2000).

In conclusion, we observe that constraint interaction is able to account for CV syllable type and for the presence of both the long and short vowels in the syllable typology of the language. The CV syllables are considered the canonical unmarked syllables of all natural languages (Cairns & Reimy, 2011). The markedness constraints ONSET, *CODA and *PEAK-C, are key constraints that are responsible for the emergence of this syllable structure through interaction with other constraints. No other stipulations are necessary in explaining the unmarked nature of the CV syllables except constraint interaction. As long as inputs have an onset consonant, the current ranking of MAX-IO and DEP-IO will ensure that the optimal surface forms are invariably of the CV type.A final observation is that no short vowels can replace long vowels because this would neutralize the contrast that exists between words that are specified as having long vowels and short vowels in the lexicon or underlying representation. The constraint responsible for maintaining contrast is undominated in the hierarchy and it ensures intelligibility among speakers of the language by maintaining semantic distinctions of words (Flemming, 2004).

3.2. The CCV (V:) Syllable Structure

Lubukusu has a CCV syllable structure that is restricted to the CGV, which is a Consonant Glide and Vowel (either short or long) sequence. Similar to a number of other languages, it prohibits consonant clusters of any other kind in the onset (Mutonyi, 2000; Nandelenga, 2013). While a syllable with an onset is the unmarked situation, the onset is preferably simple (CV). The preference (unmarked state) of the CV type and the markedness of the CCV clusters is often explained in terms of articulatory effort (ease of articulation) and perceptual distinctiveness between the segments making up the cluster (Chotoran et al., 2002; Flemming, 2004; Raphael et al., 2007). Both articulatory and perceptual studies show that it is easier to produce and perceive a CV syllable than a CCV. This explains why in cases where clusters are allowed in the language, there are specific restrictions on the segment type allowed and the sequencing that may be permissible (Blevins, 1995; Morelli, 2003; Smith, 2003). Only clusters that adhere to the Sonority Sequencing Principle may be permitted. A number of languages simplify onset cluster to the simple CV through vowel epenthesis and consonantal deletion. The data that follow depict this syllable type using monosyllabic words. In Lubukusu, there are two glides; the voiced palatal glide [j] and the voiced labio-velar glide [w], each represented in (A) and (B), below respectively. (Note: C1= Initial consonant)

(9) The CGV syllable type in Lubukusu monosyllabic words.

C1	(A)CjV type			(B)CwVtype		
(a) Plosives:	(i)/pje/	[pje]	'very hot'	(ii)/kwa/	[kwa]	'fall (V)'
(b) Fricatives:	(i) /sja/	[sja]	'grind'	(ii)/fwa/	[fwa]	'die'
(c) Nasals:	(i) /nja/	[nja]	'defecate'	(ii) /ɲwa/	[ɲwa]	'drink'
(d) Prenasals:	(i) /N-lja/	[ⁿdja]	'I eat'	(ii) /ŋ-gwa/	[ᵑgwa]	'I fall'
(e) Liquids:	(i) /rja/	[lja]	'fear (V)!'	(ii)/lwa/	[lwa]	'of'

The data show that glides can follow any consonant in the onset to form a cluster except another glide (there is no sequence of GGV) due to the active OCP (Obligatory Contour Principle) effects which in OT is formulated as a markedness constraint. In addition, Lubukusu has no geminates. Why are glides the only consonants that can follow the rest of the consonants in such an onset cluster? There are a number of phonetically based explanations. First, a glide has vowel like characteristics (often referred to as semi-vowels) due to the open stricture in articulation, hence glides can follow any consonant without obscuring the perception of such consonants. This is true especially for the stop consonants whose perception depends on the release burst. Any other consonant following the stop tends to obscure its perception, contrary to perceptual distinctiveness (Flemming, 2004). This is because of the overlap in the release phase of the stop that inhibits the audible burst (Byrd, 1992; Chotoran et al., 2002) which is critical for stop perception. Secondly, a glide has the highest sonority index than any other consonant in the sonority hierarchy; this ensures that the resultant onset cluster respects the SSP (Sonority Sequencing Principle) constraint; the pre-onset consonant is invariably of a lower sonority than the glide which guarantees a rising sonority to the peak.

In some languages, the CG sequence is conceived as CV the preferred and unmarked syllable type. Such a conception views its articulation and perception as being similar to the universal CV. However, in Lubukusu, previous studies have concluded that this sequence is, in fact, a CG cluster (and so does this study) based on the following reasons. First, in Lubukusu, the glide is a pure consonant not a semi-vowel. This means that it can never occupy the syllable peak position and also, it is non-moraic. Only moraic segments can be syllabic consonants in Lubukusu (Mutonyi 2000; Nandelenga, 2013). Secondly, the articulation of the glide involves a primary constriction; it has a clear formant structure in spectral analysis; it has a primary articulation rather than a secondary one. In this context, the [j] is a glide consonant phoneme not a palatalized secondary articulation. The same is true for the [w]; it is a true consonant not a labialized secondary articulation.In hiatus resolution, the markedness of a sequence of two dissimilar hetero-syllabic vowels is normally repaired and in Lubukusu, the high front unrounded vowel [i] glides to the palatal glide [j], while the high back rounded [u] glides to the homorganic labio-velar glide [w] (Mutonyi, 2000; Nandelenga, 2013). This is only possible if the glides are pure consonants and not semi-vowels.

Furthermore, nowhere in the phonotactics of the language are the glides banned in the onset position of the syllable structure as already seen in the discussion of CV onset types.Related to this argument is the fact that the palatal glide is consistently epenthesized to provide an onset in the reduplication process mainly because it is underlyingly specified as [+consonant] and not [-consonant]

(Nandelenga, 2013). This specification is fundamental in determining syllabification of 'ambivalent' segments such as laterals and glides. Finally, rising diphthongs are banned in Lubukusu syllables and the formation of diphthongs is not an option in hiatus resolution. This is evident that the glides in Lubukusu are true consonants with a primary articulation. This analysis is in accord with Smith's (2003) contention that if a language allows or has on-glides in its inventory, then it should also have the true onset glides. The true onset glides are the unmarked status of the glides rather than the reverse.

Having established the status of the glides as true onset segments, it is necessary to identify constraints responsible for the unmarked status of the CGV syllable type. In OT, there should be some markedness constraints that evaluate CGV as the most harmonic cluster in Lubukusu language. This requires that we construct a harmonic scale of the possible Lubukusu onset clusters. In the following specification, the initial C stands for the pre-onset consonant, the following O = Obstruent, N = Nasal, L= Liquid and finally, G = Glide.

(10) Harmonic/markedness scale of Lubukusu onset clusters

*CO ≫ *CN ≫ *CL ≫ *CG

Most marked ⟵⟶ Most harmonic

The far left of the markedness scale indicates the cluster that is the most marked because such a cluster has either a sonority plateau (e.g. [*pk], [*sg], onsets) or sonority reversal (e.g. [*lp], [*wk], onsets). The far right represents the most harmonic cluster; consequently, the only attested onset type in the Lubukusu language. It is possible to convert the above scale into constraints in which the non-occurring clusters are assumed to be undominated markedness constraints. This gives a markedness ranking as follows; *CO, *CN, *CL, ≫ *CG. Such constraints are part of a family of constraints subsumed under the general anti-cluster constraint; *COMPLEX$_{ONSET}$ which requires onsets to be simple. However, because we shall be using *CG throughout our analysis, a possible definition proposed is as follows; 'a cluster of the form 'Consonant-Glide' sequence is not allowed in the onset'. Such a constraint is considered a prohibiting markedness constraint and is normally preceded by the asterisk (*). In our subsequent analysis, we use only two of the above markedness constraints in the analysis of the input word [fwa] 'die'.

The relevant constraints are; *CO and *CG, but include faithfulness constraints that ensure input segments are not deleted to avoid the marked clusters or use of epenthesis to break up the same clusters. The faithfulness constraints are MAX-IO, which prohibits deletion and DEP-IO, which prohibits epenthesis of segments in the output. These two constraints must be ranked above the *CG$_{ONSET}$ markedness constraints to allow the CG clusters of the language to be judged as optimal and, therefore, parsed faithfully. The DEP-IO (Kager, 1999; McCarthy, 2002, 2004; Fery & Van de Vijver, 2003) states that output segments must have input correspondents (no epenthesis). In this analysis, these constraints are ranked as follows; *CO$_{ONSET}$ ≫ MAX-IO, DEP-IO ≫ *CG$_{ONSET.}$

(11a) /fwa/→ [fwa] 'die'

/fwa/	*CO$_{ONSET}$	MAX-IO	DEP-IO	*CG$_{ONSET}$
a. ☞[fwa]				*
b.[wfa]	*!			
c.[wa]		*!		
d.[fu.wa]			*!	

Table 8

The optimal candidate violates the low ranking constraint but satisfies the high ranked and undominated markedness constraint *CO$_{ONSET.}$ Candidate (b) violates the sonority profile of Lubukusu language because it has a sonority reversal; the more sonorous glide precedes the less sonorous fricative. The two final candidates violate the faithfulness constraints that demand input-output correspondence through deletion in (c) and epenthesis in (d). These constraints are ranked higher than *CG$_{ONSET}$, hence render these candidates sub-optimal in spite of having just one violation mark. It should be noted that candidate (b) actually violates the SSP (Kager, 1999; Morelli, 2003), which requires that between any member of the syllable margin and the peak, a sonority rise must occur. This constraint is normally fully observed in the language because it is an undominated constraint. To recast the above tableau, we replace *CO$_{ONSET}$ with SSP because the violation incurred by candidate (b) is in fact a sonority reversal.

(11b) /fwa/ → [fwa]'die'

/fwa/	SSP	MAX-IO	DEP-IO	*CG$_{ONSET}$
a. ☞[fwa]				*
b.[wfa]	*!			
c.[wa]		*!		
d.[fu.wa]			*!	

Table 9

Candidate evaluation results in exactly the same optimal candidate as in the preceding tableau. Note that the rationale for introducing SSP in place of *CO$_{ONSET}$ is based on the realization that it is possible to violate the *CO$_{ONSET}$ without violating SSP. For example, having a voiceless plosive followed by a voiceless fricative [*ts, *pf] does not violate SSP but *CO$_{ONSET.}$ The SSP is based on the universal sonority hierarchy that accords each sound some sonority index depending on some acoustic properties that make sounds have the propensity for voicing, among other properties. From the universal sonority hierarchy, (Selkirk, 1984) it is possible to build a language specific sonority hierarchy of Lubukusu which offers some predictions of possible clusters and therefore, onset syllabification. This is conceivable because the sonority properties of sounds are inherent depending on the sound types (based on manner of articulation and laryngeal state/voicing, etc). For example, universally vowels are inherently more sonorous than consonants; sonorants are inherently more sonorous than obstruents and voiced sounds are inherently more sonorous than voiceless sounds. This is based on the universal sonority scale as follows:

(12) Universal sonority scale (Selkirk, 1984; Parker, 2002; Morelli, 2003)

Oral stops	Fricatives	Nasals	Liquids	Glides	Vowels
Least sonorous					Most sonorous

From the foregoing universal sonority scale, we construct a sonority scale of Lubukusu based on its phonemic inventory including voicing distinctions among the obstruents.

(13a) Lubukusu sonority scale

voiceless plosives,	prenasal stops	voiceless fricatives,	voiced fricative,	pure nasals,	liquids,	glides,	vowels
[p,t,c,k]	[^{m}b, ^{n}d, ^{ɲ}ɟ,^{ŋ}g]	[f,s,x]	[β]	[m,n,ɲ,ŋ]	[l,r,]	[j, w]	[a,e,i,o,u]
Less sonorous							More sonorous

Detailed sonority distinctions can be provided by, for example, assigning the liquids different sonority index; the lateral is less sonorous than the trill. Among the vowels, finer distinction in sonority is made based on height; low vowels are universally more sonorous than the mid vowels, which are in turn more sonorous than the high vowels based on acoustic studies (Raphael et al., 2007). This gives us the final analysis of Lubukusu sonority scale in which the least sonorous sounds are the voiceless plosives [p, t, c, k] while the low open vowel [a] is the most sonorous. In the following hierarchy, we assign a sonority index to each sound (phoneme) of Lubukusu ranging from 1(one), the least sonorous, to 11(eleven), the most sonorous based on the Lubukusu phonemic inventory.

(13b) Lubukusu sonority hierarchy

Sound	Sonority Index	
		Most sonorous
[a]	11	
[e,o]	10	
[i,u]	9	
[j,w]	8	
[r]	7	
[l]	6	
[m,n,ɲ,ŋ]	5	
[β]	4	
[f,s,x]	3	
[^{m}b,^{n}d,^{ɲ}ɟ,^{ŋ}g]	2	
[p,t,c,k]	1	
		Least sonorous

In the examination of consonant clusters, the role of sonority becomes apparent due to the requirements of Sonority Sequencing Principle (SSP). The sonority index of the above sounds, especially the consonants, plays a role in onset clusters syllabification. The glide has the highest sonority hence if it is preceded by any other consonant in the CG onset, SSP is invariably observed because there is a rise in sonority in the cluster. It also predicts that only [+sonorant} sounds can occupy the nucleus of the syllable, hence the presence of syllabic nasals (are [+sonorant]). In the analysis of cluster harmony, we propose a ranking in which the faithfulness constraints of MAX-IO and DEP-IO are higher ranked because neither deletion nor epenthesis is used to avoid the consonant cluster. These constraints dominate the markedness constraints; *CG$_{ONSET,}$ this is the only accepted cluster, but not the *CO$_{ONSET,}$ because there is no cluster of the form CO (Consonant, Obstruent). The permissible cluster satisfies the SSP as an inviolable constraint hence the following ranking is adopted: SSP, *CO$_{ONSET}$ $\gg$ MAX-IO, DEP-IO $\gg$ *CG$_{ONSET}$.

(11c) /fwa/ →[fwa]‘die’

/fwa/	SSP	*CO	MAX-IO	DEP-IO	*CG
a. ☞[fwa]					*
b.[wfa]	*!	*			
c.[wa]			*!		
d.[fi.wa]				*!	

Table 10

The winning candidate violates the lowest ranked constraint. Candidate (b) is sub-optimal in incurring a fatal mark for violating the two undominated constraints. Candidate (c) violates the faithfulness constraint against deletion although it improves on markedness by removing the cluster resulting in the unmarked CV. The anti-cluster constraint is ranked below the anti-deletion MAX-IO making the resultant CV sub-optimal. The same observation is made in respect to candidate (d) which inserts an epenthetic vowel to remove the cluster but violates DEP-IO. This analysis is relevant in the examination of the rest of the onset clusters. The general universal constraint against clusters is *COMPLEX. This constraint can be relativized to specific positions in the syllable so that there are specific anti-cluster constraints targeting onsets and codas. In this study, we adopt *COMPLEX$_{ONSET}$ (Kager 1999; McCarthy 2002, 2004) because this is the only position with a cluster in Lubukusu. This constraint states that no more than one consonant may be associated with the onset position of the syllable. In the ranking, it is observed that CG cluster is permissible in Lubukusu hence these two constraints should be dominated by some faithfulness constraints that require underlying input segments to be parsed. Accordingly, the ranking should be: SSP, *CO ≫ MAX-IO, DEP-IO ≫ *CG, COMPLEX$_{ONSET}$. We evaluate the CG cluster in /li-kja/ → [li.kja] 'foot crack'

(14a) /likja/ →[likja]'foot crack'

/likja/	SSP	*CO	MAX-IO	DEP-IO	*CG	*COMP$_{ONSET}$
a. ☞[li.kja]					*	*
b.[li.jka]	*!	*				*
c.[li.ja]			*!			
d. [li.ki.ja]				*!		

Table 11

The tableau indicates that the violation of the new low-ranked constraint against the complex onset is of no consequence because the optimal candidate violates this constraint but with little effect on its harmony *vis-a-vis* other competitors. Candidate (b) actually performs worse on this constraint because metathesis of the onset consonants does not change the demands of the anti-cluster constraint. It is harmonically bound by the optimal candidate that violates just a subset of the violations incurred by candidate (b). The remaining candidates (c) and (d) do not violate *COMPLEX$_{ONSET}$ but because they have already violated constraints above it, they are sub-optimal. Similar result would be obtained if we replaced the markedness constraints *CO and *CG with one undominated faithfulness constraint (MAX-IO (CG) or PARSE-CG) leaving the rest of the constraints and their ranking intact.

(14b) /likja/ →[likja]'foot crack'

/likja/	SSP	MAX-IO (CG)	MAX-IO	DEP-IO	*COMP$_{ONSET}$
a. ☞[li.kja]					*
b.[li.jka]	*!				*
c.[li.ja]		*!	*!		
d. [li.ki.ja]				*!	

Table 12

Note that MAX-IO (CG) is satisfied by candidates (b) and (d) regardless of precedence relations and epenthesis respectively. In conclusion, Interaction of markedness constraints; *CO, SSP, *CG and COMPLEX$_{ONSET}$ on one hand, and the faithfulness constraints on the other hand, enable us to determine the optimal cluster of the Lubukusu syllable onset. Though the constraints are universal, the language-particular ranking proposed is adequate in selecting one optimal candidate. The surface oriented nature of determining the permissible cluster is clearly superior to rule-ordering that derives non-occurring/unattested onset clusters. In particular, sonority requirement of SSP is responsible for the preference of the CG onset cluster; regardless of the initial consonant; the following glide has the highest sonority among consonants ensuring the clusters have a rising sonority. Reference to sonority is thus inevitable in accounting for the preference of the CG onset cluster. Some syllables are unmarked (CV) while others have clusters (CCV) all resulting from the interaction between the opposing constraints.

3.3. The V (V) Syllable Structure

Lubukusu has syllables with onsets but also has onsetless syllables or syllables with zero onsets. In Optimality Theory, this is explained purely in terms of constraint interaction, such that if the underlying input form has no onset consonant, then the output will surface faithfully without an onset. This is possible only if the faithfulness constraints dominate markedness constraints demanding that syllables have onsets. There are syllables that have vowels at word initial, medial and final positions including monosyllables, bisyllabic and polysyllabic prosodic words either with short or long vowels. The data in (15) below gives examples of word initial onsetless syllables.

(15) The [V] syllable structure types

(i) Input	Output	Gloss	(ii) Input	Output	Gloss
(a) /ao/	[a.o]	'there	/ano/	[a.no]	'here'
(b) /eno/	[e.no]	'this side'	/ea/	[e.a]	'it gives'
(c) /ixa/	[i.xa]	'descend'	/ima/	[i.la]	'take to'
(d) /ona/	[o.na]	'heal'	/oja/	[o.ja]	'you burn'
(e) /ula/	[u.la]	'subdue'	/una/	[u.na]	'pierce'

While the data (15) show initial syllables without an onset, from our previous discussion of CV syllable structure (see 3.1), syllables without onsets are considered marked. This implies that some markedness constraints demanding onsets are dominated in the constraint ranking in Lubukusu. Conversely, there must be some faithfulness constraints that dominate such markedness constraints. This analysis is to determine these constraints based on the above data.The constraint ONSET is relevant because it has to assess the presence or absence of an onset. None of the above data has a coda consonant in line with syllable structure typology examined earlier. This is because the *CODA constraint is consistently enforced in Lubukusu. The syllables emerge without onsets and no attempt to insert a consonant or delete the onsetless syllable is due to the demands of the DEP-IO and MAX-IO constraints. These constraints must dominate the markedness constraint against onsetless syllables; the ONSET.
Finally, all the relevant syllables are headed by the vowels in the nucleus position due to the *PEAK-C.However, nasal consonants can occupy syllabic peak position, therefore, *PEAK-C is ranked below some faithfulness constraints. The ranking proposed for these constraints is; *CODA ≫ MAX-IO, DEP-IO ≫ ONSET, *PEAK-C.

(16)/ula/ → [u.la]'subdue'

/ula/	*CODA	MAX-IO	DEP-IO	ONSET	PEAK-C
a.☞ [u.la]				*	
b.[ul.a]	*!			*	
c.[la]		*!			
d.[lu.la]			*!		
e.[u.l.a]				**!	*

Table 13

The tableau reveals that as long as the markedness constraints (ONSET and *PEAK-C) are dominated by the faithfulness constraints (MAX-IO and DEP-IO), the onsetless vowels heading syllables are allowed in the phonology of Lubukusu. The single consonant in the input can only be syllabified as the onset of the second syllable based on the MOP (Maximum Onset Principle) if it is preceded by a vowel in the input. This ensures that such a consonant cannot be syllabified as a coda consonant in the output. This explains why candidate (b) would never be optimal based on this ranking. Unmotivated violations are the case in the candidates that either insert or delete segments; candidates (c) and (d). They incur violation marks because these changes in the input form do not improve their harmony. Onsetless syllables can also be composed of long vowels. As the following data indicate, there are long vowels spanning the entire vowel space of the canonical inventory of five vowels of Lubukusu.

(17) The [VV (V:)] syllable structure

(i) Input	Output	Gloss	(ii) Input	Output	Gloss
(a) /a:na/	[a:.na]	's(he) gives'	/a:ja/	[a:ja]	's(he) hunts'
(b) /e:ji/	[e:ji]	'an oxen'	/e:la/	[e:la]	'breath(V)'
(c) /i:ra/	[i:ra]	'that kills'	/i:ma/	[i:ma]	'that stands'
(d) /o:ja/	[o:ja]	'seduce'	/o:na/	[o:na]	'chase'
(e) /u:na/	[u:na]	'get up early'	/u:ja/	[u:ja]	'migrate'

The same analysis adopted for the short onsetless syllables is pertinent with respect to the long vowels. As it may be familiar up to this stage, vowel length is contrastive and, therefore, it cannot be changed without neutralizing the contrast between the words having the long and short vowels. This principle is encoded in two constraints, MAX-IO(μ) and IDENT-IO (length). Furthermore, it is assumed that these vowels emerge without onsets because the ONSET constraint is dominated by the above constraints in addition to the DEP-IO which prohibits insertion of consonantal onsets. In addition, both the short and long vowels have distinct meaning in the language and, therefore the constraint; CONTRAST, is responsible for ensuring that this semantic distinction is maintained. The following pairs of words differ only in terms of the length of the initial vowel.

(18) Contrast between pairs of short and long vowels

(a)Short initial vowels			(b) Long initial vowels		
Input	Output	Gloss	Input	Output	Gloss
(i) /ana/	[a.na]	‘give’	/a:na/	[a:.na]	‘s(he) gives’
(ii) /ela/	[e.la]	‘get extinct’	/e:la/	[e:.la]	‘breath(V)’
(iii) /ica/	[i.ca]	‘come’	/i:ca/	[i:.ca]	‘it comes’
(iv) /oja/	[o.ja]	‘get burned’	/oja/	[o:.ja]	‘seduce’
(v) /una/	[u.na]	‘pierce’	/u:na/	[u:.na]	‘get up early’

With the foregoing contrast in mind, it is apparent that shortening or lengthening of any of the above pairs of words will result in both phonological (length) and semantic (meaning) neutralization. This is against the constraint CONTRAST and other faithfulness constraints. In the evaluation that follows, we use MAX-μ-IO only in the hierarchy because it has the same effect with IDENT-IO$_{LENGTH}$ in maintaining vowel length during the input-output mapping. *CODA constraint maintains its top ranked position in the hierarchy. The *PEAK-C constraint is meant to ensure that the medial consonants are syllabified as onsets and not as syllable nucleus.

The ranking *CODA, CONTRAST ≫ MAX-μ- IO, DEP-IO ≫ ONSET, *PEAK-C is proposed in the evaluating the harmony of the input word /o:ja/ →[o:.ja] ‘seduce’.

(19)/o:ja/ →[o:.ja] ‘seduce’

/o:ja/	*CODA	CONTRAST	MAX-μ-IO	DEP-IO	ONSET	*PEAK-C
a.☞ [o:.ja]					*	
b.[o:j.a]	*!				*	
c.[o.ja]		*!	*		*	
d.[ja]			*!			
e.[lo:.ja]				*!		
f. [o:.j.a]					**!	*

Table 14

From the tableau, key inferences can be made. First, reducing the long vowel to a short one results in a vowel similar to a form that already exists in the lexicon of the language. This is in violation of the contrast that exists between the two forms. This is the reason why candidate (c) cannot be optimal. In addition, the candidate also incurs unmotivated violation of MAX-μ-IO. Deletion does result in reduction of the mora count contrary to the mora preservation principle requirement that moras should be preserved in the deletion process. There is no other segment to take on the mora of the deleted vowel.It is important that the markedness constraints are ranked below the faithfulness constraints MAX-μ-IO and DEP-IO, otherwise, candidate (a), the true output of the language, would be rendered sub-optimal. This is because candidates (d) and (e) violate one constraint each, similar to the optimal candidate. What decides the optimal candidate is the ranking because these two candidates violate a high ranked faithfulness constraint. The violations by candidates (b) and (f) are totally gratuitous because they arise from infelicitous syllabification that introduces a coda and a syllabic consonant that does not qualify for the peak/nucleus position. In essence, it can be observed that language-particular ranking of universal constraints determines the emergence of long/short vowels if they match their correspondents in the inputs. Furthermore, onsetless syllables are permitted in the language because the ONSET constraint is dominated by input/output faithfulness constraints.

3.4. The N̩ Syllable Structure

Lubukusu allows nasals to function as syllabic consonants; [N̩]. This is also observed in other languages including English in which sonorant consonants are allowed to occupy syllable peaks. In such cases, syllabic consonants are often used to break unacceptable onset or coda clusters. These sonorants may be promoted to the syllable peak position. Another reason why nasals in Lubukusu have this privileged status is because they are moraic (Mutonyi, 2000; Nandelenga, 2013). The circumstances when nasals can be syllabic vary across languages, however, in Lubukusu, only one environment engenders this type of syllabification: when two nasals follow each other. In Lubukusu, nasals have four places of articulation in the oral cavity resulting in four types of nasals. These nasals differ only in the dimension of place of articulation parameter. The four nasal types are bolded in these examples.

(20) Lubukusu nasals

Place	Nasal type	Example	Gloss
(i)Lips (both)	[m], a voiced bilabial nasal stop	[**m**a.ji]	‘mother’
(ii) Alveolar ridge	[n], a voiced alveolar nasal stop	[**n**a.**n**u]	‘who?’
(iii) Hard palate	[ɲ], a voiced palatal nasal stop	[**ɲ**a.xa]	‘suffer’
(iv) Soft palate	[ŋ], a voiced velar nasal stop	[**ŋ**o.la]	‘prophesy’

In Lubukusu, there is a nasal archiphoneme /N/ sound that, also, morphologically signals the first person singular morpheme prefix (the 1st person singular pronoun ‘I’ of English). This sound is referred to as an archiphoneme because underlyingly it is unspecified for place of articulation hence represents all the nasals of the language. It is realized differently depending on the place of articulation of the following consonant. This is because it has long been argued that nasals are underlyingly unspecified for the feature [place]. Consequently, they acquire the place of articulation of the following consonant sound in assimilation processes. Whenever the /N/ archiphoneme is prefixed to a stem beginning with a nasal, it is transformed into a syllabic nasal in Lubukusu. The data (21) show that if the prefix nasal is followed by another nasal, it becomes syllabic.

(21) Syllabic Nasals in Lubukusu.

Prefix 'I'+ stem	Surface form	English gloss
(a)(i) /N-nula/	[n̩.nu.la]	'I snatch'
(ii)/N-naβa/	[n̩.na.βa]	'I weave'
(b)(i)/N-mala/	[m̩.ma.la]	'I complete'
(ii)/N-miɲa/	[m̩.mi.ɲa]	'I overwhelm'
(c)(i)/N-ɲala/	[ɲ̩.ɲa.la]	'I can/ am able'
(ii)/N-ɲola/	[ɲ̩.ɲo.la]	'I get'
(d) (i)/N-ŋona/	[ŋ̩.ŋo.na]	'I make'
(ii)/N-ŋola/	[ŋ̩.ŋo.la]	'I prophesy'

From the data, it is apparent that any sequence of two nasals cannot be syllabified in the onset position of the same syllable because they violates the SSP of the language and goes against the constraint that bans any onset cluster except the CG type. Typically, a NN cluster violates the *CN markedness prohibition of the markedness scale constructed for the clusters in (10) above. Only the CG onset was said to be admissible; being the lowest ranked in markedness, and therefore, violable. Two nasals in the onset position create a sonority plateau. On the other hand, it could be argued that the prohibition of NN onset cluster is based on OCP (Obligatory Contour Principle) effects (Myers, 2004). This is an active constraint against adjacent melodies (sounds/segments) of similar quality or features. OCP forbids representations in which identical elements are adjacent. In OT, OCP has been recast into a constraint responsible for a number of dissimilatory effects. Finally, the markedness of NN sequence is probably because the language does not have geminates in its phonemic inventory. Consequently, a NN sequence cannot be syllabified as a geminate. From the available phonological repair mechanisms of deletion, insertion, fusion and dissimilation, none is utilized; instead, the initial nasal is promoted to the syllable peak as a syllabic nasal.

The data shows that neither epenthesis nor deletion is an option in avoiding the NN sequence. In this respect, MAX-IO and DEP-IO constraints are invoked besides *PEAK-C. Two constraints that could be working in synchrony or independent of each other are OCP (Myers, 2004; Yip, 2007; McCarthy, 2002, 2004) and *GEMINATE (Fery & van Vijver, 2003) are at the core of the *NN prohibition. These two constraints state that adjacent identical elements are prohibited (no identical adjacent segments) and geminates are disallowed respectively. Another constraint that is relevant is the undominated *CODA which is not violated in the cluster repair mechanism; neither the first nor the second nasal is syllabified as a coda consonant.

Finally, it is possible for the grammar of the language to change the second nasal into a glide resulting in the acceptable CG cluster. However, this option is not exploited implying that a faithfulness constraint against segmental feature change is in operation. This constraint must originate from the IDENTITY family of constraints; IDENT-IO$_{NASAL}$ which prohibits any change of the [+ nasal] feature in the input to [-nasal] in the output. The ranking recommended is as follows: two constraints, *CODA and OCP, dominate the faithfulness constraints MAX-IO, DEP-IO and IDENT-IO (nasal). In turn these three constraints dominate the markedness constraints ONSET and *PEAK-C. The constraint; *GEMINATE, is left out because it has the same effect as OCP in this context.

(22) /N-nula/ →[n̩.nu.la] 'I snatch'

/N-nula/	*CODA	OCP	MAX-IO	DEP-IO	IDENT-IO ($_{NAS}$)	ONSET	PEAK-C
a.☞[n̩.nu.la]							*
b. [n.nu.la]	*!						*
c. [nnu.la]		*!					
d. [nu.la]			*!				
e. [ni.nu.la]				*!			
f. [nwu.la]					*!		

Table 15

The result from the foregoing tableau indicates that markedness constraints will rule out any syllable that has identical segments because of the effects of OCP which dominates faithfulness constraints hence disqualifying candidate (c) as being sub-optimal. The *CODA is ranked as an undominated constraint and inviolable, consequently disqualifying candidate (b). Neither epenthesis nor deletion to provide the canonical CV syllables is utilized because ONSET is dominated by faithfulness constraints against deletion and epenthesis. Similarly, the input nasal segment cannot be changed into a glide to match the CG cluster that is an acceptable onset form in Lubukusu. This is ruled out by the constraint requiring outputs to match their input correspondents in terms of phonological feature values. The constraint IDENT-IO (nasal) evaluates this mismatch as sub-optimal because it is ranked above *CG$_{ONSET}$ which would have evaluated the [nwu] in candidate (f) as permissible.

In a nutshell, the proposed constraints and ranking yield a syllabic nasal as the best repair given the markedness of a *NN sequence. The constraint against syllabic consonants is overridden by the markedness of a nasal-nasal sequence and a nasal, being a sonorant, qualifies for syllabic peak position. However, a further test is warranted to be certain that these constraints cannot yield non-recurrent candidate forms or lead to multiple optimal outputs. This is done through construction of a tableau within a tableau (*tableau des tableaux*). Based on the four syllable types in the language, the comparative test uses input words from all the four syllable types utilizing similar constraints and ranking.

(23): The four syllable types

Type	Input	Output	Gloss
(i) CV(V)	/liila/	[li:.la]	‘eat with’
(ii) CCV(V)	/mu-ana/	[mwa.na]	‘you scream’
(iii) V(V)	/ona/	[o.na]	‘heal’
(iv) Ṇ	/N-naβa/	[ṇ.na.βa]	‘I weave’

The four syllable types and examples of words are used and the constraints we have already invoked in the analysis of these syllable types are used leaving out those that may be redundant in having the same effects. Others may be merged so that we use the general rather than the specific without compromising their ability to select a distinct optimal candidate as follows; *CODA, SSP ≫ MAX-IO, DEP-IO, IDENT-IO ≫ ONSET, *PEAK-C, *COMP$_{ONSET.}$ The ranking must be maintained from tableau (22) because this is at the core of an OT analysis.

(24) The *tableau des tableaux* for all syllable types

(i)	CV:	/liila/	[li:.la]	‘eat with’
(ii)	CCV:	/mu-ana/	[mwa.na]	‘you scream’
(iii)	V:	/ula/	[o.na]	‘heal!’
(iv)	Ṇ	/N-naβa/	[ṇ.na.βa]	‘I weave’

/liila/	*CODA	SSP	MAX-IO	DEP-IO	IDENT-IO	ONSET	*PEAK-C	*COMP $_{ONSET}$
a. ☞[li:.la]								
b.[li.la]			*!		*			
c.[li:.li.la]				*!				
d. [li:l.a]	*!					*		
/mu-ana/								
a.☞[mwa.na]								*
b.[mwa:.na]					*!			*
c.[ṃ.wa.na]							*!	
d.[wa.na]			*!					
/ula/	*CODA	SSP	MAX-IO	DEP-IO	IDENT-IO	ONSET	*PEAK-C	COMP $_{ONSET}$
a. ☞[u.la]						*		
b.[u:.la]					*!	*		
c.[ku.la]				*!				
d. [la]			*!					
/N-na.βa/								
a. ☞ [ṇ.na.βa]							*	
b.[nna.βa]		*!						*
c.[na.βa]			*!					
d. [ni.na.βa]				*!				

Table 16

The result from the *tableau des tableaux* (24) mirrors the previous analysis, especially at the level of constraint choice and ranking; there is no change in the optimal candidate for each syllable type. By adopting a fixed ranking schema throughout the analysis, we could argue that the syllable structure of Lubukusu is accounted for by these constraints based on the ranking. One pertinent observation is that we could limit the number of competing candidates in the tableaus in which the winning candidates do not violate any constraint such as tableau one [li:.la). On the ranking, it is worth noting that there must be crucial ranking between *COMPLEX$_{ONSET}$ and *PEAK-C, otherwise, candidates (a) and (c) of tableau two would match in violation marks. Candidate (c) of the same tableau is worse because it is not possible to have a syllabic nasal except if it is followed by another nasal. The phonological environment does not justify a nasal [ṃ] before a following glide. In tableau, three, the role of faithfulness constraints and their ranking is crucial in determining the optimal candidate. In tableau four, the SSP and the faithfulness constraints are central, neither epenthesis nor deletion results in optimal outputs.

4. Summary, Conclusion and Further Issues

In essence, the *tableau des tableaux* show that it is possible to describe and account for the entire syllable structure typology of the language through a limited set of rankable and violable universal constraints. The entire syllable types can be evaluated by the same constraint hierarchy, a fundamental thesis in OT. In the light of our stated objective, we have been able to describe the syllable structure of Lubukusu in terms of constraint interaction by determining a particular ranking that is Lubukusu specific. The analysis reveals that universal constraints, when appropriately identified and ranked, are able to account for the syllable structure of Lubukusu. Markedness constraints demanding syllable wellformedness interacting with faithfulness constraints, that prohibit any disparity between input and output, are able to adequately account for the syllable structure of Lubukusu. Markedness constraints *CODA, *PEAK-C, ONSET and ALIGN-R/L interacting with faithfulness constraints MAX-IO, DEP-IO, IDENT-IO, UNIFORMITY-IO, LINEARITY were able to determine the syllable structure of Lubukusu. The CV- syllable structure is a result of markedness constraints dominating some faithfulness constraints. When *CODA, *PEAK-C, ONSET, ALIGN-R/L and *COMPLEX$_{ONSET}$ outrank faithfulness constraints MAX-IO, DEP-IO, IDENT-IO, UNIFORMITY-IO and LINEARITY, only the CV syllable structure will be permitted. Lubukusu has open syllables only based on the ranking in which the constraint *CODA is undominated thus inviolable.

Similarly, findings on the syllable structure show that the Lubukusu language has onsetless syllables, this implies that the markedness constraint; ONSET, is not undominated in the general phonology of the language. That is, in the absence of other markedness constraints, an underlying onsetless syllable must be mapped faithfully on to the surface output.In this regard, the rest of the markedness constraints are not applicable except the ONSET which is dominated by MAX-IO and DEP-IO leading to the emergence of the [V] type of syllables. In addition, it is possible to account for the presence of the CCV type of syllables. The CCV syllable type may surface optimally given the undominated *CODA because it is an open syllable. Secondly, the CCV syllable structure is strictly CGV due to SSP constraint that militates against sonority reversal or plateau. The constraint (*COMPLEX$_{ONSET}$), must be dominated by a faithfulness constraint demanding the parsing of a CG onset sequence (such as MAX- CG$_{ONSET}$).

Conversely, an onset markedness scale of the type *CO > *CN > *CL > *CG, which reads 'is more marked' implies that a Consonant Glide onset cluster is less marked and would be tolerated than the more marked clusters above it in the hierarchy. Given an input with a different sound in the post-onset position, the markedness scale predicts that it will not surface as an optimal output. However, any underlying CG onset will be parsed faithfully onto the surface because of the low ranking *CG and or the top ranked PARSE CG/ MAX-CG$_{ONSET}$ constraints.

The findings regarding the syllabic nasal [N̩] show that the language allows nasals to form a syllabic peak. These syllabic nasals emerge purely from constraint interaction of markedness and faithfulness. In Lubukusu, only a CG onset sequence is licit and, therefore, whenever there is an onset of the form NN (nasal-nasal), it has to be repaired. The language invokes markedness constraints against such a sequence in the form of either SSP, *GEMINATE or OCP, dominating the anti-consonant peak markedness constraint *PEAK-C. If the *PEAK-C constraint is dominated by any one of these constraints, it will rule out a /N+N/ onset sequence. The available repair strategy is to promote the initial nasal in the nasal cluster into the syllable peak position as a syllabic nasal consonant. Further findings from this syllable type show that nasals, being sonorants, have high sonority and, therefore, are suitable syllabic consonants. However, there are some outstanding issues relating to too many solutions. It remains indeterminate what constraints are responsible for the unmarked CG cluster. There is redundancy in whether it is the low ranked *CG or the top ranked MAX-IO (CG) or PARSE-CG that ensures only this cluster is licit. Equally, the emergence of the syllabic nasal could be attributed to the demands of either OCP, *GEMINATE, SSP or *NN (*CN) markedness constraints. This over-generation of constraints militates against the principle of computational economy that is at the core of the adequacy required of any linguistic theory. Further research is needed in this regard especially with respect to learnability of what seems like redundant constraints.

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