Quality-conditioned stress as length: glide epenthesis in Moksha

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Last updated January 20, 2024

Abstract

In Strict CV, it has been argued that stress can be represented by syllabic space, i.e. by empty CV slots (Larsen 1998, Szigetvári & Scheer 2005). Stress is assumed to be computed above the skeleton and therefore to be independent of melody (Scheer 2004), so the existence of genuinely quality-conditioned stress is not expected. It can, however, be reanalyzed with virtual length (Lowenstamm 1991, 2011, Saïd 2011, Enguehard 2018). When the quality contrasts relevant to stress are represented with quantity in the phonology, the problem of quality-driven stress is solved. This paper presents a reanalysis of quality-conditioned stress in Moksha, which helps model the interaction between stress and glide epenthesis in Moksha, where /i/ and /u/ can spread to form a glide before vowel-initial suffixes. Vowel spreading can happen after polysyllabic nouns but not after the monosyllabic ones. This rule is linked to the representation of stress as underlying phonological length.

Keywords: stress, vowel length, Strict CV phonology, Element Theory, glide epenthesis, vowel-glide alternations, Moksha

1 Introduction

Strict CV is a lateral autosegmental approach to phonology (Lowenstamm 1996, Scheer 2004, 2012), an offshoot of Government Phonology (Kaye, Lowenstamm & Vergnaud 1990). Phonological representations have two tiers: a syllabic tier that consists of syllabic slots with the universal CV structure and a melodic tier, where segments are situated. The two tiers are linked with association lines.

In Strict CV, there is a special exponent for stress – the syllabic unit, or an empty CV (Larsen 1998, Szigetvári & Scheer 2005). The idea behind this representation is that it is a non-diacritical phonological object that can handle the effects that occur in vicinity of stress.[1]

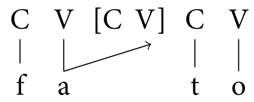
An important property of syllabic space as an exponent of stress is that it is purely skeletal. Strict CV presupposes the existence of two tiers, one syllabic and one melodic, which play different roles in the phonological computation. The processes that take place on the melodic level are strictly local. The melodic tier is not directly accessible to morphosyntax and such above-the-skeleton processes as stress and tone placement, infixation or phonologically-conditioned allomorphy (Scheer 2019b). Changes in the skeleton can cause melodic alternations, since melody is linked to skeletal slots with association lines, but melody cannot affect the skeleton. Stress is among the suprasegmental phenomena, so it belongs to the syllabic tier and can have effects on the melody, mediated by association lines.

For instance, a CV unit inserted by the stress algorithm can lengthen vowels or consonants. A classic example of an analysis featuring the empty syllabic unit as stress is Larsen's (1998) discussion of

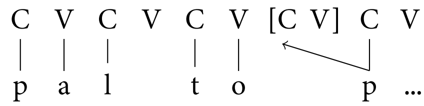
[1] These effects are constrained: not every process can be triggered by stress. See Giavazzi (2010) for the discussion of stress-induced effects and Szigetvári & Scheer (2005) on the explanation of some of them in Strict CV.

the interaction that tonic lengthening and *raddoppiamento sintattico* (lengthening of word-initial consonants) have with stress. Larsen (1998) suggests an explanation that rests on the representation of stress as an empty CV inserted after the stressed syllable. Tonic lengthening applies to stressed vowels, making them bipositional and therefore long (1). *Raddoppiamento*, on the other hand, causes the consonant to lengthen (2). Word-finally, long vowels are prohibited, that is why the syllabic space provided by final stress is taken up by the consonant.

(1) *fàto* [fa:to] 'destiny'
(Italian; Larsen 1998: p. 90)



(2) *paltò pulito* [paltoppulito] 'clean coat'
(Italian; Larsen 1998: p. 92)



So, stress can be exponed by syllabic space, and thus contribute to length. Length, in turn, can determine stress placement: in languages with contrastive length and a weight-dependent stress algorithm, syllables with long vowels are often heavy. Long vowels are considered bimoraic in the standard metrical theory of stress (Hayes 1995), and this is replicated in Strict CV, where long vowels take up two skeletal slots. Strict CV Metrics (Faust & Ulfsbjorninn 2018, Ulfsbjorninn 2022), a metrical theory that makes use of the Strict CV skeleton and a mechanism of prominence projection and incorporation, provides a mechanism of stress assignment where bipositional long vowels can project higher than the short ones. This is achieved be means of empty nuclei, which are metrically relevant: if a vowel is associated to a second position, this additional slot can be incorporated to lend more prominence to the vowel.[2]

In Wolof, which is a weight-sensitive language, syllables with heavy vowels are heavy. By default, stress falls on the leftmost syllable, however, if the initial syllable is light and the second one is heavy, the stress shifts to the heavier one (Ka 1988, Ulfsbjorninn 2022). For instance, in *kalá:me* 'to accuse', the second syllable has a long vowel, which receives stress because it projects to the highest level, having incorporated its second V-slot.

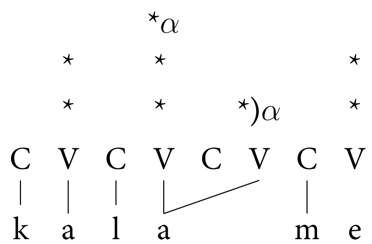


Figure 1: Incorporation in *kalá:me* 'to accuse'

By parametrisation of empty nuclei, their projection and incorporation, Strict CV Metrics allows us to model weight-dependent stress assignment. It is still only the skeleton and the autosegmental levels of projection that participate in it; no melody is involved.

So, both the exponent and the assignment process of stress are predicted by the theory to go on above the skeleton, independently of the melodic tier. But what if stress is quality-dependent, that is, stress assignment tracks vowel quality rather than quantity? Consider the example of sonority-driven stress from Gujarati (3), reported by de Lacy (2002) and discussed by Shih (2016).

[2] Projection of prominence is a classical feature of metrical theory; see Hayes (1983, 1995), Halle & Vergnaud (1987) on grid theories of stress.

(3) Gujarati stress in brief (data from de Lacy 2002: p. 72, cited by Shih 2016: p. 1)

a. Default stress on penult
   [sáɖa] 'plus 1/2'
   [dʒája] 'let's go'

b. Stress falls on ultimate [a] if penult is a non-[a]
   [ʃikáɾ] 'recently'
   [hɛɾán] 'distressed'

c. Stress falls on penultimate [a] if ultima is a non-[a]
   [sáme] 'in front'
   [sáɖu] 'plain'

Vowel quality is relevant to the Gujarati stress rule: the vowel [a] is different from the others. By default, stress falls on the penultimate syllable, however, if [a] is in the final syllable but not in the penult, the stress shifts to the ultimate [a]. In other words, syllables with [a] in the nucleus are heavy and other syllables are light. If stress is computed above the skeleton, how can it be conditioned by vowel quality, which belongs to the melodic tier? Such a stress rule would be an example of melody affecting a suprasegmental process, which is not predicted to exist.

One way to model quality-conditioned stress is via virtual length (see Lowenstamm 1991, 2011, Saïd 2011, Enguehard 2018, Ulfsbjorninn 2021 on virtual length in vowels and Ségéral & Scheer 2016 on virtual geminates). Virtual length refers to phonological length that manifests phonetically in ways other than duration, for example, as vowel quality. Since this is an apparent mismatch between phonetics and phonology, the existence of rules referring to virtual length can be used to argue for the absence of phonetic substance in the phonological computation, which is the thesis of Substance-Free Phonology (Hale & Reiss 2008, Scheer 2019a, Chabot 2021).

For instance, it is often the case that the full range of vowel quality contrast available in a language only exists in stressed vowels, whereas the unstressed ones are reduced. One such case is Russian vowel reduction. If stress is assumed to be represented by underlying vowel length in Russian, then there is a direct correlation between the number of privative features that make up the vowel (Enguehard 2018). A long vowel is assumed to be able to hold more featural material, which is why we observe more contrastive segments in stressed lengthened vowels than in the unstressed shorter ones. Table 1 shows the vowel inventory in stressed syllables, which contains 5 phonemes; Table **??**, on the other hand, demonstrates the reduced range of three segments that exist in the unstressed syllables.[3]

/i/	/u/
/e/	/o/
/a/	

Table 1: Full vowel inventory of Russian

[ɨ̞]	[ʊ̞]
[ɐ]	

Table 2: Reduced vowels in pretonic syllables (non-palatalized context)

Recasting vowel quality as length solves the problem of making stress related to quality, since stress is already known to interact with quantity. Two kinds of phenomena reduced to one is a favorable change of perspective. For Strict CV, it is particularly beneficial, since it presupposes that stress cannot depend on melody directly. Some proposals have come out that go against the existence of quality-driven stress as such (Shih 2016, Rasin 2016).

This paper presents another piece of data with a virtual length analysis of quality-conditioned stress. The data comes from intervocalic glide epenthesis in Moksha. In this case, I suppose that stress coincides

[3]The precise nature of Russian vowel reduction depends on the context. With palatalized and non-palatalized consonants, as well as in the pretonic and non-pretonic syllables, the phonetic realisation of the reduced consonants is different. Nevertheless, at least some quality contrast is erased in every context, so just one of them is enough for demonstrational purposes.

with length: both stressed and underlyingly long vowels are bipositional. This assumption allows a reanalysis to a rule that seems to refer to mono- versus polysyllabicity. I also argue that even though stress is dependent on vowel quality on the surface, the distinction between "heavy" and "light" vowels is better modelled in terms of phonological length.

The paper is laid out as follows: Section 2 introduces the data and summarises the patterns of behaviour of suffixes that start with schwa, /a/ and the high vowels /u/ and /i/, as well as the stress placement in Moksha. Section 3 contains the proposed analysis of the glide insertion as spreading of short vowels and the corollary accounts of other phenomena reviewed in connection to the glide insertion. Section 4 concludes the paper.

2 Data

Moksha is a Mordvinic language that belongs to the Uralic language family and is spoken in Mordovia republic, a region located in the European part of Russia, as well as in some neighbouring regions. The primary sources of data for the present study are the Moksha corpus, Kukhto's (2018) chapter on Moksha phonology and Kozlov & Kozlov's (2018) chapter on morphophonology. If not stated otherwise, examples come from the corpus. A practical transcription adopted from Toldova & Kholodilova (2018) is used throughout the paper; the IPA correspondence table is provided in the appendix. In the following section, I will give a brief introduction into Moksha phonology and morphophonology.

2.1 Moksha

As described by Kukhto (2018), the vowel inventory of Moksha comprises 7 phonemes (see Figure 2 below).

i		(ɨ)		u
e	(ɘ)		ə	o
ɛ		a		

Figure 2: Vowel inventory of Moksha

[ɨ] is an allophone of /i/ that occurs after non-palatalised vowels (4) and [ɘ] is an allophone of schwa that comes after palatalised consonants (5).[4]

(4) *ksti* [ɨ] 'berry' – *kšt'i* [i] 'dance.CN'

(5) *mol'əms* [ɘ] 'to go'

The consonant inventory, which is characterised by contrastive palatalisation and voicing, can be found in Figure 3 below. The phoneme /x/ only occurs in loanwords.

[4] /l'/ corresponds to a palatalized /l/ (see the IPA correspondence table in the Appendix).

m		n n’				
p b		t d t’ d’				k g
	f v	s z s’ z’		š ž šč	j̊	(x)
		c c’		č		
					j	
			r̥ r r̥’ r’			
		l̥ l	l̥’ l’			

Figure 3: Consonant inventory of Moksha

Default stress is on the leftmost syllable, however, vowel quality affects stress placement (Kukhto 2018). Syllables can be divided into *heavy* (with /a ɛ e o/ as nuclei) and *light* (with /u i ə/). The stress is borne by the leftmost heavy syllable (6–7), or, in words without heavy syllables, by the leftmost light one (8).[5]

(6) *ˈt’ɛd’ɛ*
‘mother’

(7) *kuˈvaka*
‘long’

(8) *ˈkijə*
‘who’ (Kukhto 2018: p. 34)

The stress rule is synchronically non-productive: consider late Russian loanwords in examples (9–10), which defy the rule of stressing the leftmost heavy syllable. In both *ˈkruška* ‘cup’ and *ˈkniga* ‘book’, the initial light syllable is stressed, despite the following syllable being heavy, because the original Russian stress is preserved.

(9) *ˈkruška*
‘cup’

(10) *ˈkniga*
‘book’ (Kukhto 2018: p. 34)

Stressed vowels are longer than the unstressed ones; unstressed vowels are centralised but not neutralised (Aasmäe et al. 2013, Kukhto 2018).

This paper will focus on glide epenthesis, therefore, it is important to describe some positional restrictions on the occurrence of vowels in native Moksha words, i.e. which vowels can create the hiatus on the boundary between the base and the suffix.

When it comes to bases, /e/ can only be found in stressed initial syllables (Kukhto 2018: p. 30), it can occupy the word-final position in monosyllabic words like *pe* ‘end’. The search of the dictionary by Serebrennikov, Feoktistov & Poljakov (1998) and the Moksha corpus reveals a lack of non-borrowed words that end in /o/; although Kukhto (2018) provides an example of an /o/-final word – *oc’o* – a dialectal variant of the word *oc’u* ‘big’, I will assume that /o/-final bases are extremely rare to nonexistent in Moksha. Word-finally, we can find /a ɛ e ə u i/, as exemplified in Table 3 below.

[5] I will continue to refer to the vowels that constitute the nuclei of heavy and light syllables as heavy and light vowels respectively.

Final vowel	Word	Translation
/a/	*ava*	woman
/ɛ/	*pr'ɛ*	head
/e/	*pe*	end
/ə/	*kizə*	year
/u/	*kelu*	birch
/i/	*kši*	bread

Table 3: Examples of vowel-final bases

The vast majority of affixes in the Moksha language are suffixes, with a very small minority of prefixes (Kholodilova & Korjakov 2018). There are no suffixes that start with /o/, /e/ or /ɛ/; examples of suffixes that start with other vowels – /a ə u i/ – are provided in Table 4.

Initial vowel	Suffix	Gloss	With C# base	Translation
/a/	*-an*	1SG	*az-an*	say-1SG
/ə/	*-ən'*	GEN	*ruz-ən'*	Russian-GEN
/u/	*-u/v/i*	LAT	*kud-u*	home-LAT
/i/	*-i/j*	3SG	*ul'-i*	be-3SG

Table 4: Examples of vowel-initial suffixes

I will focus on the behaviour of schwa-initial suffixes, which is superficially determined by syllable count but can instead be successfully linked to the stress pattern. Section 2.2 explores the data on the schwa-initial suffixes in detail. Section 2.3 is dedicated to /a/-initial suffixes, which do not pattern with the schwa-initial ones and whose behaviour I will show to be independent of stress.

2.2 Schwa-initial suffixes

There is a rule that is described by Kozlov & Kozlov (2018) as an glide insertion occurring after bases ending in /u/ or /i/ before vowel-initial suffixes. This can be analyzed as a process of homorganic glide epenthesis: /v/ is inserted after /u/ (11) and /j/ is inserted after /i/ (12).[6]

(11) *jožu + əl' → jožuv-əl'*
‘(3SG was) smart-IPF’ (Kozlov & Kozlov 2018: p. 42)

(12) *t'ɛči + ən' → t'ɛčij-ən'*
‘today-GEN’

The epenthetic /v/ and /j/ will be referred to as glides for the sake of simplicity, despite /v/ not being a glide phonetically. After Kozlov & Kozlov (2018), I assume, however, that that /v/ behaves as a glide in the phonology, since it can alternate with the vowel /u/. There are several suffixes in Moksha that start with a high vowel, for instance, *-i/j* ‘NPST.3SG’ and *-u/v/i* ‘LAT’ (Kozlov & Kozlov 2018). As evident from my exposition of these morphemes, they alternate between the vowel and the glide.[7]. The glide comes after vowels, the vowel – after consonants; see (13–15) for the allomorphs of the 3SG agreement marker and (16–17) for the lative.

(13) *jaka-j* ‘go-3SG’

(14) *šam-i* ‘empty-3SG’

[6]The part of the gloss in parentheses is not a part of the actual translation and serves to indicate that these forms are used as nominal predicates.

[7]The lative case marker has an additional variant *-i* that appears after palatalised consonants.

(15) *magazin-u*
'shop-LAT'

(16) *vir'-i*
'forest-LAT'

(17) *lavka-v*
'shop-LAT' (Kozlov & Kozlov 2018: p. 52)

Homorganic epenthetic glides only appear after /u/ and /i/ but not after the non-high vowels /a e ɛ/ (18–20). In this context, the hiatus is avoided by deleting the initial schwa of the suffix.

(18) *pe + ən' → pe-n'*
'end-GEN'

(19) *at'ɛ + ən' → at'ɛ-n'*
'end-GEN'

(20) *ava + əl' → ava-l'*
'(3SG was a) woman-IPF'

After consonant-final bases, the suffixal schwa is retained (21–22).

(21) *ruz + ən' → ruzən'*
'Russian-GEN'

(22) *ruz + əl' → ruzəl'*
'(3SG was) Russian-IPF'

A curious proviso to the glide insertion rule is that no epenthesis happens with monosyllabic bases (23–25).

(23) *ši + ən' → ši-n'*
'day-GEN'

(24) *mu + əms → mu-ms*
'find-INF'

(25) *vi + əms → vi-ms*
'bring-INF'

The behaviour of glides in between /u i/ and suffixal schwa is summarised in Table 5 below. A# corresponds to the non-high vowels /a e ɛ/.

<table>
<tr><th></th><th>C#</th><th>A#</th><th>u#</th><th>i#</th></tr>
<tr><td>monosyllabic</td><td rowspan="2">ən'</td><td rowspan="2">n'</td><td>n'</td><td>n'</td></tr>
<tr><td>polysyllabic</td><td>vən'</td><td>jən'</td></tr>
</table>

Table 5: Suffix *ən'* 'GEN' with different kinds of bases

All monosyllabic bases exhibit the same behaviour – no glide epenthesis and no schwa in the suffix. Polysyllabic bases differ according to the final segment: if it is /u/ or /i/, the schwa remains and a homorganic glide appears; if it is some other vowel, the schwa disappears; after final consonants, the suffix appears with a schwa.

It is important to note that the glide insertion is not synchronically productive, that is, it does not affect loanwords. The strategy for loanwords is to treat /u i/ exactly like other vowels: to drop the schwa altogether (26–28). The syllable count is of no importance with loanwords: no glide appears either after the disyllabic toponym *soči* 'Sochi' or after the monosyllabic personal name *li* 'Li'.

(26) *žuri + ən' → žuri-n'*
'jury-GEN'

(27) *soči + ən' → soči-n'*
'Sochi-GEN'
(Kozlov & Kozlov 2018: p. 42)

(28) *li + ən' → li-n'*
'Li-GEN'
(online fieldwork)

Epenthesis of glides is not restricted to schwa-initial suffixes. It can also happen with the /a/-initial ones but in a different set of contexts.

2.3 /a/-initial suffixes

Suffixes that begin with /a/ only cause homorganic glide epenthesis when attached to /u i/-final polysyllabic bases, as exemplified in examples (29–30). These suffixes are agreement markers *-an* '1SG' and *-at* '2SG', which can mark both verbal and nominal predicates (Kholodilova 2018, Toldova 2018).

(29) *jožu + an → jožuvan*
‘(I am) smart-1SG’

(30) *vidi + an → vidijan*
‘(I am) a sower-1SG’

The peculiar property of the /a/-initial suffixes is that in monosyllabic bases ending in /u i/, no matter which vowel it is, /j/ is inserted at all times (31–32). This pattern is in stark contrast with the schwa-initial suffixes: there *is* a glide after monosyllabic bases, and this glide is not homorganic with the preceding vowel: it always surfaces as /j/.

(31) *mu + an → mujan*
‘(I) find-1SG’

(32) *li + an → lijan*
‘(I) fly-1SG’

Final full vowels /a ɛ/ coalesce with the suffix-initial /a/ (33–34). Both /aa/ and /ɛa/ become /a/. This phenomenon is described by Kozlov & Kozlov (2018) as “a-coalescence”.

(33) *jaka + at → jakat*
‘(you) go-2SG’

(34) *at’ɛ + an → at’an*
‘(I am an) old man-1SG’

In single-syllable bases ending with /a/, no a-coalescence occurs and /j/ is inserted (35–36).

(35) *sa + an → sajan*
‘(I) come-1SG’
(Kozlov & Kozlov 2018: p. 57)

(36) *šna + an → šnajan*
‘(I) praise-1SG’

The pattern is summarised in Table 6.

	C#, ə#	A#	u#	i#
monosyllabic	*an*	*jan*	*jan*	*jan*
polysyllabic		*n*	*van*	

Table 6: Suffix *an* ‘NPST.1SG’ with different kinds of bases

Monosyllabic bases are once again all similar but in a different way: with schwa-initial suffixes, there was no epenthesis. When situated next to a suffix-initial /a/, schwa disappears. With /a/-initial suffixes, however, /j/ is inserted both after /u i/ and after /a ɛ/. With polysyllabic bases, we observe a pattern almost identical to that of schwa-initial suffixes – loss of the suffix’s vowel and homorganic glide insertion. The suffix loses the /a/ after full vowels /a ɛ/ but retains it after consonants and schwa (the schwa disappears); with final /u i/, there is homorganic glide insertion.

2.4 Summary

To summarise the behaviour of schwa- and /a/-initial suffixes, several different processes can be noted that happen at the word-internal V#V boundary that they form with vowel-final bases (37–38). First, hiatus resolution can involve vowel deletion (see example (37) below).

(37) Vowel deletion in hiatus

a. Full vowel deletion:
/ɛ+a/ → /a/
at’ɛ + an → at’an ‘(I am) old man-1SG’
/a+a/ → /a/
ava + an → avan ‘(I am) woman-1SG’

b. Schwa deletion after heavy vowels:

/ə+a/ → /a/
vir'-sə + an → vir'san 'forest-IN-1SG' (Kozlov & Kozlov 2018: p. 40)
/a+ə/ → /a/
ava + ən' → avan' 'woman-GEN'

c. Schwa deletion after stressed light vowels:
/u+ə/ → /u/
mu + əms → mu-ms 'find-INF'
/i+ə/ → /i/
ši + ən' → ši-n' 'day-GEN'

When two heavy vowels form a hiatus, it is escaped by deleting one of them. In an /aa/ sequence, just one vowel /a/ remains; in an /ɛa/ sequence, the first vowel – /ɛ/ – is preserved (37a). Heavy vowel deletion in hiatus is restricted to polysyllabic words. As previously described, after vowel-final monosyllabics, glide insertion is observed. Hiatus between a schwa and a heavy vowel is resolved by deleting the schwa, no matter its position (37b). Stressed light vowels behave the same: the schwa is deleted after them (37c).

To generalize further, heavy vowels are subject to deletion only after non-initial syllables. Schwa, which is a light vowel, is deleted in hiatus next to a heavy vowel or a stressed light vowel.

Another group of strategies involved glide insertion, which comes in two types (38).

(38) a. Homorganic glide insertion (polysyllabic bases only):
/uə/ → /uvə/
kelu + ən → keluvən' 'birch-GEN'
/iə/ → /ijə/
t'ɛči + ən' → t'ɛčij-ən' 'today-GEN'

b. /j/-insertion (monosyllabic bases only):
/aa/ → /aja/
sa + an → sajan 'come-1SG'
/ua/ → /uja/
mu + an → mujan '(I) find-1SG'

First, homorganic glide insertion targets polysyllabic bases that end with /u/ or /i/ and makes a glide appear in the middle of the hiatus (38a). This glide is homorganic because its place of articulation depends on the base-final vowel: /v/ is inserted after /u/ and /j/ comes after /i/.

The other type of glide insertion is not homorganic: it always involves /j/ and is restricted to monosyllabic bases (38b). It can take place only before a heavy vowel (/a/).

I will now attempt to answer several questions regarding vowel deletion and glide insertion (39).

(39) Questions for phonological analysis

a. Schwa deletion happens both after heavy vowels (37b) and after stressed light vowels (37c). What can put those into one natural class?

b. Is there a reason why homorganic glide insertion only affects polysyllabic bases?

c. Can the non-homorganic insertion of /j/ be explained in a similar way?

d. Why are heavy vowels deleted in hiatus only after non-initial syllables?

Not all of these questions can be answered satisfactorily by a virtual length analysis of the Moksha stress pattern. While it provides easy answers to questions (39a–c), it cannot meaningfully address question (39d), since it treats all heavy vowels as representationally equivalent. I will, however, suggest possible solutions to this problem that cannot be incorporated into the virtual length analysis at present.

I argue that a rule underpinning homorganic glide insertion exists and it is the stress pattern: /u/ and /i/ can only spread when unstressed. Heavy and stressed light vowel fall into the same natural class because they are both long in the phonology. Since the surface realisation of /a/-initial suffixes does not depend on stress, the stress-based rule is not extendable to them. The next section elaborates on the proposed analysis.

3 Glide epenthesis is conditioned by stress

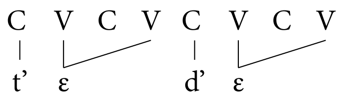
The core part of my proposal is that I treat the sonority-driven stress rule in Moksha as length-based.

I claim that the heavy vowels /a o ɛ e/ and the stressed light vowels /u i ə/ are long; in Strict CV terms, they are associated to two CV slots. The stress falls on the leftmost long vowel, and where there are no long vowels, an empty CV is inserted to the right of the leftmost vowel so that it is lengthened.

Those vowels that can trigger homorganic glide insertion – both /u/ and /i/ – are light in the stress assignment algorithm. At the end of a polysyllabic word, where homorganic glide insertion happens, a light vowel is always short, since it cannot be stressed. In other words, what triggers glide insertion are base-final unstressed light vowels.[8]

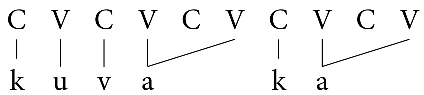
Consider several illustrations of vowel quality represented as bipositionality. In *t'ɛd'ɛ* 'mother', for example, both vowels are heavy, that is, bipositional, and the leftmost one is stressed (40).

(40) *t'ɛd'ɛ* ['t'ɛd'ɛ] 'mother'



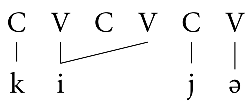
In *kuvaka* 'long', however, the first syllable contains a light vowel /u/, whereas the other two syllables ahve long vowels as nuclei. The /u/ in the initial syllable remains unstressed and hence phonologically short. The leftmost heavy vowel, which is in the second syllable, receives the stress (41).

(41) *kuvaka* [ku'vaka] 'long'



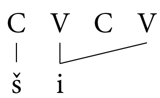
Finally, if there are no heavy vowels in the word, like in *kijə* 'who', the stress falls on the initial syllable. Since the vowel in the first syllable is light, it is lengthened by means of an inserted syllabic unit (42).

(42) *kijə* ['kijə] 'who'

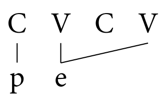


The assumption that stressed and heavy vowels are bipositional makes the vowels that do not participate in the glide insertion, that is, heavy vowels and the stressed base-final light vowels (i.e. light vowels in monosyllabic bases) into a natural class: they share a property of being long. As shown in examples (43–45), both final light vowels, like in *ši* 'day', and final heavy vowels, like in *pe* 'end' and *ava* 'woman', are phonologically long.

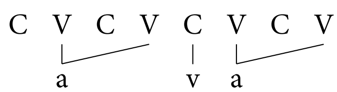
(43) *ši* ['ši] 'day'



(44) *pe* ['pe] 'end'



(45) *ava* ['ava] 'woman'



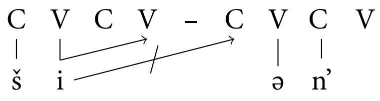
Representing stress and quality-dependent weight as length helps determine which vowels can and cannot spread. Long vowels cannot spread further than the two slots they already occupy, so no homorganic glide can appear after them. The restriction on triple association, or extra-long segments, as pointed out by an

[8]Except schwa, which is a light vowel that cannot produce a glide. Rather, it is deleted.

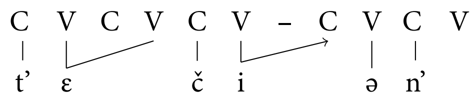
anonymous reviewer, is widely attested and may be universal (Chekayri & Scheer 2004, Enguehard 2018, Faust & Ulfsbjorninn 2018, Balogné Bérces 2023).

The mechanism of glide insertion proceeds by spreading a light vowel to the closest available C-slot, which belongs to the suffix. When the final light vowel is stressed and there is an empty V-slot provided by the stress CV, spreading onto a C-slot is not possible anymore (see example 46 for the derivation of *šin'* 'day.GEN'). When no V-slot is available, the unstressed and hence monopositional light vowel can spread and form a consonant, like in *t'ɛčijən'* 'today-GEN' (47).

(46) *ši + ən' → šin'* [šin']



(47) *t'ɛči + ən' → t'ɛčijən'* [t'ɛčijən']



I have demonstrated that the homorganic glide insertion rule does not depend on syllable count, like it seems on the surface. The job of accounting for the distribution of homorganic glides after bases with final /u i/ is done by the stress algorithm, which can only lengthen the final vowel of a monosyllabic base. Since long vowels are not expected to spread further, no glide insertion occurs with them. I now turn to /a/-initial suffixes, which appear to constitute a problem for the analysis just presented.

3.1 Vowel deletion

Apart from glide insertion, another hiatus avoidance strategy in Moksha is vowel deletion. Schwa is deleted in hiatus with any vowels that are phonologically long, i.e. heavy and light stressed vowels. The heavy vowel /a/ is only deleted after unstressed heavy vowels.

In the previous subsection I have demonstrated how the light vowel /u/ and /i/ can spread from unstressed positions onto the neighboring C-slot to form a glide. Schwa, while also being a light vowel, cannot spread; when directly adjacent to a heavy vowel, it becomes zero. Note that the only hiatus context where schwa is preserved is when it is confronted with a spreadable light vowel (/u/ or /i/; see (11) repeated in (48) for an example).

(48) *jožu + əl' → jožuv-əl'*
'(3SG was) smart-IPF' (Kozlov & Kozlov 2018: p. 42)

(49) *kizə + ən' → kizə-n'*
'year-GEN'

In all other contexts, including a hiatus of two schwas (49), schwa is dropped. I propose that schwa is different from other light vowels in that it cannot surface as a glide. There is no way to map a schwa associated to a consonantal slot to any phonetic realisation in the Moksha language. Since spreading is not an option, and since hiatus has to be avoided, schwa is deleted. A double-schwa hiatus is avoided via schwa deletion for the same reason. Neither of the two schwas can spread to break the hiatus, so one of them is omitted.

A-coalescence, or the deletion of /a/ in /aa/ or /ɛa/ sequences in polysyllabics, is more difficult to explain, since the hiatus of two heavy vowels can be avoided in two ways: (a) vowel deletion after polysyllabics and (b) /j/-insertion in monosyllabics. While the special behavior of monosyllabic words with light vowels is easily explained via stress-related lengthening, heavy vowels are not changed by stress, so the discrepancy between mono- and polysyllabic heavy-final words cannot explained by the virtual length proposal.

What is more, final heavy vowels in polysyllabics can be stressed (50). The stress pattern guarantees that final light vowels are unstressed, but that is not true of heavy vowels. In *juma-n* '(I am) lost-1SG', the final /a/ is stressed, since the initial syllable contains a light vowel. Still, the /a/ of the suffix is deleted.

(50) *juma + an → juman*
'(I am) lost-1SG'

I will now attempt to address a-coalescence and /j/-insertion, which happen exclusively in the context of /a/-initial syllables. I will show that these phenomena are unrelated to stress and require an explanation outside of the virtual length analysis.

3.2 /a/-initial suffixes

Hiatus resolution with heavy-initial suffixes involves vowel deletion and glide insertion. The pattern of glide insertion is different from what we saw with the spreading of /u/ and /i/ before schwa: not all glides are homorganic. After monosyllabic bases, /j/ is inserted (51-54), whereas homorganic glide insertion is limited to polysyllabic bases ending in /i/ and /u/ (55-56).

(51) *sa + an → sajan*
'come-1SG'
(Kozlov & Kozlov 2018: p. 57)

(52) *šna + an → šnajan*
'praise-1SG'

(53) *mu + an → mujan*
'find-1SG'

(54) *li + an → lijan*
'fly-1SG'

(55) *jožu + an → jožuvan*
'(I am) smart-1SG'

(56) *vidi + an → vidijan*
'(I am) a sower-1SG'

As previously demonstrated in Table 6, /u i/ spread before *-an* 'NPST.1SG' in polysyllabic bases, similarly to schwa-initial suffixes like *-ən*' 'GEN', whereas the /a/-final bases make the /a/ of the suffix disappear. All monosyllabic bases ending in vowels, however, share a pattern of /j/-insertion. If we take this common behaviour to be indicative of some shared property, this is different from the stress-conditioned pattern of homorganic glide insertion: stressed heavy vowels, like /a/ in *ˈšnajan* '(I) praise-1SG', would be grouped together with unstressed light ones, like /u/ in *muˈjan* '(I) find-1SG'.

I contend that the /j/ inserted in between heavy vowels has nothing to do with spreading or stress. The insertion of /j/ does not depend on stress placement. Final light vowels can only be long in monosyllabic bases with suffixes containing no heavy vowels – this is the only context where they can be stressed, lengthened and therefore non-spreading. In unstressed positions, light vowels can and do spread. With heavy vowels like /a/, on the other hand, the rule that singles out monosyllabic bases is not reducible to stress. Both mono- and polysyllabic bases can have a final stressed /a/: monosyllabic bases – by virtue of having just one syllable and the polysyllabic ones – if all vowels before the final /a/ are light. Consider the example of such a polysyllabic base, which a final stressed heavy vowel (see example (50) repeated in (57) below). No /j/-insertion occurs before *-an*. Still, after monosyllabic bases, the glide does appear (58).

(57) *juma + an → juman*
'(I am) lost-1SG'

(58) *šta + an → štajan*
'wash-1SG'

So, the generalization that best approximates the data about /j/ insertion is that it targets monosyllabics. As pointed out by an anonymous reviewer, this could be analyzed as an effect of word minimality: the reason that monosyllabics are special is that it is important for them to retain their only vowel. The pattern of a-coalescence is such that the vowel of the base is lost and the vowel of the suffix remains. The /ɛa/ sequence is reduced to /a/: *at'ɛ + an → at'an* '(I am an) old man-1SG'. I leave the formalization of this rule as an open question that may later find a solution that my analysis does not provide.

3.3 Misprediction problem

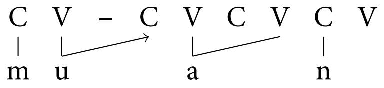
The behaviour of the /a/-initial suffixes poses a challenge to the proposed analysis of glide insertion before schwa-initial suffixes. The problem is that monosyllabic bases that end with /u/ and /i/ are subject to the exact same rules as the /a/-final ones, that is, /j/ appears after monosyllabic bases regardless of what the final consonant is; the glide is not homorganic and is therefore unlikely to come from spreading. Consider examples (59–60) that feature /u/ and /i/-final monosyllabic bases – the glide is always /j/.

(59) *mu + an → mujan*
'find-1SG'

(60) *li + an → lijan*
'fly-1SG'

Under the spreading-based analysis, the expected outcome in the /i_#a/ and /u_#a/ contexts is homorganic glide insertion: /i/ and /u/ are always unstressed because they are followed by a heavy vowel, so they should be able to spread, but they do not. For instance, in *mujan* 'find.2SG', the light /u/ in the first syllable is not stressed, since the second syllable contains a heavy vowel /a/. An unstressed light vowel is monopositional and, in theory, will spread (see the hypothetical representation in example 61). Still, in *mujan* 'find.2SG', there is a non-homorganic /j/.

(61) Expected:
*mu + an → *muvan* 'find-2SG'



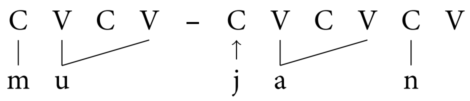
In order to account for the behaviour of /a/-initial suffixes, the proposed analysis needs to be amended: stress and spreading alone are not enough to explain why there is /j/ in *mujan* 'find.2SG' and not /v/. On the other hand, the fact that the non-homorganic /j/ has nothing to do with stress also means that its behaviour is not a fatal counterexample for the stress-based analysis.

A possible line of reasoning that could account for the exceptional example *mujan* 'find-2SG' is to show that the vowel /u/ in the first syllable is actually long. That would immediately place this vowel in the long vowel class, and the fact that it patterns with /a/ in monosyllabics would be explained. In order to show that, one could assume that Moksha stress is in fact not sonority-driven but fixed on the initial syllable.

This would be backed up by phonetic evidence that comes from the survey of Moksha prosody by Aasmäe et al. (2013).[9] They conclude that The vowels /u/ and /i/ are shorter than others and are a little bit lengthened when stressed. The speakers occasionally stress the initial high vowels, but they are so much shorter than the low vowels that stressed /u/ and /i/ are shorter than unstressed /a/, for example, which might make initial stress less perceptible.

If Moksha stress is actually initial, this does not change the most important point of my analysis: stressed high vowels would still be restricted to the initial syllable. Also, the *mujan* counterexample would be explained: the vowel /u/ is stressed and therefore lengthened, so it cannot spread (62).

(62) *mu + an → mujan* 'find-2SG'



In this case, the insertion of /j/ would only target the hiatus of two long vowels between the first and the second syllable. If the /u/ in *mujan* is stressed, it is long, so /j/ insertion is expected. *Mujan* will be the same context as, for example, *štajan* 'wash-1SG', where there is an /aa/ sequence broken up by the glide /j/.

The hypothesis that Moksha has fixed initial stress is promising and works better with the virtual length proposal. Nevertheless, accepting it would involve conflating two conflicting descriptions. It is not unrealistic that signs of initial stress are observed in the dialect reported by Toldova & Kholodilova (2018)

[9] Aasmäe et al. (2013) is based on data from "sub-dialects of the central Moksha area", and the present paper is based on a description of a northern-central dialect. These two sources report very close varieties of Moksha, if not the same dialect.

but making this claim requires additional phonetic evidence from that particular variety of Moksha. At the moment, the initial stress hypothesis remains a hypothesis.

4 Conclusion

This paper presents a reanalysis of sonority-driven stress with virtual length which helps explain the choice of hiatus escape strategy. In particular, I have proposed a novel analysis of the glide insertion in Moksha – a phenomenon of homorganic glides appearing in between base-final /u/ and /i/ and vowel-initial suffixes, but only in polysyllabic bases. The rule that appears to depend on syllable count, receives a local explanation under two assumptions. First, I suppose that heavy vowels that attract stress are underlyingly long, and so are all stressed vowels. Since stress falls on the leftmost syllable in the absence of heavy vowels, the only bases where final light vowels can be long are monosyllabic bases. Thus the bases that participate in glide insertion form a natural class – those are short base-final vowels.

The second assumption is that /u/ and /i/ can spread onto neighbouring C-slots. Short base-final vowels can spread, whereas long vowels cannot. Additionally, I have reviewed a different case of epenthesis – a non-homorganic /j/, which sometimes appears before suffixes with initial heavy /a/, and vowel deletion, both of which are strategies of hiatus resolution in Moksha on par with homorganic glide insertion. Schwa deletion tracks underlying length, i.e. it only happens after the vowels that are either long or lengthened by stress. The insertion of /j/ and deletion of heavy vowels, however, are not stress-related. Finally, I have discussed the limitations of my virtual length-based analysis and possible lines of reasoning that can help deal with them.

Appendix

IPA correspondence table

IPA	Transcription
m	m
n̪	n
n̪ʲ	n’
p	p
b	b
t̪	t
t̪ʲ	t’
d̪	d
d̪ʲ	d’
k	k
g	g
x	x
f (ɸ)	f

IPA	Transcription
v (β)	v
s̪	s
s̪ʲ	s’
z̪	z
z̪ʲ	z’
ʃ	š
ʃʲː (ʃt͡ʃ)	šč
ʒ	ž
t͡s̪	c
t͡s̪ʲ	c’
t͡ʃ	č
ç	j̊
j	j
ɾ̥	r̥

IPA	Transcription
ɾ̥ʲ	r̥’
ɾ	r
ɾʲ	r’
ɫ̪	l̥
ɫ̪ʲ	l̥’
l̪	l
lʲ	l’
i	i
u	u
e	e
ə	ə
o	o
ɛ	ɛ
a	a

List of glossing abbreviations

1 first person
2 second person
3 third person
CN connegative
GEN genitive
IN inessive case
INF infinitive
IPF imperfective
LAT lative case
NEG negative
NPST non-past
PL plural
PST past
SG singular

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