

Defining the prosodic word with segmental processes in Dagbani

FUSHEINI HUDU* 

Department of Linguistics, University of Ghana, Legon, Ghana

Received: November 8, 2020 • Revised manuscript received: December 14, 2021 • Accepted: December 14, 2021

Published online: January 28, 2022

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ABSTRACT

Few studies have explored the relevance of metrical structures in segmental processes. This paper shows that Dagbani (Gur, Ghana), has a prosodic word dominating a trochaic foot which licenses segmental processes and phonotactics. The foot is the domain for marked vowels and unmarked consonants. The prosodic word regulates the sequencing of syllables of different degrees of sonority and weight within a word. The Optimality Theoretic analyses make use of classical metrical theory and prosodic principles used in defining the prosodic word in stress languages to highlight the typological relevance of these principles and the prosodic universality of these metrical structures.

KEYWORDS

prosodic word, trochaic foot, mora, segmental processes, Dagbani

1. INTRODUCTION

In a recent study of Dagbani phonology, [Hudu \(2010\)](#) argues that Dagbani (a Gur language of Ghana) has a weight-sensitive prosodic system with a strictly bimoraic foot regulating vowel distributions in the language. He argues that the distribution of [–ATR] vowels is conditioned by the weight of the syllable within the morphological unit in which the vowel occurs. In providing an analysis of the vowel system of the language, Hudu argues for recognising the role of the mora, a prosodic unit that had hitherto not been considered by previous researchers on the language or claimed to be of no relevance in the analysis of Dagbani. His analyses of Dagbani

* Corresponding author. E-mail: fahudu@ug.edu.gh

vowel distribution show that non-low [–ATR] vowels in the language [i, u, ə, ε] require a morphological domain with a minimum of two morae to licence their distribution. These vowels do not surface in a phonological word that has fewer than two morae. Hudu concludes that the metrical foot is an active phonological unit in the language.

This paper shows that in addition to an active mora and a prosodic foot, Dagbani has a prosodic word dominating all relevant units of the prosodic structure. The paper defines the prosodic word in Dagbani with all the components that are attested in a stress language, including the prosodic foot, foot structure and headedness, as well as the alignment of the boundaries of prosodic units with those of morphological units. It demonstrates that the active role of prosodic bracketing and the prosodic foot in Dagbani is manifested in other aspects of Dagbani morphophonology beyond Hudu's (2010) observations. The issues analysed here are of four broad categories. These are phonotactics, segmental processes, the structure of morphological units and morphophonological regularities. In Dagbani vowel distribution, non-low [–ATR] vowels only surface in a domain of two or more morae. At the segmental phonological level, a bimoraic trochaic foot plays an active role in licensing place-changing phonological processes. The application of these phonological processes shows that mora-footing proceeds from left to right. Word structure in the language is regulated by a weight-sensitive prosodic structure. Within the morphophonology, moraic structure is aligned with morphological structure as foot boundaries are aligned with morpheme boundaries.

The rest of this introductory section reviews the literature on the role of metrical structure in segmental processes, presents a background on Dagbani segments, the morphophonology as well as the relevant prosodic theories used for this study. It also includes detailed evidence for the active role of the mora in Dagbani phonology. Section 2 focuses on the role of the prosodic foot in vowel distribution, as presented by Hudu (2010). Beyond the review of relevant literature, the analysis in the rest of the paper is presented in a bottom-up fashion. Section 3 presents the descriptive and theoretical analyses of the foot as the prosodic domain that licences the loss of buccal consonantal place features. I also discuss foot structure, arguing that the language has a trochaic foot. Section 4 is devoted to defining the prosodic word and its boundaries using the patterning of syllables of different weight within the word and evidence from the application of debuccalisation. The analyses show that when two different words or lexical roots are compounded, each word or lexical root forms a separate prosodic word, as the prosodic word does not cross the boundaries of two different lexical roots. It also shows that derivational and reduplicant affixes are not part of the prosodic word. The section also discusses the direction of footing syllables within the prosodic word.

1.1. The role of the metrical structure in non-prosodic phonology

The existence of metrical structures in non-stress languages, including most African languages, is a largely neglected subject. Most of the few studies that explore the existence of metrical feet and prosodic bracketing in African languages focus on tone (e.g. Pulleyblank 1986; Leben 2002; Bickmore 2003; Weidman & Rose 2006; Pearce 2006; Green 2010; Rose & Jenks 2011). Studies that explore the role of metrical structures in the non-prosodic phonologies of African languages are much rarer. With few exceptions (e.g. Akinlabi & Urua 2002; Anttila & Bodomo 2019), these observations relate to Nilotic languages of East Africa.



While the prosodic foot is recognised as a category of sound organization (e.g. Hayes 1980, 1987, 1995; Nespor & Vogel 1986; McCarthy & Prince 1986; Halle & Vergnaud 1987), it has primarily been used for the analysis of prosodic units and phenomena. Because the prosodic foot in metrical theory plays the role of rhythmic organisation of phonological units, it does not readily come to mind in analyses of segmental phenomena, especially in languages that lack stress and rhythm. In such languages, it is often assumed to play no role or even not to exist.

There have been some notable exceptions to this in the past few decades, including Kiparsky (1979), Prince (1980) and Flemming (1994) (see Vaysman 2009 and Bennett 2012 for extensive discussion and case studies). Kiparsky argues that “. . .the foot establishes the domain of close contact between adjacent segments in English” serving as a superordinate structure that binds processes that are “supposedly characteristic of ambisyllabic consonants” (Kiparsky 1979, 439). Harris (2004) presents a similar argument in a study that rejects ambisyllabicity. Prince (1980) sees the prosodic foot as “. . .an ineliminable category of phonological description (the domain of rules, both segmental and prosodic”. Flemming (1994) shows that assimilation can be analysed as autosegmental spreading within the metrical foot. While these may be viewed as exceptions, they are mostly claims about stress languages, for which the metrical foot is independently established.

In the study of African languages and non-stress languages in general, few studies have noted the role of metrical feet in segmental and morpho-phonological analyses. Akinlabi & Urua (2002) presents a detailed analysis of suffixation in Ibibio, a Cross-River language of Nigeria, arguing that phonological generalisations regarding root-suffix structures can only be achieved by assuming a disyllabic prosodic foot. Pearce (2003) argues that Kera, a Chadic language, has an iambic foot structure that serves as one of three harmonic domains in the language. The other harmonic domains are the prosodic word and the phonological word. Green (2010) shows that the foot plays a crucial role in driving segmental reduction in Bamana (Bambara), a Mende language of Mali. Downing (2004, 2010) provides surveys of extensive literature that point to the relevance of the prosodic foot in segmental phonotactics in Khoisan languages of Southern Africa and Delta Cross languages of Nigeria. She shows that the asymmetries in the distribution of vowels and consonants in various morphological units cannot be analysed without reference to metrical foot structure. Dimmendaal (2012) and Franich (2018) make similar arguments in their respective studies on Nilotic languages and Medumba, a Grassfields Bantu language of Cameroon.

The relevance of prosodic bracketing in Dagbani is manifested in vowel phonotactics, the application of segmental phonological rules, the sequencing of syllables of different degrees of sonority, and the sequencing of syllables of different weight profiles within a word. Some of the just noted observations on the relevance of the prosodic foot to analysis of non-prosodic phonological rules apply to Dagbani. In addition to the vowel distribution already noted by Hudu (2010), place-changing rules such as debuccalisation affecting consonants of different place specifications take the foot as their domain of application. In such rules, the trigger and target of the rule are required to be part of the same foot. Within the putative prosodic foot that licences the phonological processes, mora-contributing units (vowels, syllabic consonants, coda consonants) have a unique structure, as the unit occupying the left branch is of a higher prominence, and more active or dominant over the unit occupying the right branch. It is the vowel that triggers the phonological processes under discussion in this paper. Thus, while the more prominent syllable does not bear stress, the structure of the prosodic foot under discussion



in this paper displays other relevant properties of a trochaic foot in stress languages. The sequencing of syllables at the word level also mirrors the foot-level structure. A light syllable does not precede a heavy one in words of two or more syllables.

The study is largely descriptive, but employs various theories, theoretical assumptions, and approaches in the analyses of the issues under discussion, including Optimality Theory (OT) (Prince & Smolensky 1993; etc.). The overarching goal of the paper is to situate the phenomena discussed in this paper within a typological perspective and not necessarily to demonstrate the relative strength of the theories and approaches that are used in the analyses. This overarching goal is what influenced the level of descriptive and analytical detail and the choice of theories and approaches to use. Optimality Theory in particular, plays a minimal role in arriving at the conclusions. Its choice is aimed at demonstrating that the same constraints regulating metrical units and processes are at the heart of the segmental processes discussed here. The study is agnostic about the relevance of alternative theories that could be employed to analyse these phonological processes and patterns.¹

1.2. Dagbani segments and tone

From recent studies of Dagbani phonology (Dakubu 1997; Olawsky 1999; Hudu 2010, 2013, 2014a, b, 2016), the language is shown to have 11 contrastive vowels: 6 short and 5 long. Contrastive vowel features are length, height and backness. There is an active tongue-root vowel harmony, which produces a surface [a̠], a vowel that otherwise does not surface in the language. The vowels [u, e, o, a̠] are respective surface variants of /ʊ, ɛ, ɔ, a/.

(1) Dagbani segments (Hudu 2018, 204). (Surface variants are in square brackets)

a. Short vowels			Long vowels	
i	ɪ	[u]	i:	u:
		ʊ		
[e]		[o]	e:	o:
ɛ		ɔ		
	[a̠]			
	a		a:	

b. Consonants

Labial	Labial-Cor.	Coronal		Labial-Dorsal	Dorsal	Glottal
p b	[tp] [db]	t d		kp gb	k g	[ʔ]
m	[nm]	n		ŋm	ŋ	
			ʃ dʒ			
f v		s z	[ʃ] [ʒ]			[h]
		l [ɾ]		j	w	

¹The focus of the present paper on segmental phonological issues precludes an investigation into the role of metrical structures in Dagbani tone system. However, being a tone language, such an investigation, which currently does not exist, would be of great interest and should have preceded the present paper. It certainly deserves attention in the future.



Consonants, on the other hand, show contrast at the labial, coronal, dorsal and labial dorsal places of articulation. The labial-dorsal /kp, gb, ŋm/, surface as [tp, db, nm] respectively in two of the three dialects (Ladefoged 1968). The glottal sounds [ʔ] and [h] are post-vocalic variants of /k, g/ and /s/, while [ʃ] and [ʒ] are respective surface realisations of /s/ and /z/ before front vowels. The alveolar [r] is also a product of flapping affecting /d/.

The literature on Dagbani phonology shows that most segmental phonological issues surface at the phonology-morphology interface. This is because phonological processes in Dagbani typically involve a segment in a bound CV or CVC root and another in a CV or V affix. The segmental processes affecting a word in its underlying form thus feed on a morphological process concatenating two bound units into a phonological word typically consisting of a minimum of two CV syllables.

There is much less research on the tone system of Dagbani. The few studies focused on the tonal patterns include Wilson (1970) and Hyman & Olawsky (2004). From these and many studies on the phonology and make brief references to the tonology of the language (Olawsky 1999; Hudu 2010; etc.), it is known that the language contrasts two tonemes: High and Low. As will be seen in the tone markings in this paper, falling tones also surface in some (especially the Eastern) dialects, although no systematic study exists on this.

A lot of the data used in the paper are secondary data. Primary data were elicited from native speakers of the language. The data largely reflects two of the three major dialects of Dagbani, the Eastern and Western dialects. Blench (2006) and Naden (2014) were also consulted for the meanings of some of the words. The tone marks reflect the tonal patterns of the Eastern Dialect.

1.3. Prosodic theory and the theory of syllable weight

The analysis in the paper is based on classical prosodic theory, including the theory of syllable weight (Hyman 1985; McCarthy & Prince 1986, 1990; Hayes 1986, 1989, 1995; etc.) and the notion of universal prosodic categories and hierarchy shown in (2) (Selkirk 1980; McCarthy & Prince 1986). The relevant foot types are shown in (3) (McCarthy & Prince 1986; Hayes 1986, 1995).

- (2) Prosodic hierarchy
- | | |
|------|---------------|
| PrWd | Prosodic Word |
| | |
| Ft | Foot |
| | |
| σ | syllable |
| | |
| μ | mora |

- (3) Prosodic foot types
- a. Syllabic trochee: [σ σ] (Quantity-insensitive)
 - b. Moraic trochee: [μ μ] (Quantity-sensitive)
 - c. Iamb: [σμ σμμ] (Quantity-sensitive)

Of particular interest is the role and relevance of the mora as a unit of weight in Dagbani phonology. In addition to Dagbani having a vowel length distinction, the phonological processes



discussed here take place within domains that are constituted by a number of morae, not segments or syllables. Dagbani phonology has a mora-counting prosody. Thus, both codas and vowel length contribute to the weight of a syllable. This produces two syllable types based on weight distinction. A (C)V or (C)N syllable contains one mora while a CVC and CV: contain two morae. A third possibility (a CV:C with three morae) has no effects on the phonology, as will be demonstrated in this paper.

The relevance of the mora in Dagbani segmental phenomena can be seen in the segmental length and compensatory lengthening phenomena affecting nasals in the language. Crosslinguistic observations on compensatory lengthening form one of the most robust sources of evidence supporting moraic theory (Hayes 1989). As argued by Hudu (2018) and other previous studies, Dagbani nasals are the only non-vocalic tone-bearing units. Compensatory lengthening affects only /m, ŋ/ in word-final positions and affects nouns and adjectives, not verbs, as the vowel whose loss is compensated for by the lengthening of the nasal is typically a nominal marker suffixed to nouns and adjectives. This is illustrated in (4), where the long, tone-bearing nasals are contrasted with minimal or near minimal pairs with short, toneless nasals. The words with long nasals are from Hudu (2014a). Each noun in the singular form has three morae. The verbs (with short, toneless nasals) have two morae each.

(4) Lengthened nasals in nominal forms versus short nasals in verbs

	SG.	PL.		verbs with short, toneless nasals
a.	kòŋj: /kòn-gá/	kòn-sí	'leper'	kòŋ 'lose'
b.	zòŋj: /zón-gá/	zón-sí	'bat'	zòm 'go blind'
c.	sòŋj: /sòm-gá/	sòm-á	'good'	súm 'sap'
d.	bùŋj: /bùn-gá/	bùn-sí	'donkey'	bòm 'apply (liquid) in excess'

Evidence for the underlying forms of the singular nouns in (4) comes from Dagbani nominal classification. Nouns and adjectives that take the [-si] plural suffix take the [-ga] in their singular form (Olawsky 1999; Hudu 2005, 2018; etc.). The lengthened velar nasal is the surface form of a coalescence of underlying /n/ or /m/ and /g/ consonants.²

In the Eastern Dialect, there are other nouns with long final nasals similar to those in (4) but are not the product of coalescence (Hudu & Nindow 2020). According to Hudu & Nindow, the lengthening is a diachronic process, with no trace of their singular suffixes. In the plural forms, the nasals are short and toneless. These are shown in (5).

(5) Diachronic loss of singular nominal marker and compensatory lengthening of suffix nasal (Hudu & Nindow 2020, 538)

	SG.	PL.		verbs with short, toneless nasals
a.	tám:	tám-á	'manure'	tàm 'forget'
b.	dám:	dám-à	'wine'	dàm 'shake'
c.	kám:	kòm-à	'water'	kám 'any'
d.	lám:			lám 'taste'

²It is worth noting that for some of these words (e.g. kòŋj: and bùŋj:), the deletion and compensatory lengthening are optional for some speakers. Thus, they may be pronounced as kòŋá and bùŋá. This is yet another piece of evidence that the suffix is /-ga/, not /-gu/.



Similar data in (6) with CVN roots and CVN-a plural forms with [n] as the nasal show that the lengthening in (5) is in compensation for a lost -í suffix. The lengthening fails in (6) because [n] is not a word-final nasal in Dagbani.

(6) Preservation of suffix vowel in CVN- roots (Hudu & Nindow 2020, 538)

	SG.	PL.	
a.	tàn-í	tàn-á	‘fabric’
b.	pàn-í	pàn-á	‘vagina’
c.	gòn-í	gòn-á	‘expert’
d.	gbàn-í	gbàn-á	‘gristle’

In another context, also noted by Hudu (2018), the underlying /CVCm/ words are verbs, whose final /m/ optionally gets lengthened when the third person singular animate pronoun /o/ follows it. This is illustrated below.

(7) Nasal lengthening (Hudu 2018, 217)

a.	/làʔm/	[là.ʔm̩. ó]	/ [làʔ.m ó]	‘meet him/her (a euphemism for sexual intercourse)’
b.	/sàʔm/	[sà.ʔm̩. á]	/ [sàʔ.m á]	‘spoil you’
c.	/jɔ́hm/	[jɔ́.hm̩. á]	/ [jɔ́h.m á]	‘deceive you’
d.	/bèhm/	[bè.hm̩. ó]	/ [bèh.m ó]	‘doubt him/her’
e.	/tʃílm/	[tʃí.lm̩. ó]	/ [tʃíl.m ó]	‘delay him/her’

The bilabial nasal also displays limited contrastive length in the morphophonology, in a suffix that changes a verb into a self-ingratiating activity. In (8), this suffix is contrasted with the imperative marker, which is a singleton. This is discussed by Hudu & Nindow (2020), from where the data in (8) are cited.

(8) Contrast between geminates and singletons in Dagbani (Hudu & Nindow 2020, 537)

	root		geminate suffix		singleton (imperative) suffix	
a.	kòh[í]	‘sell’	kò.hm:â	‘selling’	kò.h[í]má	‘sell!’
b.	dà	‘buy’	dàm:â	‘purchasing’	dà.má	‘buy’
c.	ɲá	‘obtain’	ɲàm:â	‘gain/earning’	ɲà.má	‘see!’
d.	bò	‘seek’	bòm:â	‘seeking activity’	bò.má	‘seek!’
e.	dì	‘eat’	dìm:â	‘livelihood’	dì.má	‘eat!’
f.	ɲú	‘drink’	ɲòm:â	‘drinking’	ɲù.má	‘drink!’

Having established the importance of the mora in Dagbani phonological analysis, the next two sections show its relevance in defining and characterising the prosodic foot and the prosodic word. With few additions and further arguments, Section 2 presents the work of Hudu (2010, 2014b), the first studies of Dagbani phonology to argue for the presence of the mora and the prosodic foot.

2. THE PROSODIC FOOT AS A DOMAIN OF VOWEL PHONOTACTICS

Hudu (2010, 2014b) shows that the [-ATR] high vowels [i, u] are excluded from CV lexical words. They occur in CVC words and words of more than one syllable. The back vowel [u] also



surfaces in a nominal/adjectival CV root where the root either has a nominal suffix or precedes another suffixed root in a larger construction. A closer examination of the data shows that the restrictions can be generalised to cover all vowels in the language, beyond the analysis offered by Hudu. In an uninflected CV lexical word, the only vowels that surface are [i, u, e, o, a].

- (9) Lexical root-final position for [i, u, e, o, a] (Hudu 2014b, 139)
- | | | | | | | | | | |
|----|-----|----|----------|----|----------|-----|-----------|----|------------|
| a. | [i] | bì | ‘cooked’ | tì | ‘give’ | ɕí | ‘short’ | mí | ‘rain (v)’ |
| b. | [u] | bú | ‘beat’ | tú | ‘insult’ | gù | ‘block’ | lù | ‘fall’ |
| c. | [e] | bè | ‘ugly’ | tè | ‘filter’ | ɕé | ‘dislike’ | mè | ‘build’ |
| d. | [o] | bò | ‘seek’ | tò | ‘pound’ | gò | ‘travel’ | ló | ‘tie’ |
| e. | [a] | bá | ‘ride’ | tà | ‘smear’ | ŋmá | ‘break’ | là | ‘laugh’ |

The non-low [-ATR] vowels [ɔ, ɛ, i, u] occur in free-standing CVN words, where the non-contrastive advanced vowels [e, o, u, ɔ] do not surface. The only context where all vowels surface is domains with more than one syllable. CVN words are shown in (10). Copious data on words with two or more syllables are shown in the rest of the paper.

- (10) CVN words
- | | | | | | | | | | |
|----|-----|-----|--------------|-----|------------|-----|----------|-----|------------|
| a. | [i] | d̩m | ‘bite’ | t̩m | ‘send’ | n̩ŋ | ‘do’ | z̩ŋ | ‘miss’ |
| b. | [u] | m̩m | ‘close’ | t̩m | ‘work’ | d̩ŋ | ‘enmity’ | k̩ŋ | ‘empty’ |
| c. | [ɛ] | p̩m | ‘arrow’ | d̩m | ‘play’ | b̩ŋ | ‘pond’ | l̩m | ‘umbrella’ |
| e. | [ɔ] | t̩m | ‘bitterness’ | n̩m | ‘smell’ | z̩ŋ | ‘hall’ | m̩ŋ | ‘deprive’ |
| f. | [a] | d̩m | ‘shake’ | d̩ŋ | ‘relation’ | t̩m | ‘forget’ | m̩m | ‘lover’ |

The prosodic restrictions are summarised in the table below, a slight modification of what is in Hudu (2010, 2014b).

- (11) Restrictions on the distribution of Dagbani vowels
- | | Position | Proscribed | Permitted |
|----|------------------------|-----------------|------------------|
| a. | Lexical CV word | i, u, ɛ, ɔ, ɔ̄ | i, u, e, o, a |
| b. | free-standing CVN word | u, e, o, ɔ̄ | i, u, i, ɛ, ɔ, a |
| c. | More than one syllable | No restrictions | |

Two generalisations emerge here. One is the distributional disparity between CV words and words of CVC syllable structure. The other is the distributional similarity between CVC words and words of two or more CV syllables. Hudu (2010) accounts for these generalisations using Weight by Position, by which weight is assigned to coda consonants (Hayes 1989). Thus, CV and CVC differ in their weight, one having one mora, the other having two morae. CVC and CV.CV roots have equal weight, with two morae. Hudu concludes that the distribution of high vowels is regulated by a prosodic minimality requirement, noting that a [-ATR] high vowel occurs in a word that is minimally bimoraic. A lexical CV word is sub-minimal because it has only one mora, which explains why [i, u] fail to surface in such words.

As already noted, this conclusion is not restricted to high vowels. The bimoraic domain licensing requirement applies to vowels of all height specifications when combined with different [ATR] feature specifications. The [-low, -ATR] vowels [i, u, ɛ, ɔ] and the



[+low, +ATR] [a̠] are only licensed in a bimoraic domain. Significantly, of these vowels, only the advanced low vowel [a̠] is non-contrastive. The remaining [i, u, ε, ɔ] are contrastive vowels. This leads to the generalisation that when the two features [–low] and [–ATR] are combined in a segment, that segment requires a bimoraic phonological word to licence its distribution. The remaining contrastive short vowels [a, i] have an unrestricted distribution.

The other restriction is that, all the [+ATR] vowels [u, e, o, a̠] that fail to surface in CVN domains are restricted respective surface variants of /u, ε, ɔ, a/. In the CVN domain, all contrastive vowels surface. In other words, for the full realisation of vowel contrast in Dagbani, a CVN domain or a domain with two or more syllables is required. In a prosodic analysis, it implies that the prosodic foot is the minimal domain required for the realisation of the full vowel contrast in the language. In a sub-minimal domain like the (monomoraic) CV, the phonetic or phonological contrast between vowels that differ only in one feature is neutralised as in (12). The surfacing of /u, i, ε, ɔ/ respectively as [u, i, e, o] is akin to the process of domain-final tensing that takes place in some languages (Chomsky & Halle 1968; Mohanan 1986; Harrington 2006).

(12) Vowel neutralisation in sub-minimal domains

- a. Low vowels: [a, a̠] → [a]
- b. Mid vowels: [ε, e] → [e]
[ɔ, o] → [o]
- c. High vowels: /i, i/ → [i]
[u, u] → [u]

There is an interesting markedness dimension to the role of the prosodic foot in licensing full vowel contrast. In subminimal domains, the vowels that surface turn out to be specified for the unmarked value of the tongue-root feature distinguishing the two vowels in each pair. For all the non-low vowels, this unmarked value of the feature [ATR] is [+ATR]. For the low vowels, the unmarked value of [ATR] is [–ATR] (see Archangeli & Pulleyblank 1994; Bakovic 2000). This implies the prosodic foot serves as the domain for the preservation of marked features and feature combinations. It may well be the case that the feature value [–ATR], when combined with [–low] is so marked that it requires a prosodic foot to licence its appearance. In a subminimal domain, the protective cover provided by the foot is missing, leaving the vowel exposed to other constraints targeting the contrastive [–ATR] feature.

In the next section, evidence for the role of prosodic bracketing in the segmental phonology of Dagbani is provided using the place-changing process of debuccalisation.

3. THE PROSODIC FOOT AS DOMAIN FOR PLACE FEATURES

In Dagbani, the application of post-vocalic debuccalisation is difficult to account for without recourse to prosodic domains. The loss of the buccal place features of consonants in Dagbani has been discussed in some previous studies (e.g. Olawsky 1999; Hudu 2010, 2018). Debuccalisation targets the dorsals /k, g/ and the coronal /s/. The dorsals surface as [ʔ] after a short vowel; they



maintain their place features when preceded within the prosodic word by a long vowel, a closed syllable or two syllables. This contrast can be illustrated with two place names, both suburbs of Tamale, the largest city in the north of Ghana: /bagabaga/ [baʔabaʔa] and /sa:kasa:ka/ *[sa:ʔasa:ʔa]. Further data are shown in (13) and (14).

- (13) Post-vocalic debuccalisation (/k, g/ → [ʔ]/ V_) (Hudu 2018)
- | | | | |
|----|----------|----------|-----------------|
| a. | /sɔ́-gô/ | [sɔ́-ʔô] | ‘broom-SG’ |
| b. | /dà-gú/ | [dà-ʔú] | ‘wood-SG’ |
| c. | /sàkà/ | [sàʔà] | ‘be sufficient’ |
| d. | /lóg-lí/ | [lúʔ-lí] | ‘side-SG’ |
- (14) No debuccalisation of /k, g/ after long vowels or closed syllables
- | | | | |
|----|---------|--------|---------------|
| a. | /má:gâ/ | *má:ʔâ | ‘become cold’ |
| b. | /lè:gâ/ | *lè:ʔâ | ‘become’ |
| c. | /bó:gâ/ | *bó:ʔâ | ‘reduce’ |
| d. | /tú:gâ/ | *tú:ʔâ | ‘mash’ |
| e. | /pòbgâ/ | *pòbʔâ | ‘uncover’ |
| f. | /dàrgâ/ | *dàrʔâ | ‘pull’ |

Each word in (14a – d) has two possible surface forms. The other forms, not shown here, are without the dorsal [g] (má:i, lè:i, bó:i, tú:i), as discussed extensively by Hudu (2018). The forms given here are intended to show that when the optional dorsal deletion is not applied, the buccal place features of the dorsal are maintained. The loss of buccal place feature in /s/ is shown in (15).³ Debuccalisation is blocked only when /s/ is preceded by two syllables or a closed syllable, as in (16). Most of the data are from Hudu (2018).

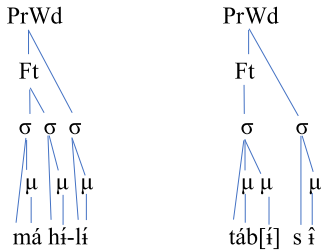
- (15) Post-vocalic debuccalisation (/s/ → [h] / V_)
- | | | | |
|----|------------|----------|---------------------|
| a. | /mò-sâ/ | mò-hâ | ‘become reddish-PL’ |
| b. | /nè-sâ/ | nè-hâ | ‘awaken-PL’ |
| c. | /má-sí-lí/ | má-hí-lí | ‘cool weather’ |
| d. | /mí-sí-lí/ | mí-hí-lí | ‘a sour thing’ |
| e. | /bí-sí/ | bí-hí | ‘child-PL’ |
| f. | /ŋa.si-bá/ | ŋahi-bá | ‘maternal uncle’ |
- (16) No /s/ debuccalisation
- | | | | |
|----|---------|---------|----------------|
| a. | /tábsâ/ | *tábhâ | ‘touch’ |
| b. | /zàʔsâ/ | *zàʔhâ | ‘refuse’ |
| c. | /sàʔsâ/ | *sàʔhâ | ‘advise’ |
| d. | tàr-sí | *tàr-hí | ‘end point-PL’ |

³The underlying form of some of the data in (15) apparently had a long vowel, (/CV:sV/) that was lost historically, as evidenced in Mampruli. However, the apparent diachronic process of vowel shortening has no connection with the /s/ → [h] change, given that the vowel shortening takes place in words that lack the consonant /s/ (e.g. /da:m/ [dam] ‘liquor’).



In deliberately slow speech, the words in (14e–f) and those in (16) may be pronounced with a weak epenthetic vowel [i] between the coda of the first syllable and the onset of the second, producing three open syllables on the surface. In the orthography of Dagbani, these words are spelt with an epenthetic [i]. However, the consonants [s, k, g] maintain their place features whether a vowel is inserted or not. In (17), the prosodic structures of the forms that permit debuccalisation and those that block the process are illustrated.

(17) The prosodic hierarchy in environments that permit debuccalisation



The second representation shows that with or without an epenthetic vowel, debuccalisation is blocked. The insertion adds a syllable to the word, making it a CVCVCV word. However, the mora count remains three as it is when the word is CVC.CV, without vowel insertion. Thus, debuccalisation is triggered by a preceding vowel within the same foot, not just any preceding vowel. The foot boundary is thus an opaque prosodic wall that blocks a vowel from transmitting its inherent non-buccal place properties onto segments within or outside its (the foot's) domain.

One important generalisation emerging out of the loss of buccal place features is that, within a grammatical word, a minimum of one foot is established. This is akin to the culminative property of stress, which ensures that every grammatical word has prosody, and can be enforced by the constraint $GRWD=PRWD$ (Kager 1999).

(18) $GRWD=PRWD$: A grammatical word must be a prosodic word.

Since the loss of buccal place features requires footing of segments, one measure to ensure the preservation of these features is to leave syllables containing these segments unfooted. Thus, satisfying the demands of the constraint $GRWD=PRWD$ comes at the cost of preservation of buccal place features. The crucial observation that must be considered in determining the relevant constraint is the restriction of the prosodic licensing requirement to buccal place features. The present analysis adopts the analysis of Steriade (1987), Clements (1985) and others to the effect that the laryngeals [h, ʔ] are placeless (see Yamane 2013 also for extensive discussion on placeness of segments). Debuccalisation is thus a case of deletion of a labial, coronal or dorsal place feature, not a change from one feature to another. Using the theory of Correspondence (McCarthy & Prince 1995; Kager 1999), the constraint that enforces the preservation of place features is the Maximality constraint $MAXIO(Place)$.



- (19) MAXIO(Place) (MAX(Place)): Every input place feature has a correspondent in the output.

For debuccalisation to take place MAXPLACE must rank below GRWD=PRWD and the constraint deriving debuccalisation. Following de Lacy (2006) and others, a markedness approach to place neutralisation is adopted here. The prosodic foot is the domain for surface unmarked segments, driven by various markedness constraints prohibiting the surfacing of place features. In the case of the /g, k/ → [ʔ] change, the prohibition is against the dorsal place. Some coronal and all labial consonants maintain their place specifications in postvocalic positions without restrictions. The relevant constraint is *DORS/V_{foot}, defined in (20).

- (20) *DORS/V_{foot}: Within prosodic feet, post-vocalic dorsal place features are banned.

In the /s/ → [h] change, it is the stricture that appears to be prohibited, not the place feature. Coronals that are plosives (e.g. [t, d]), liquids (e.g. [l, r]) and nasal [n] are permitted in post-vocalic positions without restrictions, but not buccal fricative or affricate. A moderate measure, compared with outright deletion, to enforce the prohibition is the loss of the place feature of the fricative. The relevant constraint is *PLACEDELREL/V_{foot}, defined in (21).

- (21) *PLACEDELREL/V_{foot}: Within prosodic feet, post-vocalic [+delayed release] consonant with a place feature specification is banned.

The effect of this constraint is not restricted to [s] but all other fricatives [f, v, s, z, ʃ, ʒ]. Dagbani phonotactics supports the prediction of this constraint, as fricatives do not surface in postvocalic position within a foot. The drivers of debuccalisation *DORS/V_{foot} and *PLACEDELREL/V_{foot} each ranks as highly as GRWD=PRWD. The interaction between these constraints is shown in (22) and (23).

- (22) Debuccalisation (/k, g/ → [ʔ])

/sɔ́-gɔ́/	*DORS/V _{foot}	GRWD=PRWD	MAX(Place)
a. (sɔ́-gɔ́)	*!		
b. sɔ́-gɔ́		*!	
c. (sɔ́-ʔɔ́)			*

- (23) Debuccalisation (/s/ → [h])

/mɔ́-sɪ/	*PLACEDELREL/V _{foot}	GRWD=PRWD	MAX(Place)
a. (mɔ́-sɪ)	*!		
b. mɔ́-sɪ		*!	
c. (mɔ́-hɪ)			*

The first two candidates in each of the tableaux in (22) and (23) satisfy MAX(Place). However, in doing so, (sɔ́-gɔ́) and (mɔ́-sɪ) incur fatal violations of the markedness constraints against the preservation of the relevant place or manner features for /g/ and /s/ within a prosodic foot. The



only means to satisfy both the markedness constraints and MAX(Place) is to avoid parsing any of the syllables into a foot, as in *sɔ́-gô* and *mɔ́-sà*. However, that incurs a violation of GRWD=PRWD. The optimal forms surface at the cost of violations of MAX(Place).

In a domain with three morae in which the dorsal or /s/ is part of the syllable with the third mora, the crosslinguistic observation that feet contain two syllables or morae (Prince & Smolensky 1993) would exclude it from getting parsed into the initial foot. This is enforced by FT-BIN-μ, (24).

(24) FT-BIN-μ: Feet are binary under a moraic analysis.

This constraint obviously outranks PARSE-SYL (Prince & Smolensky 1993; Kager 1999), a constraint that blocks surface forms with syllables that are not parsed into feet.

(25) PARSE-SYL: Syllables are parsed by feet.

The effect of FT-BIN-μ in regulating the number of morae in a foot is shown in (26). There is no evidence for the relative ranking of PARSE-SYL and MAX(Place), so the ranking stands as FT-BIN-μ, *DORS/V_{foot}, GRWD=PRWD » PARSE-SYL, MAX(Place). The tableau also shows that while the optimal candidates will typically violate MAX(Place), this constraint can nevertheless be crucial in ruling out place feature loss in segments that are not footed. In (26)c the loss of the place features for /s/ leads to an extra violation of MAX(Place), compared with the optimal candidate.

(26) Effect of FT-BIN-μ on words with three morae

	/zàqsi/	FT-BIN-μ	*DORS/V _{foot}	GRWD=PRWD	PARSE-SYL	MAX(Place)
a.	(zàq)si		*!		*	
b.	zàʔsi			*!		
c.	(zà)(qsi)	*!				
d.	(zàʔ)hi				*	**!
e.	(zàʔ)si				*	*

The data provide evidence that the third mora in a word with three morae is not footed along with the first two. Following McCarthy & Prince (1986), Hayes (1986) and others, I assume that a monomoraic syllable cannot form a foot by itself. For this reason, an output form like (zàʔ)(sì) cannot be optimal.

An important issue to address on the debuccalisation of dorsal segments is how the language treats labial-dorsal segments. Since they have the dorsal feature, they must be subject to the same process affecting plain dorsals; more so because they are complex, and presumably more marked. Thus, there are two issues to discuss here: whether the labial-dorsals are more marked than the plain dorsals and whether they lose their buccal features in the same contexts that plain dorsals do. On the question of the markedness, Hudu (2018) suggests that the plain dorsals are more marked than plain labials and all other place features for that matter. This is based on evidence from different markedness diagnostics, including segment distributions, sound neutralisation, fortition and lenition, among others. However, whether the labial-dorsals may be subject to the loss of buccal features that plain dorsals are subject to is difficult to confirm, given



that the labial-dorsals do not appear to have the same distributional patterns as the plain dorsals. Unlike the dorsals, /kp, gb/ neither surface in coda nor suffix onset positions. In onset position of non-initial syllables that are not suffixes, only six words (from [Hudu 2018](#)) are available. These are shown in (27).

- (27) Labial-dorsals in coda of non-initial syllables ([Hudu 2018](#), 220)
- | | | |
|----|-----------|---|
| a. | dàgbán-à | ‘A Dagomba person-SG’ |
| b. | àkpà?là | ‘fever accompanied by rigor’ (Western Dialect) |
| c. | kpàkpí-jà | ‘tortoise-PL’ |
| d. | nàkpà-á | ‘portion of farmland-SG’ |
| e. | sàgbò-ó | ‘small calabash bottle-SG’ (Naden 2014) |
| f. | bùkpàhá | ‘wizard’ |

However, a closer look at these words casts doubt on the generalisation that the labial-dorsals have a comparable distribution with plain dorsals as non-initial onsets. Three of the words (27d–f) appear to be root compounds, which combine two CV lexical roots with the CV suffix of the second root (see further discussion of this in Section 4.2.1). As discussed in that section, a dorsal segment in initial position of the second lexical root is not subject to debuccalisation. Data illustrating this are shown in (45), (46), (47) and (48). The word in (27c) also appears to have a reduplicant prefix. Prefixes of all kinds do not trigger changes to the place features of plain dorsals, as demonstrated in Section 4.2.3, with relevant data in (51). This leaves only two words, which also present doubts because one is a proper noun widely claimed to be a phonologically integrated form of the Hausa phrase *dan Gombe* ‘the descendants of Gombe’; while the other has an initial vowel which suggests that it is a loan or the output of a derivation. The crucial piece of evidence needed to conclude that labial-dorsals can be non-initial onset is simple CVCV nouns or verbs such as those illustrated in (13). While there is copious such data for the plain dorsals, there is none for the labial-dorsals. These distributional gaps make it impossible to compare dorsals and labial dorsals and their behaviour within the prosodic foot.

3.1. Place features versus other features

Other processes like tapping are not subject to the restriction that debuccalisation is subject to. Tapping affects the onset of a second syllable in a word following a short vowel, (28a–b), after a long vowel, (28c–d), and after a CVC syllable, (28e–f). The only context in which it is blocked is a post-nasal position, (28g–h).

- (28) Tapping (/d/ → [ɾ])
- | | | | |
|----|------------|----------|----------------|
| a. | /bìdì/ | bìɾì | ‘sow (seed)’ |
| b. | /wòlgì-dá/ | wòlgì-rá | ‘separat-ing’ |
| c. | /tè-dá/ | tè-rá | ‘remember-ing’ |
| d. | /tò-dá/ | tò-rá | ‘fetch-ing’ |
| e. | /wòb-dì/ | wòb-rì | ‘harvest-ing’ |
| f. | /dá?dî/ | dá?ɾî | ‘filth’ |
| g. | /tʃén-dî/ | *tʃén-rî | ‘walk-ing’ |
| h. | /kpám-dî/ | *kpám-rî | ‘aged-ness’ |



While there is a near-consensus that [r] is an allophone of /d/, the exact environment it surfaces in is difficult to characterise. Unlike debuccalisation, tapping (which produces [r]), applies in virtually any position that is not word-initial. It does not require the post-vocalic environment to apply. [Olawsky \(1999\)](#) says that the relevant environment is intervocalic, but also shows that it surfaces after consonants. For this and other reasons, he suggests that it is a pseudo-phoneme. What is obvious here is that, from a prosodic approach to the analysis of tapping, the tap may surface after one or more syllables, regardless of whether the preceding syllable is open or closed. It even surfaces in initial position of a word that is the second lexical root in a root compound (e.g. /bí-dǎb-gá/ [bí-rǎb-gá] ‘child-male-SG’ ‘boy’). As discussed in Section 4.2, debuccalisation does not affect consonants when the trigger and target belong to different lexical roots.

In seeking an answer to why tapping is not subject to the same limitations as debuccalisation, I explore the hypothesis that only place-changing processes are subject to the licensing restriction of prosodic feet. Unlike debuccalisation, tapping is a place-preserving phonological change targeting the stricture, while debuccalisation deletes the place of articulation of the consonants. A related question is whether the process merely changes the place feature specification or is required to render the segment placeless. To test this, I take a closer look at other place-changing phonological processes in Dagbani. Across the Eastern and Western dialects of Dagbani, the range of phonological processes includes palatalisation, labialisation, gemination, degemination, deletion, coalescence and nasal place assimilation (see [Olawsky 1999](#); [Hudu 2010, 2018](#); etc.). Of these, palatalisation, labialisation, coalescence and nasal place assimilation target place features for changes, neutralisation or loss. Palatalisation and labialisation take place within the domain of the syllable, with the nucleus as trigger. Front vowels trigger palatalisation and back (round) vowels trigger labialisation. The target in each case is the onset. This means that in each case, the prosodic foot remains the domain of application.

The remaining two place-changing processes, coalescence and nasal place assimilation, require more detailed attention. There are two patterns of coalescence in Dagbani. One involves nasals, discussed earlier, with data in (4), repeated in (29), where the nasal in a CVN root takes the dorsal place of a suffix-initial /g/ and surfaces as [ŋ]. Of the five contrastive nasals, only /m, n/ surface underlyingly in coda position. The remaining nasals only surface in coda as output of nasal place assimilation.

(29) Root-final nasal coalescence

	SG.	PL.	
a.	kòŋj: /kòŋ-gá/	kòŋ-sí	‘leper’
b.	zòŋj: /zòŋ-gá/	zòŋ-sí	‘bat’
c.	sùŋj: /sùŋ-gá/	sùŋ-á	‘good’
d.	bùŋj: /bùŋ-gá/	bùŋ-sí	‘donkey’
e.	tòŋj: /tòŋ-gá/	tòŋ-sí	‘gourd plant’

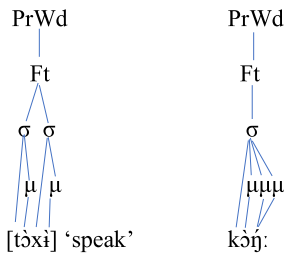
The other is unique to one sub-dialect of the Western Dialect, in which hetero-syllabic sequences of [g] and [s] coalesce to produce [x], as noted by [Hudu \(2010, 2018\)](#). Most of the data in (30) are from [Hudu \(2018, 224\)](#).



- (30) Coalescence in Tolon sub-dialect
- tò.xì /tòg.sì/ 'speak'
 - jà.xím /jàg.sím/ 'delight/sweetness'
 - zà.xì /zàg.sì/ 'refuse'
 - jà.xí /jàg.sí/ 'toss'
 - wò.xì /wòg.sì/ 'loosen'

There are different outcomes of coalescence in the two datasets. In (29), the nasal loses its place but maintains its nasality and prosodic position as a coda. In (30), the dorsal loses its stricture and coda position, but maintains its place feature. The difference in the outcome appears to be due to the oral/nasal distinction. In Dagbani and crosslinguistically, nasals easily lose their place specification even when no coalescence is at stake (e.g. Padgett 1995). In both cases, the change in the feature specification of the coda appears to be inconsistent with the hypothesis that a consonant in a prosodic foot does not get targeted by a place-changing phonological process triggered by a segment from a different prosodic foot. However, what is at stake here differs from what is observed in debuccalisation in two ways. First, in the process of coalescence, there is no clear trigger or target. The two segments each maintains some features and loses other features. Second, the output of the entire process produces one prosodic foot. The prosodic structure of the words with coalesced sounds is presented in (31).

- (31) The prosodic hierarchy in environments that permit coalescence



The last place-changing phonological process is nasal place assimilation (NPA). Unlike debuccalisation and coalescence, there are copious data in previous studies suggesting that nasal place assimilation does not respect the boundaries of the prosodic foot. This is illustrated below with the singular forms of nouns with roots ending in [m], which assimilate the coronal place feature of singular suffix [l]. The plural forms with the suffix -a provide the evidence that the nasal in the nominal roots is underlyingly [m]. The data are from Hudu (2014a).

- (32) Trigger and target of NPA across foot boundary (Hudu 2014a, 14)
- | | SG. | PL. | |
|----|-------------|----------|----------|
| a. | (gbí.ʔŋ)-lí | gbíʔ.m-á | 'lion' |
| b. | (sá.lŋ)-lí | sál.m-á | 'gold' |
| c. | (zì.lŋ)-lí | zìl.m-á | 'tongue' |
| d. | (kpá.rŋ)-lí | kpár.m-á | 'cheek' |



Assuming that the footing of syllables begins from the left edge of the prosodic word, as discussed further in Section 4.3, assimilation of the nasals would lead to a rejection of the hypothesis that the prosodic foot is a domain for place-changing processes, and uphold the more restricted hypothesis that the foot is a domain for processes that delete place features of consonants.

An alternative analysis may be to invoke the nasal-oral distinction and treat nasals as an exception to the foot licensing role of place-changing processes. Past studies on the nasal and why it is subject to place changes (e.g. Padgett 1995) note that nasals are perceptually less salient when they lack a tautosyllabic liquid or vocoid into which they can be released, the exact environment in which NPA is observed to occur crosslinguistically. Acoustically, Ohala (1975), citing much earlier researchers also observes that formant transitions of nasals and adjoining vowels present weak and ineffective cues for distinguishing place features of nasals compared with those of oral obstruents. This relative phonetic excrement explains the failure of nasals to pattern with oral consonants with respect to prosodic domain restrictions on place feature loss.

3.2. Foot structure

In stress languages, the primary indicator of headedness within the prosodic foot is stress. The syllable or mora that bears stress heads the foot. In addition to bearing stress, the head syllable or mora has other strong properties. It has a relatively strong vowel, and is the target of enhancement such as lengthening and diphthongisation. The non-head, on the other hand, typically contains a relatively weak vowel such as schwa, and is the target for reduction and weakening, including vowel shortening. In a non-stress language like Dagbani, headedness can only be determined using these other (non-prosodic) criteria. A closer look at the quality of mora-contributing units in Dagbani shows that in contexts where different segments occupy the nucleus positions within the Dagbani prosodic foot, the unit that contributes the first mora is typically of higher sonority than the one that contributes the second mora. When comparing the sonority profiles of the segments that occupy the nucleus position, two distinctions can be made. One is between a syllable with a vowel as nucleus and another with a syllabic nasal. The second distinction is between vowels, by which a distinction can be made between the placeless central vowel /i/ and all other vowels.⁴

On the quality of the nucleus, a syllable with a syllabic nasal does not precede one with a vowel nucleus within a prosodic foot. In two syllable words with two morae, a syllabic nasal does not surface word-initially, (33a–b). In three-syllable words with three morae, the syllabic nasal is the second syllable, contributing the second mora to the bimoraic foot, (33c–d). In words with more than three morae, the syllabic nasal contributes the second or fourth mora, (33e–f). Thus, in words of all lengths, a syllabic nasal does not contribute the first or third mora, if that would make it the initial syllable in a prosodic foot.

⁴This is an overly simplified analysis. Vowel strength distinction is a gradient one. However, for the purpose of the analysis here, this distinction is sufficient.



- (33) Location of syllabic nucleus within a foot
- | | | |
|----|------------------|--------------------|
| a. | (t̩.hm) | ‘sneeze’ |
| b. | (b̩.rm) | ‘confuse’ |
| c. | (gb̩.ʔŋ)-lɛ | ‘lion’ |
| d. | (s̩.lŋ)-lɛ | ‘gold’ |
| e. | (ká.hŋ)(kɔ-ʔú) | ‘crow-SG’ |
| f. | (kaŋ)(gba.rŋ)-ga | ‘a species of yam’ |

On the quality of the vowel contributing the mora, the weak vowel /i/ is the most common second vowel in a prosodic foot, preceded by any other vowel. It contributes an even numbered mora in a word. It does not contribute an odd numbered mora to a word unless it is immediately followed by another /i/, a syllabic nasal or a coda consonant contributing the next mora. The data in (33b–c) show examples of word-initial syllable with /i/ that is followed by a syllabic nasal. Words with a sequence of [i] are also very common in the language (*bɛn-t̩* ‘thing-SG’ and *t̩ʔi* ‘become satiated’), as are word-initial CiC syllables (e.g. *d̩b-gá* ‘chewing stick-SG’).⁵

These patterns cannot be accidental. Rather, they point to a systematic phonotactic rule driven by the prosodic requirement that within the prosodic foot, no even-numbered mora can be of higher sonority than the immediately preceding (odd-numbered) mora. This is characteristic of a typical trochaic rhythm. The only difference is that, in a stress language, the prominence of the head syllable or mora within the foot is determined primarily by stress, and aided by other indicators of vowel quality such as length and overall sonority. The similarity between the structure of the foot in Dagbani and that of stress languages provides sufficient evidence to conclude that Dagbani has a trochaic foot.

4. THE PROSODIC WORD

Having established the active role of the mora and the structure and role of the prosodic foot in licensing segmental processes, it is now time to look at the prosodic word. To understand the prosodic word, I look at word-level syllable weight patterns as well as the morphological units that constitute the prosodic word.

4.1. Word-level syllable weight patterns

Structurally, a light syllable does not precede a heavy one in a Dagbani phonological word. A non-initial syllable always has the same or lesser weight than the word-initial one, regardless of the root vowel involved. In disyllabic forms, the root and the suffix could both be light syllables as shown in (34), or the root may be bimoraic, as in (35)–(36). The data in (35) show roots with coda consonants, those in (36) have heavy roots with long vowels.

⁵The only exceptions I have found to this are two words (*b̩l-á* ‘small-SG’ and *b̩r-á* ‘roselle-PL’). The word *b̩l-á* has as its plural form *b̩l-hí*, the same plural form for *b̩l-á* (‘child-SG’). The singular form of the word *b̩r-á* is *b̩r-lí*.



- (34) Nominal forms with CV.(C)V structure
- a. Nouns: pú.-lî ‘stomach-SG’ sɔ́.-ʔú ‘broom-SG’ pú.-rî ‘farm-PL’
 b. Adjectives: zè.-hî ‘red-PL’ ɕí.-á ‘short-SG’ tʃé.-ʔú ‘(broken) piece-SG’
- (35) Root-initial syllables with heavy closed syllables
- a. /k, g/[ʔ]: sàʔ.-rî ‘rubbish’ bɔʔ.-lî ‘pit-SG’
 b. /ŋ/ tɪŋ.-lî ‘bottom-SG’ ŋɔŋ.-lî ‘grass cutter-SG’
 c. /m/ sám.-lî ‘debt-SG’ gòm.-dí ‘cotton-SG’
 d. /b/ dàb.-lî ‘slave-SG’ jé̃b.-sî ‘crocodile-PL’
 e. /l/ jí̃l.-gú ‘horn-SG’ kúl.-sî ‘river-PL’
 f. /t/ gór.-tî ‘sickle-PL’ kúr.-lî ‘old-SG’
- (36) Root-initial syllables with long vowels
- a. [i, u:] bí:n.-sî ‘experts’ dú:n.-sî ‘mosquito-PL’ tù:.-lî ‘first’
 b. [e, o:] tèt:ŋ.-gá ‘beard’ so:n.-sî ‘rabbits’ bét:n.-í ‘shin’
 c. [a:] tá:t:ŋ.-gá ‘shea nut tree’ dà:n.-sî ‘hearth-PL’ tá:t:n.-í ‘shea nut’

In words with three syllables, the same patterns just described prevail: all light syllables or a heavy root-initial syllable followed by two light syllables, the third usually a suffix.

- (37) Words with three root syllables
- a. CV.CV-CV pò.lɔ́.-lî ‘toad-SG’ tà.ká.h-î ‘challenge’ tá.lá.h-í ‘compulsory’
 b. CV.CN-CV gbí.ʔn.-lî ‘lion-SG’ sà.ʔŋ.-gá ‘abdomen-SG’ kò.rŋ.-gá ‘francolin-SG’
 sá.ln.-lî ‘gold-SG’
 c. CVN.CV-CV nám.dí.-lî ‘sandal-SG’ gón.dí.-lî ‘pawpaw-SG’ ɕèŋ.kú.n-ò ‘pussy cat-SG’
 kùn.dò.n-á ‘hyena-PL’ sám.bá.n-î ‘front yard-SG’ ɕén.gbá.n-í ‘leopard-SG’
 d. CV:N.CV-CV tà:n.tʃí.l-í ‘loin cloth-SG’ dà:m.bá.l-ò ‘spokes person-SG’

Words that may be conceived to contain a heavy second syllable in a root are those with CN. In the orthography, these words are written with a vowel between the consonant and the nasal, and most previous studies transcribe such words with the weak vowel [ɪ] as nucleus preceding the nasal. The accuracy of such transcriptions is in doubt for three reasons. First, morphological evidence shows that the second syllable clearly lacks a vowel between the consonant and the nasal. Any such vowel would, at best, be epenthetic and optional. The respective plural forms for *gbí.ʔn.-lî* and *sá.ln.-lî* are *gbí.ʔ.m-a* and *sá.l.m-a*, which lack a vowel between the coda of the preceding syllable and the onset of the following one. Second, the fact that the nasal is a syllabic segment in Dagbani shows that the perceived vowel, which is never any other than the weak vowel [ɪ], does not exist. If this syllable really had a phonological vowel between the consonant and the nasal, we would expect vowels of different qualities to occur in that position, as is the case with the word-initial CVN syllables. As already noted in Section 2, a root syllable that is not



domain-final licenses vowels of all feature specifications (see [Dakubu 1997](#) for a similar observation). The third evidence comes from the tonal melody of words containing the CN sequences. The assumed weak vowel between the onset and the nucleus always bears the same tone as the vowel preceding this sequence. If this vowel were underlying, it would come with its underlying contrastive tone.

There are also words containing a sequence of two heavy syllables within the lexical root with a CV suffix.

- (38) Words with two heavy root syllables: CVN.CVCV-CV
- ɕ̥ɛ̃ŋ.kún.-tî 'pussy cat-PL'
 - bàn.tàb.-gâ 'turban-SG'
 - sòm.póʔ.-lî 'a menstrual disorder'

The sequencing of syllables within verbs does not differ from nouns, even though verbs present a morphological structure that differs from nouns and adjectives. In addition to the lack of an obligatory suffix, verbs also take the form of a simple CV, CVN, CVCN or a CV:i/CV:gi. There are also underlying CVC and CVCC verbs which take a final epenthetic vowel to surface as CV.CV and CVC.CV respectively. Any verb, regardless of its underlying syllable structure may be inflected with an aspectual or some other inflectional or derivational marker, all of which have a CV structure. Data on all verb types are shown in (39).

- (39) The structure of verbs (two or more syllables)
- | | | | | | | | |
|----|----------|------------|----------|------------|-----------|----------|---------------|
| a. | CV.Cm | b̥.lm | 'roll' | b̥.rm | 'confuse' | f̥.lm | 'reduce' |
| b. | CV.CV | m̥.l[ɛ̃] | 'rub' | w̥.h̥ | 'show' | k̥.b[ɛ̃] | 'infect' |
| c. | CVC.C[V] | d̥.m.g[ɛ̃] | 'squat' | k̥.r.g[ɛ̃] | 'get old' | b̥.á.ŝ̥ | 'grind' |
| d. | CV:i | b̥.ó.g̥ | 'reduce' | t̥.ú.g̥ | 'mash' | m̥.á.g̥ | 'become cold' |

Of the different verb types shown in (39), the last two are the only verb types with a combination of a heavy and light syllable. Consistent with the observation already made for nouns and adjectives, the heavy syllable always precedes the light one. This cannot be accidental. What it shows is that, a phonological word consists of a syllabic trochee or begins with a syllabic or moraic trochee (in the case of words with more than two syllables).

The distributional patterns observed here are exactly what is expected under a prosodic system with foot binarity at the level of the mora. If foot binarity were at the syllabic level, it would permit words with initial light syllables followed by heavy syllables. Given that each foot has two morae, a monomoraic syllable preceding a bimoraic one would be left unfooted, as the non-initial bimoraic syllable would constitute a foot by itself. The proscription of an initial light syllable preceding a heavy syllable is required to avoid word-initial degenerate feet. This can be enforced using alignment constraints of [McCarthy & Prince \(1993\)](#).

- (40) ALIGN-WD-LEFT
Align (PrWd, Left, Ft, Left): Every prosodic word begins with a foot.



To achieve the right result, ALIGN-WD-LEFT has to combine forces with FT-BIN- μ . However, an undominated position of FT-BIN- μ would also block words such as *tè:ŋ-gá* ‘beard-SG’ and *kàj*: ‘a leper’, with an initial syllable containing more than two morae. FT-BIN- μ would exclude the third mora from the initial foot or a foot located anywhere in the word for that matter. However, assuming the condition of Strict Succession (Itô & Mester 2003) which is part of the Strict Layer Hypothesis (Selkirk 1984), a mora cannot be part of the prosodic word without first getting syllabified. The solution to this is an alignment constraint that forces the right edge of the foot to align with the right edge of the syllable. This is defined in (41).

- (41) ALIGN-FT-RIGHT
Align (Ft, Right, Syl, Right): The right edge of the foot is aligned with the right edge of the syllable.

When this constraint outranks FT-BIN- μ , a three-mora foot will be permitted at the expense of violation of FT-BIN- μ . Since there is still no evidence for a relative ranking of GRWD=PRWD, ALIGN-WD-LEFT and the markedness constraints deriving debuccalisation, all these constraints remain undominated and rank above FT-BIN- μ . The new ranking and its effects are shown in (42).

- (42) Effects of ALIGN-FT-RIGHT » Ft-BIN- μ

/tè:ŋ-gá/	ALIGN-WD-LEFT	GRWD=PRWD	ALIGN-FT-RIGHT	FT-BIN- μ	PARSE-SYL
a. (tè:)(ŋ-gá)			*!		
b. (tè:)ŋ-gá			*!		*
c. tè:ŋ-gá		*!			**
d. (tè:ŋ)-gá				*	*

In the absence of ALIGN-FT-RIGHT, (tè:)(ŋ-gá) would surface as the optimal candidate. It would perform better than the optimal candidate by satisfying PARSE-SYL with both syllables footed and FT-BIN- μ with two morae in each syllable. In addition to the first foot violating ALIGN-FT-RIGHT, the second foot also has a structure that is unattested in the language. It has an initial mora that is a nasal and followed by a vowel. Thus, the work of blocking the non-initial mora from surfacing as the prominent mora in the foot could alternatively be performed by the rhythm type constraint in (43), which requires that the initial mora in the foot be the more prominent mora (Kager 1999).

- (43) RHTYPE=T: Feet have initial prominence.

The problem is that, leaving the two morae unfooted is an alternative means of satisfying ALIGN-FT-RIGHT. With the ranking of FT-BIN- μ » PARSE-SYL, this will project the wrong candidate (tè:)ŋ-gá on the surface. Thus, it appears that the alignment constraint is preferred to rhythm type constraint in determining foot headedness. This is illustrated in (44).



(44) Effects of RHTYPE=T » FT-BIN-μ

/tè:ŋ.-gá/	ALIGN- WD-LEFT	GRWD= PRWD	RHTYPE= T	FT-BIN-μ	PARSE- SYL	MAX (Place)
a. (tè:)(ŋ.-gá)			*!			
b. tè:ŋ.-gá		*!			**	
^{ESP} c. (tè:ŋ)-gá				*	*	
⊗ d. (tè:)(ŋ.-gá)					*	

4.2. Defining the prosodic word

In the preceding analyses, only lexical words with simple (root-suffix) structure have been used. To define the prosodic word, determine its boundaries and the morphological units that constitute it, more evidence is required from longer morphological units like compounds and words with derivational affixes.

4.2.1. Compounds. Dagbani has word compounds, consisting of two or more words with each inflected for affixes, and root compounds that put together two or more lexical roots with only one suffix. In word compounds such as those in (45), each word of the compound constitutes a prosodic word. The suffix of the first word does not parse into one foot with the root of the second word of the compound. If that were the case, the initial /g/, /k/ or /s/ of the second word in each of the compounds in (45) would have lost its place features. The result is that, in each of the words, an unfooted suffix is left in the middle of the compound.

(45) Word compounds

a. (páʔ.)-bá (gú.-lî)	* (páʔ)-(bá ʔú)-lî	‘women’s cola nut’
b. (páʔ.)-bá (sí.m-á)	* (páʔ)-(bá hî)m-á	‘women’s groundnuts’
c. dò.-(kúr)-gú (kú.-lî)	* dò.-(kúr)-(gú ʔú)-lî	‘an old man’s hoe’
d. (ní.r)bá (sá.m-â)	* (ní.r)(bá há.)m-â	‘people’s debts’

In a root compound, foot boundaries are aligned with root boundaries. Thus, segments from different roots cannot be part the same foot. The prosodic word shares this feature of lexical root alignment with the phonological word (Hudu 2010, 2013, 2014a). Neither allows its boundary to cross the boundaries of two lexical roots.

(46) Root compounds

a. dà.-(kú.ʔ-ô)	* (dà-ʔú)g-ô	‘log’ (da- ‘wood’)
b. dà.-(zò.hî.)-gú	* (dà-zò).(sà-ʔú)	‘the eve of an event’ (da- ‘day’)
c. dà.-(zò.há)	* (dà-zò).sá	‘itinerant merchant’ (da- ‘market’)
d. nó.-(lò.-ʔú)	* (nó-lò)-gú	‘cock’ (no- ‘fowl’)
e. sà.-(kú.-gú)	* (sà-ʔó)-gú	‘grasshopper’ (sa- ‘sky/rain’)
f. tî.-(kù.bá)	* (tî-ʔù)bá	‘tale-bearer’ (tî < tîb-lí ‘ear’)



In some root compounds, the initial root undergoes some featural changes, especially vowel lowering. The only indication of their underlying forms is the meaning. For instance, the word /dà-bóg-gú/ [dà.bó-ʔú] ‘ruins of a dwelling’ contains the root *da-* ‘room’, which is underlying /dù-/. Independent evidence for this change comes from other contexts where it surfaces with [i] in the Eastern Dialect (e.g. *dî-kpîm-í* ‘wall of a room’). Similarly, the word /nà.póg-gú/ [nà.pò-ʔú] ‘hen coup’ contains the root *no-* ‘fowl’, with the vowel lowered and surfacing as [a]; and [dàgòr-lí] ‘promiscuous man’ contains the root *do-* ‘man’. The word in (46e) is ambiguous, where the syllable *sa* is either from the root for sky/cloud (cf. *sà-gbàn-á* ‘clouds’) or the word for rain *sá-á*. Other birds and insects with *sa-* are shown in (47).

- (47) *sa-* compound words for birds and insects
- sà-kàb-gá* ‘horsefly’ (also pronounced simply as [kàb-gá])
 - sà-kpálé:ŋ-gá* ‘swallow’
 - sáá-páʔá* ‘dragonfly’ (lit. ‘rain’s wife’)
 - sà-kártfè:ŋ-gá* ‘beetle-SG’

The compound in (46f) probably has an initial lexical root with the most drastic change of all. Other words with *tîb-* reduced to *tî* include those in (48).

- (48) Words with underlying root for ear as first member
- tî-kpár-á* ‘earring’
 - tî-kpàr-á* ‘deaf person’ (*kpàrì* = ‘become deaf’)
 - tî-kúm* ‘gossip’
 - tî-pá-wóm-lí* ‘stubbornness (unwilling to listen)’

In (48d), *pa-* is most likely the negative marker, as *wóm* is the verb ‘hear’. The entire word literally means ‘non-listening ear-SG’

4.2.2. Derivational affixes. A derivational suffix is not part of the prosodic word to which its base belongs. Segments in derivational suffixes cannot be part of the same foot as segments in the root. In (49), each word has two suffixes. These are the imperfective suffix *-dù/ri* and the nominal marker *-gù*. The imperfective is an inflectional suffix added to the verb. The nominal marker is the derivational suffix used to derive the noun.

- (49) Derivational affixes
- | | | | |
|----|---------------------|-------------------------|--|
| a. | (jí.ʔi)-rí-gú | * (jí.ʔi)-(rí-ʔú) | ‘fly-imperfective-Nom.sg’ (flying thing/aeroplane) |
| b. | bí-(gbám)-dí-gú | *bí-(gbám).(dí-ʔú) | ‘child-crawl-imperfective-Nom.sg. (a toddler)’ |
| c. | (bín)-(dím)-dí-gú | * (bín)-(dím)-(dí-ʔú) | ‘thing-bite-imperfective-Nom.sg. (something that bites)’ |
| d. | (bín)-(vú.hî)-rí-gú | * (bín)-(vú.hî)-(rí-ʔú) | ‘thing-breath-imperfective-Nom.sg. (an animate being)’ |



The words in (49b-d) are also root compounds, as they begin with the nominal root *bi-* ‘child’ and *bím-* ‘thing’. In these words, /-g/ (in the suffix *-gu*) does not lose its buccal place feature because it does not get footed with the preceding suffix. The failure to get footed is due to its position as a derivational suffix. The same morpheme playing the role of an inflectional suffix surfaces as *-ʔu* (as in /bó-gú/ [bó-ʔú] ‘arm-SG’).

Another illustration of the non-footing of derivational suffixes is shown in (50), where the /s/ in the nominalising suffix *-sím* maintains its place features.

- (50) *-sím* derivational suffixes
- | | | | |
|----|-----------|----------|-----------------------------|
| a. | /mò:-sím/ | *mò:-hím | ‘reddish-NOM (reddishness)’ |
| b. | /nè:-sím/ | *nè:-hím | ‘open-NOM (enlightenment)’ |
| c. | /mà:-sím/ | *mà:-hím | ‘cool/cold-ness’ |
| d. | /bì:-sím/ | *bì:-hím | ‘hotness’ |

The data in (50) resemble those in (14), which show that /g/ debuccalisation is blocked after a long vowel, a heavy syllable or two syllables. However, the failure of debuccalisation in (50) may also be subject to a different condition.

4.2.3. Prefixes. Prefixes are not footed, and for that matter, are not part of the prosodic word. This is clearly illustrated by prefixing reduplication, as shown in (51). The only obvious non-reduplicant prefix is (51a), where the ordinal number prefix *a-* is not parsed with the initial syllable of the stem [náhɛ].

- (51) Prefixes not footed
- | | | | | |
|----|-----------------|-------------------|---------------------|----------------------|
| a. | /á-násí/ | á-(náhɛ) | * (á-ná) sí | ‘NOM-four-PL (four)’ |
| b. | /kú-kɔ́g-gú/ | kú-(kɔ́-ʔú) | * (kú. ʔɔ́)-gú | ‘upland’ |
| c. | /kù-kɔ́-lî/ | kù-(kɔ́-lî) | * (kù-ʔɔ́)-lî | ‘voice’ |
| d. | /tì-kú-lɛ-kú-â/ | tì-(kú-lɛ)-(kú-â) | * (tì-ʔú)-(lɛ-kú)-â | ‘black ant’ |

4.3. Direction of footing

It is now time to look at where footing begins within the prosodic word and the direction it takes. Direction of footing does not matter in a word with an even number of morae. In (52a-c), it is illustrated with Dagbani numerals (*pi-* = ‘ten’, *sí* = ‘plural marker’).

- (52) Bimoraic feet in even numbered morae
- | | | | |
|----|---------------|------------------|--------------|
| a. | /pí-sí-jɔ́bú/ | (pí-hí)-(jɔ́.bú) | ‘sixty’ |
| b. | /pí-sí-ní:/ | (pí- hí)-(ní:) | ‘eighty’ |
| c. | /pí-sí-wɔ́í/ | (pí-hí)-(wɔ́í) | ‘ninety’ |
| d. | /sàbsì-gú/ | (sàb).(sì-ʔú) | ‘wall gecko’ |

Direction of footing matters in words with odd numbered morae. Evidence from debuccalisation shows that footing begins from the left edge of the prosodic word. When the initial syllable is heavy, it forms a foot.



- (53) LTR footing. Closed syllables and syllables with long vowels are heavy
- /jáɡ-lî/ (jáʔ)-lî *já(ɡ-lî) ‘side-SG’
 - /túɡ-lî/ (túʔ)-lî *tú(ɡ-lî) ‘joint-SG’
 - /kúɡ-sí/ (kúʔ)-sí *kú(ɡ-sí) ‘seat-PL’
 - /bóóɡî/ (bóóʔ)î *bó(óʔî) ‘reduce’
 - /mááɡî/ (máá)î *má(áʔî) ‘cool down’

Where the initial syllable is light, it is footed with the second syllable which, as already noted, must also be light.

- (54) Bimoraic feet in odd numbered morae
- /má.sí.ɡî/ (má.hî).ɡî *má.(sí.ʔî) ‘make wet’
 - /pí.sí.ɡî/ (pí.hî).ɡî *pí.(sí.ʔî) ‘postpone’
 - /bì.sì-ɡû/ (bìhì)-ɡû *bì.(sì-ʔû) ‘sea sand’
 - /bì.sì-lí/ (bì.hì)-lí *bì.(sì-lí) ‘breast-SG’
 - /pì-sì-ta/ (pì-hì)-ta *pì-(sì-ta) ‘thirty’
 - /ŋa.sì-bá/ (ŋahì)-bá *ŋa.(sì-bá) ‘maternal uncle’

The location of feet within the prosodic word is easily determined with the repertoire of constraints already established. The fact that footing begins from the left edge of the prosodic word is due to the alignment constraint ALIGN-WD-LEFT, which, as already shown, is undominated in the language. This produces the outcomes in (55) and (56). In (56), an epenthetic vowel is added to show that its presence has no effects on the outcome.

- (55) Effects of ALIGN-WD-LEFT on the direction of footing. (Even numbered morae)

/pì-sì-wóí/	ALIGN- WD-LEFT	FT- BIN-μ	GRWD= PRWD	PARSE- SYL	MAX (Place)
a. pí-(sí-wó)í	*!			**	
b. (pì)-(sí-wó)í		*!		*	
☞ c. (pì-hì)-(wó)í					*

- (56) Effects of ALIGN-WD-LEFT on the direction of footing. (Odd numbered morae)

/túɡ-lî/	ALIGN- WD-LEFT	FT-BIN- μ	GRWD= PRWD	PARSE- SYL	MAX (Place)
a. tó.(ɡ[í]-lî)	*!			*	
b. (tó.ʔ[í]-lî)		*!			*
☞ c. (tó.ʔ[í])-lî				*	*

The outcome of the constraint interaction in (55) shows that footing does not begin in the middle of the word. However, being a word with an even-numbered morae, it does not show that footing actually begins from the left edge of the word. That evidence is shown in (56), which has an odd number of morae. The insertion of the epenthetic vowel in (56) has made it possible



to entertain an output candidate like $t\acute{u}.(g[\acute{i}]-l\acute{i})$ without the risk of violating ALIGN-Ft-RIGHT constraint. The fact that ALIGN-WD-LEFT is able to rule out this output candidate means that these two constraints have clearly different effects.

5. SUMMARY AND CONCLUSIONS

The goal of this paper has been to contribute to the few existing studies that demonstrate the relevance of prosodic bracketing in the analysis of segmental processes and further demonstrate that this relevance of prosodic bracketing goes beyond languages in which the prosodic word is independently established for the analysis of prosodic phenomena. To achieve these goals, the paper goes beyond the observation that Dagbani has a prosodic foot with a limited role of regulating vowel feature distribution. It shows that the foot plays a much bigger role of regulating aspects of the phonology of vowels and consonants. It also demonstrates that the prosodic foot is part of a prosodic word with all features that are known to associate with these units in stress languages, including headedness that is determined by the relative prominence of prosodic units, a defined boundary and directionality of footing. The analyses further demonstrate that in providing a prosodic account of these segmental phenomena, all that is required is the same prosodic principles, hypotheses and formal approaches, especially within Optimality Theory (including alignment constraints, rhythm type constraints) that have been at the centre of analyses of the typology of prosodic phenomena during the past two decades. The findings of the paper draw us closer to confirming the view of Bennett (2012, 256) that ‘the foot plays a general organizational role in natural language phonology, and does not depend on the prior existence of stress, rhythmic or otherwise’.

In addition to achieving the broader goals of the paper, there are a number of specific issues that are of significant interest to the further understanding of prosody and prosodic domains, some of which are highlighted here. One is the opacity effects of the boundaries of the prosodic foot that block the effects of vowels as triggers of debuccalisation onto following segments within or outside of its domain. Viewed from a different perspective, the fact that a consonant within a prosodic foot is not subject to a vocalic trigger external to the foot may be an indication of strength. The prosodic foot may be added to the range of morphological and prosodic units such as roots, root-initial syllables, stressed syllables, and syllable onsets that have crosslinguistically been found to display positional privilege by resisting patterns of neutralisation and loss of distinctiveness (Beckman 1997).

A second issue worth highlighting is that, within the prosodic foot, a dominance relation exists between the units that constitute it, which is the basis for determining foot structure and headedness. The head mora is active and dominant, it is a relatively stronger vowel that triggers phonological processes. The non-head mora is inert and recessive, a weaker vowel or a syllabic consonant, and subject to loss of place features. In stress systems, stress is used to determine headedness. All other indications of prominence of the head foot are viewed as corollaries of stress. The phonological patterns in this paper point to a different view of the relationship between vowel quality and stress. The quality of the nucleus can be independent of stress as features that the head must possess.

A third issue has to do with the dual, seemingly contradictory role of the prosodic foot as a domain for the preservation of marked units as well as the emergence of unmarked features. The



fact that vowels are the targets in the performance of the role of preserving marked units while consonants are the products of the emergence of unmarked units is a point worth exploring in future studies. What is significant is that the prosodic foot is at the heart of the realisation of two typological universals: the maintenance of contrast and the realisation of ease of articulation.

The goals were achieved by looking into different aspects of Dagbani morphophonology, including vowel phonotactics, vocalic feature combinations and consonant place feature behaviour. The focus on putting the issues in a typological perspective steered the various analyses clear of detailed discussion on some aspects of the data and formal theoretical issues that may be of significant interest in and of themselves. In particular, the fact that tapping and nasal place assimilation are not subject to the same prosodic restrictions as debuccalisation raises questions about the differences between place and manner features. It is also possible that a greater focus on and comparison between theoretical approaches would be useful in achieving a greater understanding of the issues. In spite of what might be perceived as limitations, the paper has, beyond its immediate goals and findings, produced useful data and basic phonological discussions, even if not exhaustive, that will hopefully make a significant input in future studies on the typology of, and theoretical discussions of word-level prosody.

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