Feet in Sri Lanka Malay: no stress, please!

Abstract
We propose that Sri Lanka Malay does not make use of a conventional notion of stress or tone on the word level (contrary to previous descriptions of SLM by e.g. Bichsel-Stettler 1989, Tapovanaye 1995, and Smith et al. 2004), but nevertheless parses words into bimoraic feet. Evidence for this bimoraic foot structure comes from vowel lengthening processes in the penultimate syllable. As our instrumental measurements show, these lengthening effects cannot be interpreted as evidence for stress. In our OT analysis of the data we argue that the bimoraic feet (and with it the lengthening effects) come about by fairly general principles, while the lack of overt stress is the result of conflicting alignment constraints on headedness (as proposed by Golston (2007).

1 Introduction

The complete absence of stress and tone on the word level has been suggested for a number of languages, e.g. Betawi Malay (Roosman 2007), Javanese Indonesian (Goedemans & van Zanten 2007), French (Dell 1984), among others (Bella Coola, Tamazight, Bengali, see Hyman 2006:237 and references therein; Hyman 1977a, Ladd 1996:156, Fox 2000). We want to add Sri Lanka Malay (henceforth SLM) to the ranks of stressless languages and furthermore provide an OT analysis of the prosodic structure of this language.

We propose that words in SLM are parsed into bimoraic feet, and that these feet are headless. Headless feet (i.e. feet that have no strong part) have been proposed and used before in relation to secondary feet (i.e. feet that do not contain main stress, e.g. Halle & Vergnaud 1987ab; Crowhurst 1991, 1996; Halle & Idsardi 1992; Prince & Smolensky 1993, Hyde 2003; Hagberg 2006; Golston 2007; Krämer 2007, 2009). These secondary feet usually serve as placeholders for the location of the foot containing main stress or they result as stressless in order to resolve a stress clash. Evidence from vowel lengthening and gemination processes in SLM suggests that in this language all feet are headless.

2 Structure of this paper

After introducing the language, its genetic and areal relations, we turn to the phonology of the language, where we discuss the vowel inventory, syllable structure and word structure and present the all-important distribution of lengthened vowels. A close analysis reveals that vowel length is predictable and therefore not phonemic. Instrumental measurements in section 5 establish the absence of stress cues like pitch or intensity. Based on this segmental and suprasegmental data, we establish a metrical representation in section 6 and an OT grammar generating the correct surface candidates in section 7.

3 A description of SLM

3.1. A brief history of Sri Lanka Malay

SLM is the language of the ethnic group of the Malays in Sri Lanka. This group is formed by the descendants of immigrants (mostly exiles and soldiers) brought by the colonial powers of the Dutch and the British between roughly 1650 and 1850 (Hussainmiya 1990). The language is an off-shoot of Trade Malay (Austronesian) with heavy morphosyntactic influence from the adstrates Sinhala (Indo-Aryan) and Tamil (Dravidian). The morphosyntactic markup has changed dramatically in the last 300 years, the phonology less so. (Adelaar 1991, Smith & Paauw 2007, Slomanson 2007, Ansaldo 2008, Nordhoff 2009). Among the most notable phonological changes are the development of retroflex stops (Bichsel-Stettler 1989, Adelaar 1991) and a series of prenasalised stops (Tapovanaye 1986, 1995, Nordhoff 2007). Suprasegmental phonology has not been subject to much scientific analysis.

Today, the Malays form 0.3% of the population of Sri Lanka, which corresponds to about 47.000 speakers (Bichsel-Stettler 1989). Since the 1950s, many Malays have switched to the majority language Sinhala, leading to a decrease in fluent speakers. The language is currently being documented by a DobeS project.

In the following, we will have a short look at the phonemic inventory and syllable structure of SLM before we turn to other prosodic aspects of SLM.

3.2. The SLM vowel inventory

SLM has a vowel systems containing the five full vowels /i e a o u/ plus schwa:[1]

i		u
e	ə	o
	a	

Table 1. Vowel Inventory

The following (near) minimal pairs establish the phonemic status of the five full vowels.[2]

(1) *ka:ki* *ka:ke* *ka:ka*
'leg' 'grandfather' 'elder brother'

(2) *ku:ciŋ* *bo:ci* *ca:ciŋ*
'cat' 'container' 'worm'

(3) *cu:cu* *ci:ci*
'grandson' 'granddaughter'

[1] For a more detailed description of the SLM segmental inventory, the reader is referred to Nordhoff (2009).

[2] Vowel length is fully predictable in SLM and will be discussed in detail in the following sections.

(4) *beːbek* *boːɖok*
‘duck’ ‘spoilt’

The phonemic status of schwa is established in example (5):

(5) *t̪aːnəm* *aːnam*
‘plant’ ‘plait’

Surfacing schwa occurs in the final syllable of a word. In penultimate position, underlying schwa can raise to [ɪ] or [ʊ].[3]The following examples show a minimal pair contrasting schwa raised to [ɪ] with a full [i].

(6) *miɳ̪ta* *mɪɳ̪ta*
‘ask’ ‘vomit’

Having established the vowel system, we will now come to an outline of the basic syllable structure in SLM.

3.3. Syllable and word structure in SLM

The basic SLM syllable consists of an optional onset, which may be complex, a nucleus, which cannot host heterogeneous vowels, and a simple, optional coda.[4] In a complex onset, the second member needs to be a liquid or a glide, which is symbolised by ‘L’. Vowels can be long, but only in open, penultimate syllables. Syllable structure can then be represented as in (7) and (8):

(7) (C)(L)V(:)
(8) (C)(L)V(C)

SLM further has a bimoraic word minimum. All monosyllabic (content) words contain either a long vowel or a coda consonant:

(9) *piː* ‘go’
(10) *pon* ‘bride’

Syllables can combine to disyllabic or trisyllabic words. In disyllabic words, we find four basic types (ignoring complex onsets):[5]

I) CVC.CV(C) e.g. t̪oppi ‘hat’/ minta ‘ask’
ii) CəC.CV(C) e.g. *mɪɳ̪ta* ‘vomit’
iii) CV:.CV(C) e.g. *t̪iːga*‘three’
(iv) CəC.CVC e.g. sɪggar 'sick'

[3] Which one of the two vowels is used is subject to variation. However, there are tendencies that [ɪ] is preferred before non-labial consonants, while [ʊ] is preferred before labial consonants Furthermore, the height of the following vowel also seems to have an influence (Bichsel-Stettler 1989, Adelaar 1991, Nordhoff 2009).

[4] Furthermore, initial extrasyllabic s- is possible.

[5] There are two words which do not fit into this list: [kubuːr] ‘bury’ and [kaːr̪tu] ‘quarter’, which we assume to be lexicalised.

The structures *CVːC.CV(C), *CV.CV(C), *Cə.CV(C) and *Cəː.CV(C) do not exist.[6] Trisyllables are less common than disyllables, which constitute about 90% of the SLM vocabulary. We limit our discussion to the following two types, which are by far the most common among the trisyllabic words.

v) CV.CV.CV(C) e.g. *pukujan* 'job'
vi) Cə.CVː.CV(C) e.g. *cəcaːʊak* 'wash'[7]

There are some compound words, mainly consisting of disyllables. The head of the compound can be to the left or to the right, which may be lexically specified. One word where both orders are possible is the word for "spectacles" given in (11).

(11) a. *kacamaṯa* [kacamaːṯa]
b. *maṯakaca* [maṯakaːca]

We observe that in those cases, only the penultimate vowel of the second member of the compound undergoes lengthening.

3.4. Lengthening, raising and gemination

On the phonetic level, words of the types given in iii) and vi) show an increase in duration of the penultimate vowel. Words in ii) and iv) raise the schwa to [ɪ] or [ʊ], while words in vi) do not. Words in iv) furthermore geminate the onset of the final syllable. All other vowels and consonants have non-alternating realizations. The following examples illustrate the relations between phonology and phonetics.

(12)	/ṯoppi/	[ṯoppi]	CVC.CV(C)	type i)
(13)	/mən.ṯa/	[mɪnṯa]	CəC.CV(C)	type ii)
(14)	/ṯi.ga/	[ṯiːga]	CVː.CV(C)	type iii)
(15)	/pə.raŋ/	[pɪrraŋ]	Cə.CV(C)	type iv)
(16)	/pu.ku.jan/	[pukujan]	CV.CV.CV(C)	type v)
(17)	/cə.ca.ʊak/	[cəcaːʊak]	CəCV.CV(C)	type vi)

4 The theoretic status of long vowels

Taking a look at the preceding list, we see that vowels in types iii) and vi) are always long, while vowels in other types are short. This raises the question of the theoretic status of these long vowels. Are they phonemic (i.e. do they contrast with short vowels) or are they the result of a phonological process? If they are the result of a phonological process, are they a correlate of stress, or are they something else?

[6] CV.CV can be found in function words like the plural marker *paḍa*, but we limit our analysis to lexical words.

[7] We gloss cəcaːʊak as 'wash' for reasons of space, but its meaning is more specific and refers to a certain type of washing of the body before going to bed. The more general word for 'to wash' is cuːci.

4.1 Is vowel length in SLM phonemic?

We observe from the list above that long vowels have a limited distribution. They can only occur in open penultimate syllables. There are no clear minimal pairs differing only in vowel length, but there are some near minimal pairs contrasting CV:CV with CVC:V. To put it differently, one word has a long vowel and a short consonant and the other one has a short vowel and a long consonant. An example is [ku:mis] 'moustache' vs. [kʊm:is] 'Thursday' (Bichsel-Stettler 1989:53). The question is, whether any of the two is underlying there. One could assume vowel length as underlyingly present, or one could alternatively assume consonant length as underlyingly present. The other quantity distinction would then result from a phonological process.

Bichsel-Stettler (1989) is a proponent of phonemic vowel length in SLM and cites some quasi-minimal pairs to prove her point.[8] However, her examples can all be explained without recurring to phonemic vowel length. First, she contrasts function words containing a short vowel with lexical words containing a long vowel. This can be explained by the different word classes these words belong to, given that function words do not always underlie the same phonological restrictions as content words do, and are often reduced in the world's languages. Second, she contrasts some disyllables with trisyllables (basically type iii and v). This neglects the importance of the number of syllables within a word, which is crucial for determining vowel length, as will be shown below. Third, she cites some words of the structure CV.GV(C) vs. CVː.GV(C), where 'G' stands for a glide. An example is [luʊar] 'outside' vs. [ɻuːʊal] 'sell'. We want to re-analyze these cases and propose that the glide is underlyingly present in the phonological form of /ɻuʊal/, but not in /luar/.[9] The /u/ in /luar/ is linked to both the nucleus of the penultimate syllable and the onset position of the following syllable. Due to hiatus avoidance, it is realised as a glide /ʊ/. In the case of /ɻuʊal/, the /ʊ/ is underlyingly present, and therefore no possibility of hiatus occurrence and subsequent avoidance. A final set of examples could not be confirmed as being SLM by our informants. A more extensive discussion of Bichsel-Stettler's data can be found in Tapovanaye (1995).

Vowel length has been analyzed as phonemic by Bichsel-Stettler (1989) and Smith et al. (2004). While they are silent about the raising of schwa, they argue that long vowels are always followed by simple consonants and short vowels are always followed by geminate consonants. Consonant gemination would then be a function of vowel length. A quick look at a words like *makanan* 'food' or *pukujan* 'job' shows that this analysis runs into problems. If short vowels were followed by geminate consonants, we would expect **makkannan* and **pukkujjan*; this is however not what we find.
The inverse position is taken by Tapovanaye (1986), who argues that vowel length is a function of syllable structure. Geminate consonants (which are phonemic) close the preceding syllable and therefore prevent lengthening. Tapovanaye (1995) refines this analysis and analyzes vowel length as a result of a minimal word requirement of four moras to explain types i-v). If a word falls short of the four-mora requirement, vowel lengthening, raising of schwa and consonant gemination take place. A schwa (normally not moraic) can be raised to [I] and [U] to gain a mora (type ii). If this renders the word still short of a mora, consonant gemination applies (type iv). Another possibility is to lengthen full vowels in penultimate open syllables as in type iii). Our analysis owes much to Tapovanaye's work, and we will discuss these processes of increasing moraic

[8] For similar forms see Smith et al. (2004).

[9] See Levi (2008) for a general discussion of phonemic and non-phonemic glides.

weight in more detail below. However, Tapovanaye assumes paragogic glottal stops after final open syllables, whose existence could not be confirmed by the data in our corpus. We therefore propose another analysis of the data in terms of a bimoraic foot requirement instead of a quadrimoraic word requirement.[10]

To sum up, there is no need to assume phonemic vowel length in SLM. All potential counter-examples can be explained by other factors, such as word class or number of syllables. Given that CC sequences are not distributionally restricted, but that VV sequences are, we argue that consonant length can be underlyingly present, but that vowel length is always the result of a phonological process. As such, the next question is whether vowel length is a phonetic cue for stress in SLM.

4.1. Is vowel length a phonetic correlate of stress in SLM?

It is a well-known fact that vowel length can correlate with stress. At first sight, the penultimate lengthening effect in SLM is reminiscent of Italian, where the short vowels of open syllables in penultimate position are lengthened when stressed (D'Imperio & Rosenthall 1999). This is known as a stress-to-weight effect (Prince 1980), which is quite common in the world's languages (another case is for instance Norwegian; Rice 2006). However, duration is not the only stress cue in Italian; D'Imperio & Rosenthall also found that open penultimates in Italian do not only have a longer duration, but also show higher intensity than surrounding syllables.

As for the analyses of the aforementioned studies of Bichsel-Stettler (1989), Tapovanaye (1995) and Smith et al. (2004), none of them identifies vowel length in SLM as a phonetic cue for stress, or as a synchronic "stress-to-weight" effect.

As for the position of stress in SLM, Bichsel-Stettler, Smith et al. and Tapovanaye all assume stress for SLM, but do not agree on a pattern. Bichsel-Stettler (1989) states that "stress predominantly falls on the penultimate syllable of the root" (50), with the exception of some Arabic loanwords.[11] She furthermore writes that generally "stressed vowels are long in open syllables and short in closed syllables", but admits that some trisyllables have short stressed vowels in the penultimate (52). Tapovanaye (1995) concurs that "stress falls on the penultimate or only syllable of each word". Smith et al. (2004) observe that stress falls on the long vowel of a word. If no long vowel is present, the first syllable will be stressed. This contrasts with the views expressed by Bichsel-Stettler and Tapovanaye, who do not assume the initial syllable as a stress-bearer unless it also happens to be the penultimate. None of these authors mention phonetic cues that are used to determine stress, nor do they explain by what means they established the position of stress. It seems that we are dealing with impressionistic statements. Furthermore, it cannot be excluded that stress was only tested on isolated citation forms, which bears the possibility of expressing phrasal stress rather than word stress. Given this state of affairs and the different analysis of Smith et al. as compared

[10] Tapovanaye's analysis furthermore runs into problems for compounds as in (13), because his analysis cannot explain why the last root undergoes lengthening while the preceding one does not. Either the whole compound is considered a phonological word, in which case it would satisfy the four-mora requirement, and there would be no need for the long vowel. Or it consist of two phonological words, of which the second component would meet the requirement, but not the first. Then the problem arises why only one of them is lengthened and not both.

[11] Loanwords of Arabic origin are treated differently in general, see Tapovanaye 1995:53f for a more elaborate discussion.

to Bichsel-Stettler and Tapovanaye, we did an instrumental analysis of stress cues in Sri Lanka Malay, presented in the next section.

5 Phonetic measurements of possible stress cues

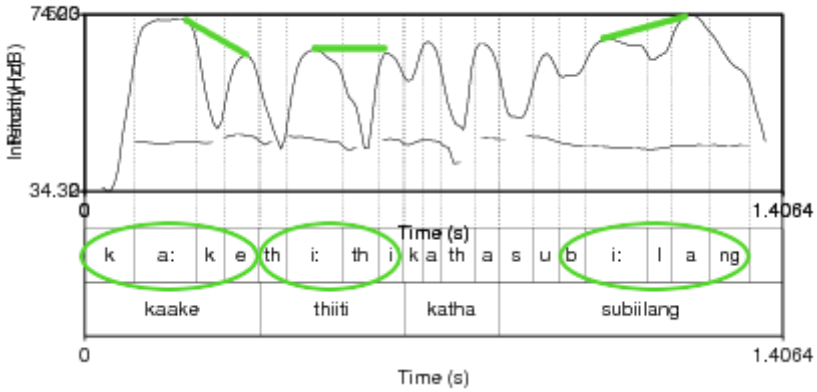
There are four main correlates of stress (stress cues) in the world's languages, namely pitch, intensity, vowel quality and vowel duration (Fry 1958). We a priori want to exclude vowel quality as a stress cue in SLM because we cannot find any effects of it (and neither have Bichsel-Stettler, Tapovanaye or Smith et al.). This leaves vowel length, pitch and intensity as possible stress cues in SLM. To investigate whether SLM makes use of any of those cues, and which, we did some phonetic measurements.

Our measurements are based on a sample of 49 words with different syllable structures, which was compiled for this purpose. These words were checked in 6 different environments with two male native speakers of SLM (18 and 19 years old) in a self-paced reading test.[12] Carrier phrases were used to reduce the effects of phrasal intonation on word intonation, e.g. *kaːke ___ kaṯa subiːlang* "Grandfather said ___". The position of the token in the middle of the intonational phrase should guarantee that phrasal effects are minimal. Furthermore, carrier phrases with different information status were used to control for different types of phrase intonation (citation, embedded citation, old information, broad focus, narrow focus, question). The sentences were presented one for one on the computer screen in random order. The speakers were asked to read the sentence aloud and then repeat it from memory (sentences were generally shorter than five words). Speakers were allowed to repeat the sentence more than once if they wished, or alter the structure to make the sentence sound better. The aim of the repetition was to eliminate information structure effects caused by a preceding sentence, and hesitations caused by the unfamiliar task of reading Sri Lanka Malay. When a sentence was done, the speakers would hit the enter key and were presented with the next token.

Results

This test gave the following results for the phrase level and the word level: Phrasal intonation is characterised by higher intensity for the initial and the final syllables, and a pitch drop towards the end. For the word in a neutral position within the intonational phrase, virtually no pitch or intensity differences could be found.

[12] The speakers are literate in Sinhala and English and were familiar with the practical orthography based on the Latin script employed in this task.



ka:ke *t̪i:t̪i* *katha* *su-bi:lang*
grandfather feed QUOT PAST-say'

Figure 1: *t̪i:t̪i* shows no intensity or pitch movement in the position which interests us. *ka:ke and bi:lang show falling and rising intensity, which is due to boundary effects.*

As far as word intonation is concerned, words in initial or final position within the phrase inherit the phrasal accent. So, for Figure 1, we find three words with the structure CV:.CV(C), namely *ka:ke* 'grandfather', *t̪i:t̪i* 'feed' and *bi:laŋ* 'say'. All of these have a long penultimate vowel, but the first has a drop in intensity, the second has level intensity and the last has a rise in intensity. Furthermore, there are no strong pitch movements, but the last one shows a drop, which is due to the utterance boundary. We conclude that in this example, intensity is used to signal both the initial and the final utterance boundary, and the final boundary is additionally signalled by a pitch drop.

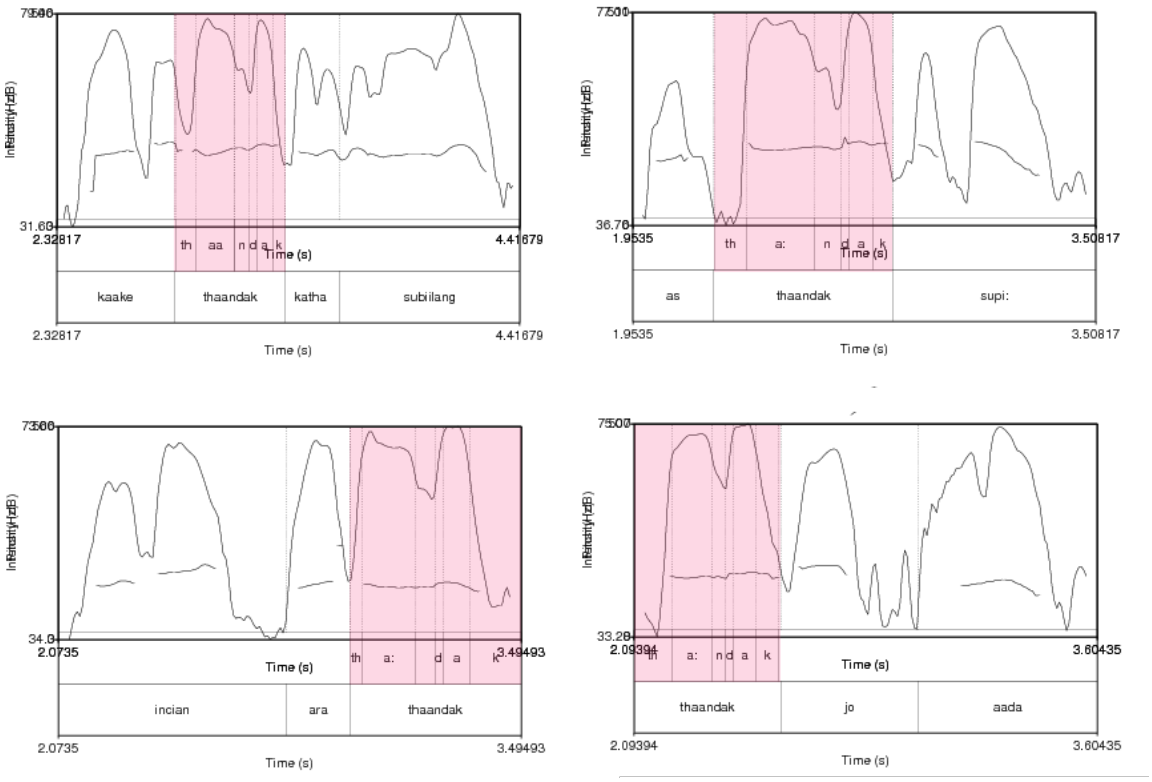


Figure 2.

Neither pitch nor intensity is used to signal anything on the word level, i.e. pitch and intensity are no stress cues in SLM. Other tokens and environments confirm this analysis. For illustration, Figure 2. shows pitch and intensity for four different contexts of the word *ˌtaː ⁿɖaˌak* ‘dance’ (where /ⁿɖ/ is a monophonemic prenasalised stop). We see a clear lengthening of the vowel in the penultimate syllable, but no accompanying intensity or pitch cues.

We conclude that neither pitch nor intensity are stress cues in SLM. This leaves vowel lengthening (as a stress-to-weight effect) as the only possible stress cue. However, trisyllabic words such as *pukujan* 'job' show that increased vowel duration is not a stress cue, either; otherwise *pukujan* should display an increase of duration as well. This is not the case, as Figure (3) demonstrates:

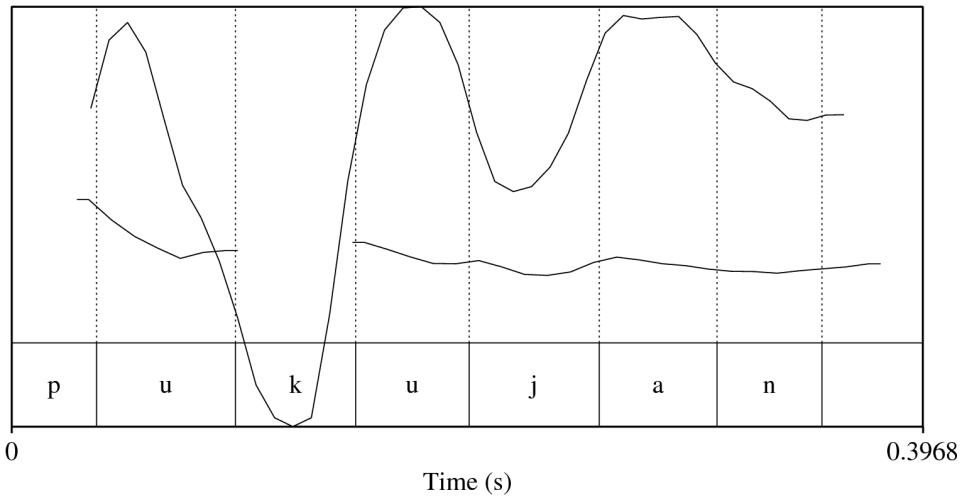


Figure 3.

The three vowels in the word do not show any sign of significantly increased duration. All three syllables have about equal intensity and pitch.[13]

So, back to the question whether duration could be a stress cue in SLM: based on our findings, we claim that duration is not a stress cue in SLM, because there are many words which do not show any lengthening effect at all. The words without lengthening comprise words with a closed penultimate, like *ˌtaksir 'think'*, or trisyllables like *pukujan* 'job' where there is no lengthening, and no closed syllable. The absence of both stress (in terms of duration, intensity and pitch) and weight (in terms of long vowels or closed syllables) in the latter example leads us to the conclusion that there is neither a stress-to-weight nor a weight-to-stress effect in SLM, nor a phonetic cue for stress.

To summarise our exposition of the facts: we first showed that neither intensity nor pitch are predictors of vowel duration in SLM. We furthermore showed that differences in vowel duration are not found in all words. We would like to propose that vowel duration in SLM cannot be a stress cue either because it does not occur in all words. While vowel duration in SLM cannot be analyzed as a cue or a consequence of stress, we will show in the following section that it is nevertheless a regular phonological process which can be explained by foot structure.

[13] The pitch movement in the first syllable is due to aspiration of the labial stop.

6 Our analysis of vowel lengthening and stress in SLM

Having said that SLM does not have stress or at least no phonetic cue for it that could determine the position of it, and having said that vowel length is a phonological process, we propose an analysis in terms of bimoraic, yet headless, foot structure.

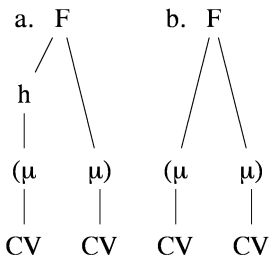
Tapovanaye's analysis of vowel lengthening in SLM was able to capture most of the facts, but had some problems. We propose a refinement of his findings that is able to deal with the problems that his analysis faces. To replace the four-mora requirement, we propose that two simple principles can account for all the variation in word structure we find in SLM, namely extrametricality of the final syllable and a requirement for bimoraic feet. With these principles, everything falls into place. The overall structure of this analysis is similar to Tapovanaye's, but instead of assuming four moras to be present in two syllables, we assume two moras in non-final syllables and nothing in particular for the final syllable, thus avoiding the empirically problematic need for the paragogic insertion of the glottal stop.

6.1. The headedness of feet and its representation

One thing which might come as a surprise is that the bimoraic feet in SLM are headless. In general, the very notion of feet implies the presence of stress, and the notion of stress implies the presence of feet (Liberman & Prince 1977). Along with it, feet and stress represent something like headedness, i.e. (binary) feet are usually divided into a strong and a weak part. The phonetically prominent syllable of a foot marks the strong part, and is deemed to be the head of the foot. As we have seen above, there is no phonetically prominent syllable in SLM, so that the application of this theory of feet becomes problematic.

However, not everyone agrees that the presence of feet imply the presence of stress and vice versa. There are numerous proposals that footing and the assignment of headedness are quite distinct mechanisms. In derivational accounts, feet were regarded as being inherently headless, and rules applied later in the cycle would take care of head assignment (e.g. Halle & Vergnaud 1987ab; Crowhurst 1991; Halle & Idsardi 1992). The idea of a disconnection of stressing and footing or inherently headless feet was later also incorporated into parallel accounts (e.g. Bye 1996; Hagberg 2006, Golston & Riad 2000, Golston 2007, Krämer 2007, 2009). Headless feet can be represented as lacking the intermediate level of head assignment. We will follow Krämer's (2007) representation, who suggested inherently headless secondary feet in Italian. For the purpose of SLM, we follow the proposal that the presence of feet does not imply the presence of stress and argue that feet in SLM are in general headless, hence stressless. The representation in (20a) is a traditional representation of foot structure, incorporating the level where headedness is assigned, while the representation in (20b) skips this level. 'F' stands for 'foot', 'h' stands for 'head', ' ' stands for 'mora' and 'CV' stands for the segments of a word (moraic and syllabic level are conflated for the ease of exposition):

(18) The representation of headed (a) and headless (b) feet



6.2. The application of bimoraic headless feet to the SLM data

After this general introduction to the idea of headless feet, we continue by applying this idea to SLM. We make the following three assumptions for SLM:

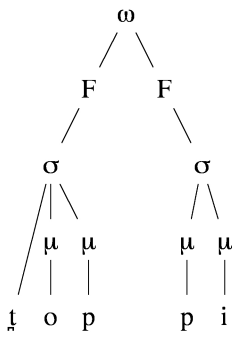
1. SLM has bimoraic feet
2. these feet are inherently headless
3. final syllables are extrametrical

With these assumptions, all three processes of vowel lengthening, schwa raising and gemination can be captured. In the following, we demonstrate the representations for the word types listed in i)-vi).

Type i) CVC.CV(C)

The representation of type i) words is straightforward: the final syllable is ignored and the penultimate provides the two moras necessary to build a bimoraic foot. Note that the double consonant is underlyingly present, and not the result of a gemination process.

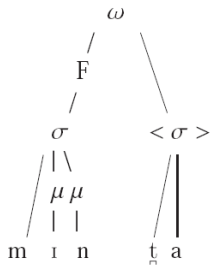
(19) The representation of type i) words: *t̪oppi* 'hat'



Type ii) CəC.CV(C)

Schwa has no moraic weight in SLM. This is why it is raised to [I] or [U], which do have moraic weight. The second mora stems from the moraic coda consonant, and a bimoraic foot can be constructed. The final syllable is ignored, as before.

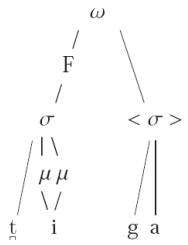
(20) The representation of type ii) words: *mɪn̪ta* ‘vomit’



Type iii) CV.CV(C)

In words of type three, there is no coda consonant which could contribute a mora. The absence of this consonant is made up by lengthening the vowel, which adds an extra mora for the bimoraic foot.

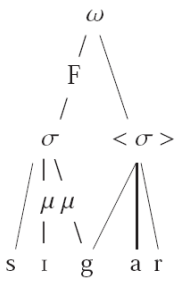
(21) The representation of type iii) words: *t̪i:ga* ‘three’



Type iv) Cə.CV(C)

In words of type iv), the penultimate has no moraic weight at all in the phonological form. Two extra moras have to be found, which is done by raising of schwa, as in Type ii), and by geminating the onset of the final syllable, which subsequently serves as the coda of the penultimate and thereby contributes moraic weight to the foot.

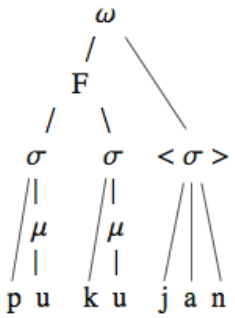
(22) The representation of type iv) words:



Type v) CV.CV.CV(C)

Trisyllabic words with full vowels can construct a bimoraic foot off the first two syllables without problems:

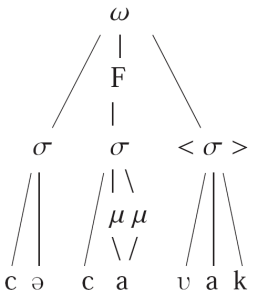
(23) The representation of type v) words:



Type vi) Cə.CV.CV(C)

Trisyllables with schwa in the antepenultimate syllables lack a mora for the bimoraic foot, which is gained by lengthening the penultimate vowel (similar to type iii) words).

(24) The representation of type vi) words:



After this exposition of the workings of the bimoraic foot requirement, we now turn to the OT grammar which can describe these facts.

7 Accounting for stressless feet in OT

The lengthening of open penultimate syllables in SLM can be explained by well-established constraints such as NONFINALITY, FOOTBIMORAIC and PARSE, listed in (25).

(25) Basic constraints:
NONF: Final syllables are not parsed into a foot.
FTBIM: Feet are minimally and maximally bimoraic.
PARSE: Syllables are parsed into feet.

A ranking between the three constraints can be established with the disyllabic words *ˌti:ga* ‘three’ and *ˌtaksir* ‘think’. PARSE ensures that words are parsed into feet at all. However, it needs to be dominated by NONFINALITY, which ensures that final syllables are not parsed into feet, and FTBIM, which requires feet to be bimoraic, when ranked accordingly. If extrametricality were not at work here there would be no reason to lengthen the penultimate, because a disyllabic word like *ˌtiga* could be parsed into a perfectly bimoraic foot (ˌtiμ.gaμ). This is illustrated in tableau (26):

(26) *ˌti:ga* 'three': NonF, FtBim >> Parse

ˌtiga	NonF	FtBim	Parse
(ˌti$_{\mu}$.ga$_{\mu}$)	*!		
(ˌti$_{\mu}$:$_{\mu}$.ga$_{\mu}$)	*(!)	*(!)	
(ˌti$_{\mu}$).<ga>		*!	*
☞ (ˌti$_{\mu}$:$_{\mu}$).<ga>			*

In words with a closed penultimate, the vowel is not lengthened. We conclude from this that coda consonants are moraic, rendering the syllable bimoraic and thus satisfying FtBim. In these cases, the penultimate vowel does not have to lengthen. This can be captured by incorporating WBP into the analysis, as defined in (27):

(27) WBP (Weight-By-Position): Coda consonants are moraic.

It does not need to be high-ranking, however, as shown in tableau (x).[14] No matter where it is inserted in the hierarchy, it rules out candidates with non-moraic codas.[15]

(28) *ˌtaksir* 'think'

ˌtaksir	NonF	FtBim	Parse	WBP
(ˌta$_{\mu}$k.si$_{\mu}$r)	*!			**
(ˌta$_{\mu}$k).<sir>		*!	*	**
☞ (ˌta$_{\mu}$k$_{\mu}$).<sir>			*	*
(ˌta$_{\mu}$:$_{\mu}$k).<sir>			*	**!
(ˌta$_{\mu}$:$_{\mu}$k$_{\mu}$).<sir>		*!	*	*

CV.CV.CV-words like *pukujan* 'job' have full vowels and do not show lengthening nor change in pitch or intensity. We argue that these trisyllabic words do not need to lengthen, because even under consideration of extrametricality, the first two syllables of the word can be parsed into a bimoraic foot, therefore satisfying the two highest-ranked constraints NonF and FtBim.

(29) *pukujan* 'job'

pukujan	NonF	FtBim	Parse
☞ (pu$_{\mu}$.ku$_{\mu}$).<jan>			*
pu$_{\mu}$.(ku$_{\mu}$:$_{\mu}$).<jan>			**!
(pu$_{\mu}$:$_{\mu}$).(ku$_{\mu}$.jan)	*!		
(pu$_{\mu}$:$_{\mu}$.ku$_{\mu}$).<jan>		*!	*
pu$_{\mu}$.(ku$_{\mu}$).<jan>		*!	**
(pu$_{\mu}$.ku$_{\mu}$:$_{\mu}$).<jan>		*!	*

However, the reader familiar with stress and OT will know that many of the world's languages do not only have stress, but also use some kind of rhythm, expressed in constraints such as Iambic and Trochaic.

[14] We refrain from marking word-final codas as moraic in the tableaux, since final syllables are always extrametrical.

[15] As long as it outranks a constraint such as *C , which requires coda consonants to be moraless.

(30) TROCH: Feet are left-headed.
(31) IAMB: Feet are right-headed.

Even when ranked low, they would force some kind of prominence to one of the syllables in the bimoraic foot. Ranked on the same stratum (since there is no evidence in SLM that these two constraints are ranked with respect to each other), there would be a 50% chance of sometimes surfacing trochaic feet, and sometimes surfacing iambic feet. Tableau (33) illustrates how the stressless candidate is suboptimal to the other two candidates, because it violates both TROCH and IAMB.

(32) Unranked TROCH and IAMB

pukujan	PARSE	TROCH	IAMB
:-(($pu_{\mu}.ku_{\mu}$).<jan>	*	*(!)	*(!)
☞ ($pú_{\mu}.ku_{\mu}$).<jan>	*		*
☞ ($pu_{\mu}.kú_{\mu}$).<jan>	*	*	

One could argue at this point that the speakers of SLM employ exactly this kind of analysis: they have arbitrary phonological stress, but do not realise it phonetically (Paul Boersma, p.c.). This would shift the problem to the phonetic level of analysis, but it would not really solve anything: how come that SLM speakers do not express stress phonetically although they have it? While speakers of Javanese Indonesian seem to employ a random notion of stress (i.e. they have prominence realised phonetically, but assign it in a random fashion, indicating that it does not mean anything to them and is not part of their phonological system; Odé 1994), SLM speakers do not. We propose that the lack of stress on the phonetic level corresponds to a lack of stress on the phonological level, while the systematicity of lengthening indicates that SLM does employ foot structure.

We accordingly need a means to express this lack of stress, forcing feet to be headless. To do so, we adopt a proposal by Golston (2007), who introduce constraints conflicting in the alignment of heads (as do TROCH and IAMB), and constraints conflicting in the non-alignment of heads. He motivates these constraints on the basis of headless secondary feet (as in Seminole, where headless secondary feet are used to establish the placement of the feet with main stress) and headless feet in general (as occurring in Japanese, where headless feet seem to be the only feet according to Poser 1990; Japanese seems to be very similar to SLM in that respect, with the difference that Japanese in addition has tone). Their constraints, listed in (33), give a better typology of foot form than IAMBIC and TROCHAIC, because they do not enforce presence of stress, but simply the position of heads, if there are any.

(33) New tools for headedness of feet:
ALLHEADSRIGHT: Every head is foot-final.
ALLHEADSLEFT: Every head is foot-initial.
NOHEADSRIGHT: No head is foot final.
NOHEADSLEFT: No head is foot initial.

The presence of stress is usually enforced by a constraint CULMINATIVITY, which is often taken as unviolable. Apparently, it needs to be a violable constraint, otherwise stressless languages would be impossible. If the NOHEADS constraints outrank the ALLHEADS constraints and furthermore CULMINATIVITY, then feet can surface as headless:

(34)

pukujan	NoHR	NoHL	AHR	AHL	Cul
☞ ($pu_{\mu}.ku_{\mu}$).<jan>			*	*	*
($pú_{\mu}.ku_{\mu}$).<jan>		*!	*		
($pu_{\mu}.kú_{\mu}$).<jan>	*!			*	

Having established how lengthening occurs in disyllabic words with open penults but not in disyllabic words with closed penults and trisyllabic words with open penults, we need to mention cases that look like an exception to the rule: trisyllabic words with open penults that *do* lengthen, such as *cəcaːʊak* 'wash'. Why do they display lengthening, in contrast to words like *pukujan 'job'*? We argue that these words differ from the *pukujan*–cases because they contain an underlying schwa in the initial syllable, as opposed to words like *pukujan*. The schwa has no mora (as has been claimed for e.g. German; Féry 1996, also see Kager 1989 for Dutch), and therefore has no basis to lengthen in SLM. Van Oostendorp (1995) proposed that this is due to limited projection abilities of schwa: schwa as an (almost) empty vowel does not have sufficient material to license all of the syllabic nodes that are necessary in order to get complex onsets or codas. Simple vowels are not allowed to project complex syllables. For that reason, schwa cannot add to the moraic content of a foot. The only possibility to achieve foot bimoraicity is then to lengthen the penultimate, as in disyllabic words.

In OT, the mora-less status of schwa can be expressed by a constraint *$ə_{\mu}$ (following Moren's 2000 constraint family *Mora[voc]):

(35) *$ə_{\mu}$: Schwa has no moraic content.

If the schwa cannot contribute to the moraic content of a foot, the bimoraic foot requirement has to be satisfied otherwise. In the case of trisyllabic words with open penults, it is the vowel of the penult that lengthens. This is done by ranking *$ə_{\mu}$ above Parse, excluding syllables with a schwa from the foot.[16] (For readability reasons, we exclude any candidates from the tableau that violate NonFin, which is high-ranking anyway):

(36) *cəcaːʊak* 'wash'

cəcaʊak	FtBim	*$ə_{\mu}$	Parse
☞ cə.($ca_{\mu}ː_{\mu}$).<ʊak>			**
($cə_{\mu}.ca_{\mu}$).<ʊak>		*!	*
cə.(ca_{μ}).<ʊak>	*!		**

Schwas in other positions than the initial syllable of trisyllabic words behave differently, and will be discussed in the next section.

7.1. Raising of schwa

In some disyllabic words such as *mɪnta* 'vomit', we find a raise to [ɪ] or [ʊ] of the initial syllable. We assume that they are allophones of underlying schwa (cf. Tapovanaye 1995), and that schwa cannot surface because of *$ə_{\mu}$, which prohibits the schwa from

[16] This could also be done with a constraint Non-Foot(ə) as proposed by Cohn & McCarthy (1994), that states that schwa-headed syllables have no metrical projection.

being moraic. Due to the pressure to satisfy the bimoraic foot requirement, schwa is raised and therefore gains a mora. The second mora is provided by the coda consonant of the initial syllable. Raising occurs only in disyllabic words with a closed penultimate, and gemination occurs only in disyllabic words with an open penult. We discuss the raising process in this section, and the gemination process in the next.

Considering only candidates that satisfy the extrametricality requirement and a minimum of parse, tableau (37) illustrates how the candidate with a monomoraic foot is excluded and how the candidate with a moraic schwa is excluded. The third option, a candidate with a raised vowel, wins because it fulfills the crucial constraints.[17]

(37) *mɪnta* 'vomit'

mənta	FtBIm	*əμ	Id-VQ
(məμnμ).<ta>		*!	
(mənμ).<ta>	*!		
☞ (mɪμnμ).<ta>			*

(NonF would be still ranked on a stratum with FtBIm, and Parse would still be ranked below *əμ).

Why, then, do we have surfacing schwa in trisyllabic words such as *cəca:ʊak*? We assume that the schwa is not raised in these cases because of intervening faithfulness to the vowel quality (Id-VQ):

(38) No rise in *cəca:ʊak* 'wash'

cəcaʊak	FtBIm	*əμ	Id-VQ	Parse
☞ cə.(caμ:μ).<ʊak>				**
(cɪμ.caμ).<ʊak>			*!	*

Id-VQ is crucially ranked above Parse. Note that this would not change the outcome of tableau (36).

If there is no coda consonant that could provide the second mora, the onset of the following syllable is recruited to double in order to become a coda to the preceding syllable. This is illustrated in the next section.

7.2. Gemination instead of lengthening

Gemination in SLM occurs in disyllabic words with an open penult containing an underlying initial schwa, and goes hand in hand with raising of schwa to [ɪ]. Only then the (required) foot gets enough moraic content to fulfil the bimoraicity requirement: the schwa itself has no moraic content and therefore raises to provide one mora. To fulfil the bimoraicity requirement, the onset consonant of the following syllable is doubled, providing the second mora to complete the foot. A constraint against the lengthening of vowels, Id-IO[v-length] (Benua 1995), prevents the raised vowel from lengthening.

[17] The question arises as to why schwa does not raise to a full vowel, which would be present in the phonemic inventory of the language. In the case of *mɪn̪ta* 'vomit' at least, this would result in homonymy: there exists already a lexical entry *minta* 'ask'. The raise to a reduced, but not a full vowel could be motivated by faithfulness reasons: a raise to a reduced vowel would preserve information about the underlying schwa, which would not be the case if the vowel were raised to a full vowel. This being said, the allophones [ɪ] and [ʊ] are only found in the inventories of some speakers; some speakers systematically raise to [i] and [u].

Instead, the geminated candidate (pɪ$_{\mu}$r$_{\mu}$).<raŋ> [pɪrraŋ] is preferred.

(39) ID-IO[v-length]: Vowel length in the output is identical to that in the input.

(40) *pɪrraŋ* 'war'

pəraŋ	FTBIM	*ə$_{\mu}$	ID-IO[v-length]
(pə).<raŋ>	*!		
(pə$_{\mu}$).<raŋ>	*(!)	*(!)	
(pər$_{\mu}$).<raŋ>	*!		
(pə$_{\mu}$r$_{\mu}$).<raŋ>		*!	
(pə$_{\mu}$ː$_{\mu}$).<raŋ>		*!	*
(pɪ$_{\mu}$ː$_{\mu}$).<raŋ>			*!
☞(pɪ$_{\mu}$r$_{\mu}$).<raŋ>			

Note that the insertion of ID-IO[v-length] between ID-VQ and PARSE (not displayed here for readability reasons) does not affect the lengthening processes in the *t̪i:ga* or *cəcaːʊak* cases, because these constraints are dominated by NONFIN, FTBIM and *ə$_{\mu}$:

(41) *t̪i:ga* 'three'

t̪iga	NONF	FTBIM	PARSE	ID-IO[v-length]
(t̪i$_{\mu}$.ga$_{\mu}$)	*!			
(t̪i$_{\mu}$ː$_{\mu}$.ga$_{\mu}$)	*(!)	*(!)		*
(t̪i$_{\mu}$).<ga$_{\mu}$>		*!	*	
☞ (t̪i$_{\mu}$ː$_{\mu}$).<ga$_{\mu}$>			*	*

By incorporating the constraint ID-IO[v-length] into the analysis, we can also explain why trisyllabic syllables with a closed antepenult are not lengthened, as it can occur for instance if a word like *t̪aksir* is inflected: [t̪aksiran] "think-NMLZR=thought", not * [t̪aksiːran]. Strict bimoraicity is preserved although a trimoraic foot becomes an option. Our ranking renders a candidate with a moraless coda consonant.

(42) *t̪aksiran* 'thought'

t̪aksiran	FTBIM	PARSE	ID-IO[v-length]	WBP
☞ (t̪a$_{\mu}$k.si$_{\mu}$).<ran>		*		*
(t̪a$_{\mu}$k.si$_{\mu}$ː$_{\mu}$).<ran>	*!	*	*	*
(t̪a$_{\mu}$k$_{\mu}$.si$_{\mu}$).<ran>	*!	*		
(t̪a$_{\mu}$k$_{\mu}$.si$_{\mu}$ː$_{\mu}$).<ran>	*!	*	*	
(t̪a$_{\mu}$k$_{\mu}$).(si$_{\mu}$ː$_{\mu}$).<ran>		*	*!	
(t̪a$_{\mu}$k$_{\mu}$).si.<ran>		**!		
t̪ak.(si$_{\mu}$ː$_{\mu}$).<ran>		**!	*	*

7.3.Lengthening in compounds

What is left to establish now is the occurring lengthening effect in compounds. In compounds like *kacama:̱ta* 'spectacles' that consist of two disyllabic words (here: *ka:ca* 'mirror' and *ma:ta* 'glass'), the penultimate syllable is lengthened although there is in principle enough material to fill a bimoraic foot. Example (43) demonstrates how the discussed constraints FtBim, Parse and Id-IO[v-length] in combination with a low-ranked alignment constraint All-Feet-Right ensure that the candidate with a lengthened penultimate syllable (a) and not the candidate with a lengthened pre-antepenultimate syllable (e) wins.

(43) *kacama:̱ta* 'spectacles'

kaca+ma̱ta		FtBim	Parse	Id-IO[v-length]	AFR
☞ a.	(ka$_{\mu}$.ca$_{\mu}$).(ma$_{\mu}$:$_{\mu}$).<̱ta>		*	*	***
b.	ka.ca.(ma$_{\mu}$:$_{\mu}$).<̱ta>		**!*	*	*
c.	ka.(ca$_{\mu}$.ma$_{\mu}$).<̱ta>		**!		*
d.	(ka$_{\mu}$:$_{\mu}$.ca$_{\mu}$).(ma$_{\mu}$:$_{\mu}$).<̱ta>	*!	*	**	***
e.	(ka$_{\mu}$:$_{\mu}$).(ca$_{\mu}$.ma$_{\mu}$).<̱ta>		*	*	****!
f.	(ka:$_{\mu}$ca$_{\mu}$)(ma$_{\mu}$:$_{\mu}$)<̱ta>		*	**!	***
g.	(ka$_{\mu}$:$_{\mu}$)(ca$_{\mu}$:$_{\mu}$)(ma$_{\mu}$:$_{\mu}$)<̱ta>		*	**!*	******

8 Alternative analyses

One could think of other analyses of the SLM facts. For instance, one could analyze SLM as having headed feet, but lacking a phonetic correlate for these heads (e.g. van der Hulst 1999).[18] We disfavour this option, since L1 learners of SLM would find no evidence for headedness and end up with a grammar that assigns heads to feet in an arbitrary fashion. While we do not object against hidden variation in grammars in general (see Apoussidou, accepted), we reject this analysis for SLM because it is not clear why the arbitrary headedness is not expressed in phonetic correlates, which is usually the case in stress languages.

Another possible analysis would be to assume level stress (e.g. Liberman 1982; Kristoffersen 1990; Riad 1992; Bye 1996) for SLM.[19] Level stress is usually assumed to spread over two light syllables within a foot. However, this does not capture all the SLM facts, where there is ample evidence for monosyllabic, yet bimoraic feet, but less evidence for disyllabic and bimoraic feet.

[18] We thank Paul Boersma for drawing our attention to such an analysis.

[19] We thank Norval Smith for this suggestion.

9 Discussion

We have shown, based on vowel lengthening and schwa raising effects, that Sri Lanka Malay makes use of the concept 'foot' in its grammar, but not of the concepts 'stress' and 'headedness' on the word level. As already argued by Crowhurst (1991, 1996) or Golston (2007; among others) the principles of foot structure and stress location can be dissociated. We conclude that this is mandatory for SLM. While other languages restrict the lack of headedness to secondary feet (see e.g. Golston et al. on Seminole and Krämer 2009 for Italian), SLM is a language without *any* heads in feet, which makes it special. Yet, its phonology can be predicted by fairly basic and well-established principles. While SLM stresslessness might be exceptional, the principles it is built on are not.

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