Autosegmental Representations Behind Quality-Sensitive Stress

Alexandra Shikunova

Supervised by Pavel Rudnev, PhD (HSE) and Noam Faust, PhD (Université Paris 8)

Abstract

Vowel sonority has been observed to guide stress assignment (Kenstowicz 1997, de Lacy 2002). However, the existence of sonority-dependent stress has also been contested (Shih 2016, Rasin 2018, Shih & de Lacy 2019). In particular, Rasin (2018) claims that stress is never determined directly by any segmental features.

Strict CV, a lateral autosegmental approach to phonology (Lowenstamm 1996, Scheer 2004, 2012) and an offshoot of Government Phonology (Kaye, Lowenstamm & Vergnaud 1990), assumes the existence of a syllabic tier with the universal CV syllable structure, and a melodic tier, which are connected with association lines. Stress is computed above the syllabic skeleton and is therefore independent of melody (Scheer 2004), so genuine quality-conditioned stress is not predicted to exist. Stress systems that do appear to track vowel quality on the surface can be reanalyzed with virtual length (Lowenstamm 1991, 2011, Ben Si Saïd 2011, Enguehard 2018).

I aim to make a case against sonority-driven stress by presenting a case from the Moksha language, where a virtual length reanalysis of a quality-conditioned stress pattern makes an accurate prediction in regard to hiatus resolution strategies. The stress rule treats non-high vowels as heavy and all others – the high vowels and schwa – as light. For the hiatus resolution rules of Moksha, non-high peripheral vowels and stressed high vowels form a natural class. If stress is assumed to track underlying length and to lengthen short vowels, the common feature of this natural class comes for free – it is phonological length.

Acknowledgements

This thesis started in 2021, when I came to Lesnoye Tsibaevo (Mordovia, Russia) to work with Moksha speakers. Although I studied morphosyntax in the field, the sounds of Moksha continued to puzzle me. I thank my Moksha consultants, the Moksha fieldwork project and all the authors who contributed to Toldova & Kholodilova (2018), especially Svetlana Toldova and Alexey Kozlov, who have been my primary advisors in fieldwork on Uralic languages.

My interest in phonology in general and Strict CV in particular is due to Tobias Scheer, Noam Faust, Shanti Ulfsbjorninn, and Alex Chabot, with whom I am incredibly lucky to have discussed some projects of mine, including the present text. Also, I would not have discovered Strict CV if not for V-NYI winter and summer schools. I am particularly grateful to Noam Faust for guiding me through this thesis.

I thank Pavel Rudnev, who taught me most of what I know about academic writing and linguistic research.

Finally, it has been a blessing to be with Daniar this whole time. He is my greatest inspiration.

Contents

1 Introduction

Stress is a suprasegmental phenomenon, meaning that it is computed on units larger than the phoneme. The stress assignment algorithm takes a certain domain containing one or several syllables as input and finds one or several syllables which receive additional prominence. While the computation of stress proceeds above the segment, it is definitely manifested on the segmental level as increased duration, higher pitch, greater loudness and/or vowel quality.

Stress rules are very diverse. They vary in the pattern of placement (e.g. whether the stressed position is at the right or at the left edge of the domain) as well as in the properties of syllables that influence stress assignment, that is, in what counts as syllable weight. First, syllable structure can be a factor in stress assignment. For instance, syllables with a long vowel (CVV) or a coda (CVC) are often considered heavy and shift the stress onto themselves. One example of a language where syllable structure affects stress placement is Classical Latin (1).

(1) Latin stress (Solopov & Antonec 2011: p. 29)

for.ˈtū.na	‘fate’
ma.ˈgis.ter	‘teacher’
ˈpo.pu.lus	‘nation’
ˈra.ti.ō	‘intellect, reason’

Syllables which have a coda, a long vowel, or both are heavy, whereas all other syllables are light. By default, stress falls on the antepenultimate syllable but if the penult is heavy, it is stressed. For instance, the penult in *ˈpo.pu.lus* ‘nation’ is light and unstressed, whereas in *for.ˈtū.na* ‘fate’, it is heavy, so the stress shifts.

Weight that is determined by syllable structure is quantitative — heavy syllables contain *more* segmental material, no matter *which kind* of material. Another group of weight factors, however, is qualitative: in such systems, the properties of the segments in the syllable make it heavy or light. For example, lax vowels can count as light, while the more tense vowels count as heavy, as is the case in Kazym Khanty (<Ob-Ugric<Uralic; Kaksin 2010, Tjutjunnikova 2022). In general, Kazym Khanty stress is trochaic and non-final but in trisyllabic words, stress placement is determined by the quality of vowels in the first two syllables (2).

(2) Kazym Khanty stress (Kaksin 2010: pp. 35–36)

ˈe.wəλ.ti	‘believe.NFIN.NPST’
ˈλu.ma.ri	‘wrinkled’
pɵ.ˈkat.ni	‘bad weather’
kʉ.ˈlaś.ti	‘fight.NFIN.NPST’
mă.ˈnɛ.ma	‘1SG.DAT’

If the vowel in the first syllable is lax (/ă, ʉ, ɵ, i/), while in the second syllable, there is a tense vowel like /a/ or /ɛ/, the second syllable is stressed, that is, tenseness contributes to weight. For instance, the stress in *ˈe.wəλ.ti* ‘believe.NFIN.NPST’ is initial, since the initial vowel is tense, but in *pɵ.ˈkat.ni* ‘bad weather’, the stress shifts to the right from the lax vowel /ɵ/.

In addition to tense-lax, the full-reduced opposition in vowels can contribute to syllables weight. In Javanese, an Austronesian language spoken in Indonesia, stress falls on the penultimate syllable. If the penult contains a schwa, however, stress is final.[1]

(3) Javanese stress (Herrfurth 1964: pp. 16–20)

Default penultimate stress		Shift to the ultima if schwa is in the penult	
ának	'child'	bərás	'rice'
puníka	'this (in Kromo Javanese)'	ləpát	'wrong'

When the distinction between full and reduced vowels affects stress assignment, as has been reported, for example, for Javanese (3), it is the number of contrastive features that matters: the more of them a vowel has, the more weight it lends to the syllable. It is, however, possible for vowels to carry an approximately equal number of features but for the *values* of these features themselves to matter for the stress algorithm (as opposed to their quantity). Vowels have been observed to form a sonority hierarchy (Kenstowicz 1997, de Lacy 2002), shown in example (4).

(4) Universal sonority hierarchy (Kenstowicz 1997: p. 162, de Lacy 2002: p. 55)

low peripheral	> mid peripheral	> high peripheral	> mid central	> high central
a	e, o	i, u	ə	ɨ

The Universal sonority hierarchy presupposes that languages can draw the heavy-light distinction between full and reduced vowels (e.g. /a e o i u/ vs. schwa) or between, for instance, high and non-high peripheral vowels (/a e o/ vs. /i u ə/). The motivations behind this have a complicated history, so I will now proceed to review the literature that describes and discusses sonority-driven stress (SDS), both from the empirical and theoretical point of view.

2 Issues with sonority-driven stress

Numerous cases of quality-dependent stress have been reported in the literature. In order to briefly illustrate their diversity, I turn to typological databases in Section 2.1 and then to specific case studies in Section 2.2. Finally, I recount the literature that conveys skepticism about sonority as a weight factor in Section 2.3.

2.1 How common is sonority-driven stress?

The chapter on weight factors in weight-sensitive stress systems in the World Atlas of Language Structures places such systems under the "Prominence" category, which means that stress placement depends on non-quantitative weight factors (Goedemans & van der Hulst 2013). Since rhythmic weight systems fall into the same category, the number of languages

1. In Herrfurth's (1964) transcription, schwa is denoted by /e/, while other mid front vowels are marked with diacritics (/é, è/). I use /ə/ for schwa; otherwise, the original transcription is preserved.

in it — 41 — constitutes an upper bound on the share of sonority-based stress systems in the sample of 500. There are also 42 languages in the "Combined" category that possibly includes quality-driven patterns.

The search for quality-dependent patterns in the StressTyp2 database (Goedemans, Heinz & van der Hulst 2014) returns 11 languages out of 699, 15 lects in total, which is much fewer than the "Prominence" category of WALS contains, so sonority-driven stress appears to be the less common kind of prominence-based systems.[2]

2.2 Different types of sonority sensitivity

The Universal sonority hierarchy of Kenstowicz (1997) and de Lacy (2002) generalizes over various kinds of individual hierarchies present in the world's languages. Stress systems can draw the line between full and reduced vowels (Chuvash; Section 2.2.1) as well as between groups of peripheral vowels (Nanti; Section 2.2.2). Apart from stress placement, sonority sensitivity can be found in languages with fixed stress where vowel quality matters for the appearance of the stressed syllable (Uyghur; Section 2.2.3).

2.2.1 Chuvash: full-reduced distinction

Chuvash is a Turkic language spoken primarily in the Chuvash Republic of Russia and the adjacent regions. The vowel inventory of Chuvash contains six full vowels (/i ɪ a e u ü/) and two reduced vowels (/ă ĕ/; Krueger 1961). Stress falls on the rightmost syllable with a full vowel; when the word contains no full vowels, stress is leftmost (5).

(5) Chuvash stress (Krueger 1961: pp. 86–87)

a. Rightmost heavy syllable is stressed

[lašá]	'horse'	[álăk]	'door'
[ĕné]	'cow'	[yĕnérčĕk]	'saddle'
[kămaká]	'stove'	[ĕślérĕmĕr]	'we worked'
[sarlaká]	'widely'	[kálăttămăr]	'we would say'

b. Default stress on the leftmost syllable

[ĕ́ślĕpĕr]	'we shall work'	[tắtămăr]	'we got up'

Chuvash therefore has a stress algorithm with sonority as a weight factor: full vowels make syllables heavy, whereas syllables with reduced vowels count as light. In some languages, however, stress can distinguish between two different non-reduced peripheral vowels in terms of weight.

2. For the query used to search StressTyp2, see the Appendix.

2.2.2 Nanti: distinction between peripheral vowels

An example of a language whose stress system tracks peripheral vowel distinctions is Nanti, as reported and analyzed by Crowhurst & Michael (2005). Nanti belongs to the Kampan branch of the Arawakan language family and is spoken in Peru. Stress in Nanti depends on a number of factors, including rhythm (preference for iambic feet, avoidance of stress clashes), quantity (presence of a coda, long vowels or diphthongs) as well as vowel quality. Table 1, which is compiled after Crowhurst & Michael's (2005) description of the pattern, illustrates how preference for higher sonority in stressed syllables wins over the left-to-right iambic rhythm[3].

	Transcription	Gloss	Foot parse
a > e	nà.p^{j}e.ʃi.gò.pi.rè.já.kse	'I rested (PF)'	(**nà.p^{j}e**)(ʃi.go)(pi.rè)(já.kse)]
a > e	à.b^{j}e.tsi.kái	'we.INCL made it again'	(**à.b^{j}e**)(tsi.kái)]
a > o	à.wo.te.hái.gʒi.ri	'we approached him/them'	(**à.wo**)(te.hái).gʒi].ri
a > i	à.tsi.to.ká.kse.ro	'it crushed it'	(**à.tsi**)(to.ká).kse].ro
a > i	nà.bi.gʒi.tá.kse.ro	'I pick it (seed-like object) out of bag'	(**nà.bi**)(gʒi.tá).kse].ro
o > i	nò.ʃi.po.ká.kse.ro	'I doused it (a fire)'	(**nò.ʃi**)(po.ká).kse].ro
o > i	nò.gʒi.wo.tá.kse.ro	'I placed it (vessel) mouth down'	(**nò.gʒi**)(wo.tá).kse].ro

Table 1: Forms with "unexpected" trochaic stress (Crowhurst & Michael 2005: p. 53).

Similarly, Table 2 provides evidence for sonority sensitivity from the cases where an iambic pattern appears despite stress clashes, i.e. sonority trumps clash avoidance.

Hierarchy	Transcription	Gloss	Foot parse
a > o	no.gà.pá.kɯi.ti	'I let it go'	(**no.gà**)(pá.kɯi).ti]
a > o	no.tsà.róo.ga.kse	'I was startled'	(**no.tsà**) (róo.ga).kse]
a > i	i.kà.mán.ta.na.ra	'he tells me'	(**i.kà**)(mán.ta)].na.ra
o > i	pi.pò.ká.kse.na	'you came to me'	(**pi.pò**)(ká.kse)].na
o > i	i.pò.kái.gai	'they.M came back'	(**i.pò**)(kái.gai)]
e > i	i.pè.gá.ka	'he changed'	(**i.pè**)(gá.ka)]
e > i	i.nè.já.ko.te.ro	'he knows about'	(**i.nè**)(já.ko).te].ro
e > i	i.nè.hái.ga.kʃi.ri.ra	'he saw him over there'	(**i.nè**)(hái.ga).kʃi].ri.ra

Table 2: Iambic feet in a stress clash context (Crowhurst & Michael 2005: pp. 53, 64).

3. Nanti has several metrically irrelevant suffixes that are unstressable and do not participate in foot parsing. Crowhurst & Michael (2005) mark the right edge of the stress domain, which excludes these suffixes, with closing square parentheses. They also use round parentheses for feet boundaries and periods for syllable boundaries.

The trochaic stress found in the second foot in each example in Table 2 is attributable to different factors. First, the heaviness of the foot-initial syllable overrides iambic stress (6).

(6) Nanti trochaic feet

(mán.ta)] instead of (man.tá)]	CVN > CV
(róo.ga)] instead of (roo.gá)]	CVV > CV
(pá.kɯi)] instead of (pa.kɯ́i)]	Ca > Cɯi (light diphthong)

Apart from the effects of weight, there is a more general ban on final stress (7).[4]

(7) Ban on final stress in Nanti

(gá.ka)] instead of (ga.ká)]	$CV_1 = CV_2$, CV_1 wins
(kái.gai)] instead of (kai.gái)]	$CVV_1 = CVV_2$, CVV_1 wins

When the final foot in the word is trochaic for whatever reason, this creates a stress clash environment, where iambic accent in the preceding foot is adjacent to the trochaic one in the next. These clashes are resolved in feet where the two syllables are equal on the weight and sonority scale (8).

(8) Trochaic 'shift' as a clash-avoidance strategy (Crowhurst & Michael 2005: p. 51)

ò.ko.rì.kʃi.tá.ka	(ò.ko).(rì.kʃi).(tá.ka)]	'she wore a nose-disc'
nò.ko.gá.ko.ta.ro	(nò.ko).(gá.ko).ta].ro	'I asked about it'

There is, however, no clash avoidance if the second syllable is higher on the sonority scale: the clash persists so that the more sonorous vowel could keep the stress. Hence, Table 2 works as evidence for the sonority hierarchy.

From the shifting rhythm and the non-avoidance of stress clashes, the sonority hierarchy of Nanti is the following: a > {e, o} > i, which is in line with the universal hierarchy proposed by Kenstowicz (1997) and de Lacy (2002). In the case of Nanti, we can see the effects of sonority without any tense-lax or full-reduced contrast. I refer the reader to Shih & de Lacy (2019: p. 27) for more cases of SDS systems that have been reported to have peripheral vowel distinctions.

2.2.3 Uyghur: sonority affecting stress exponence

Sensitivity to sonority can be seen not only in languages with variable stress placement but also in those languages where stress is fixed. McCollum (2019) discusses Uyghur, where stress is borne by the final syllable. In open stressed syllables, high vowels are longer compared to closed stressed syllables; not so with the low vowels – they exhibit no significant difference in duration relative to syllable structure (Table 3).

4. There are exceptions to this ban: a heavy final syllable can receive stress if it is the most prominent in the word (Crowhurst & Michael 2005: p. 83).

	Open final σ Surface form	Gloss	Closed final σ Surface form	Gloss
High	bæ.ˈliː	‘his/her waist’	bæ.ˈlim	‘my waist’
	ki.ˈʃiː	‘person’	ki.ˈʃim	‘my person’
	bæl.ˈniː	‘waist.ACC’	bæl.ˈdin	‘waist.ABL’
	ʧiʃ.ˈniː	‘tooth.ACC’	iʧ.ˈtin	‘inside.ABL’
Low	sæl.ˈlæ	‘turban’	sæl.ˈlæm	‘my turban’
	ti.ˈkæ	‘goat’	ti.ˈkæm	‘my goat’
	bæl.ˈdæ	‘waist.LOC’	bæl.ˈlær	‘waists’
	iʧ.ˈtæ	‘inside.LOC’	iʧ.ˈlær	‘innards’

Table 3: Uyghur tonic lengthening in the final syllable (McCollum 2019: p. 4).

Sonority, in the case of Uyghur, is a weight factor, not in stress placement but in the way stress alters the distribution of weight in the stressed syllable. Whether a vowel lengthens or not, depends on its quality. McCollum (2019) proposes to treat low vowels as bimoraic, whereas the high ones as carrying just one mora. Under this analysis, sonority is literally a weight factor on par with syllable closure.

2.3 Can stress actually access segmental features?

Although stress patterns that track vowel quality, at least superficially, *are* found in the world's languages, whether or not genuine sonority-driven stress is possible is a point of contention. The empirical claims to the existence of SDS that distinguishes between peripheral vowels, have been subject to scrutiny (Shih & de Lacy 2019). I discuss the most prominent of such cases that have been called into question in Section 2.3.1. In addition, after summarizing the history of sonority as a weight factor in phonological theory (Section 2.3.2), I review several proposals which show how to reanalyze SDS systems with full-reduced oppositions with no reference to quality (Section 2.3.3).

2.3.1 Challenging the empirical basis of SDS

Shih (2016) argues that stress in Gujarati, which is one of the most well-described cases of quality-driven stress, is actually not quality-driven. According to existing descriptions of Gujarati (Cardona 1965, Mistry 1997, Doctor 2004), while the default stress is penultimate, /a/ in the final syllable attracts stress away from a penultimate vowel that is not /a/ (9).

(9) 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’ [sáme] ‘in front’
[sáɖu] ‘plain’

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

Shih (2016) conducts a phonetic experiment in order to test the accuracy of two hypotheses: (a) that Gujarati stress is sonority-driven and, on the other hand, (b) that it is fixed on the penult. The phonetic correlates of stress (intensity, duration, F0, F1, F2) were compared for /a/ in different positions in the rightmost foot, and the empirical picture fits the fixed penultimate stress hypothesis. The vowel /a/ in the final syllable has consistently lower intensity and is more centralized than in the penult, no matter the penultimate vowel. If Gujarati stress were genuinely sonority-driven, the properties of the final /a/ after peripheral vowels other than /a/ (like in [ʃikáɾ] 'recently') would cluster with those of the /a/ in the penult with a different vowel on the right (like in [sáme] 'in front'), but this is not so. In other words, the distribution of sonority in the last two syllables does not in fact make stress shift from the penult.

Shih's (2016) contribution is stronger than just dismissing Gujarati as an example of a language with a sonority-driven stress pattern. First, Gujarati has been claimed to distinguish between peripheral vowels. Shih (2016) points out the impressionistic nature of the few descriptions of patterns that draw the line between different kinds of peripheral vowels. Since they are so rare, the successful reconsideration of empirical claims about the most well-documented of such cases (i.e. Gujarati) implies that the other ones are likely to be not so legitimate either.

A few years after Shih's (2016) paper, Shih & de Lacy (2019) made a stronger claim to the lack of reliable evidence for the possibility of *direct* causal relationship between sonority and prosody. Consider the example of the Nganasan language, which belongs to the Samoyedic branch of the Uralic family and is spoken in northern Siberia.

Helimski (1998) observes that the vowels of Nganasan form a two-level hierarchy, where the high vowels and schwa (/i, y, u, ə, ɨ/) are lighter than the mid and low vowels /a, e, o/. By default, the penultimate syllable is stressed (10).

(10) Nganasan Default Penult Stress (adapted from de Lacy 2002: p. 58)

[kóruʔ]	'house'
[kə́ndəʔ]	'sledge'
[kuhúmi]	'our (dual) skin'
[bá:rbə]	'master, chief'
[bə.lóu.kə]	'a kind of moveable dwelling on runners'

If the penult is mono-vocalic and contains a high or central vowel and therefore counts as light, and the antepenult features a non-high vowel and counts as heavy, then stress can optionally shift to the antepenult (11).

(11) Nganasan Antepenult Stress (adapted from de Lacy 2002: p. 58)

a. Antepenult [e o], penult [i y u ə ɨ]

[ɟémbiʔʃi]	'dressing'	[hóðyʔə]	'writing'
[cétəmtɨ]	'four'	[kóntuɟa]	'carries'
[nónɟiʔə]	'going out'	[hótəɟa]	'writes'

b. Retraction to [a], penult [i y u ə ɨ]

[nánunə]	'1SG.LOC'	[naɟágəjcy]	'2 younger sisters'
[tánduɟə]	'wider (attrib.)'	[ɟákəgəj]	'two twins'
[báruʃi]	'devil'	[hʲásɨrə]	'fishing rod'
[kánəmtu]	'which (in order)'		

This data, however, is just one way that the Nganasan stress pattern has been described. Shih & de Lacy (2019) have dedicated a section of their paper to the conflicting descriptions of Nganasan, as well as to the evidence from stress-induced segmental effects like consonant gradation, which does not support the sonority-drivenness of the system at hand.

Not all descriptions of Nganasan agree on the precise makeup of the sonority hierarchy that guides stress retraction from the penult: for Helimski (1998) and de Lacy (2002, 2004), the "light" vowels are [i y u ə ɨ], which include some peripheral vowels, whereas according to a more recent description of Vaysman (2009), stress only retracts from the central vowels [ə ɨ]. Importantly, if the antepenult contains one of the more sonorous vowels [i y u], the stress is predicted to shift by de Lacy (2004) but does not, according to Vaysman's (2009) data. Similarly, if [i y u ə ɨ] are all light, stress is not supposed to shift from [ə] to [u], but it does in Vaysman's (2009) description. Table 4 illustrates these discrepancies.

de Lacy (2004)	Vaysman (2009)	Translation
Expected: [(ˈbaku)nu]	[ba(ˈkunu)]	salmon
Expected: [saðu(ˈtənu)]	[sa(ˈðutə)nu]	clay.LOC

Table 4: Discrepancies between predictions of de Lacy (2004) and Vaysman's (2009) data.

Furthermore, the pattern of stress-dependent consonant gradation described by Vaysman (2009) does not reflect the supposed sonority-driven stress rule at all (12). It is as if the fortition is produced by a trochaic pattern, which is very common in the Uralic language family (Pajusalu 2022).

(12) Consonant gradation in Nganasan (Vaysman 2009: pp. 45–46, Shih & de Lacy 2019: p. 24)
-ti foot-internally, *-ði* foot-initially

a. [(ˈko-ti)] 'your (du.) ear'

b. [(ˌbaku)(ˈnu-ti)] 'your (du.) salmon'

c. [(haˈhi)-(ði)] 'your (du.) wild deer'

d. [(ˌkərï)(gəˈʎi)-(ði)] 'your (du.) march'

The cases outlined above are precedents that should cause one to doubt the existing accounts of SDS, for impressionistic descriptions are prone to errors. Their accuracy can be subject to experimental re-evaluation, similarly to Shih's (2016) study on Gujarati stress, or at least be compared with each other in order to note any inconsistencies.

Before we can assess what the fairly recent decline of trust in SDS means in the broader context of phonological theory, I will give some perspective on how sonority (as well as prominence in general) as a weight factor has been accounted for in major metrical theories of the last 40 years.

2.3.2 Theoretical perspective on prominence as a weight factor

Phonological theory has long been occupied with the question of what can and what cannot affect stress placement. Different approaches to metrics, while unanimously recognizing quantity and lexical marking as weight factors in stress assignment, have had varying levels of restrictiveness with regard to sonority sensitivity.

Halle & Vergnaud's (1987) grid theory of stress is extremely unrestrictive about prominence, because prominence projection rules can refer to any feature, thus possibly creating unattested patterns. While a rule like "Assign an asterisk to every low vowel" is plausible, "Assign an asterisk to every schwa" is not, i.e. stress algorithms tend to prioritize more sonorous vowels as opposed to schwas, for example. Nevertheless, both patterns are equally valid in the said theory, since an arbitrary class of vowels can be made to project.

The moraic theory of Hayes (1989, 1995) puts prominence-based stress patterns into a separate category, different from the one containing quantity-based patterns. Stress systems that are sensitive to quantity track mora count and build a foot structure in order to assign stress, while those sensitive to prominence do not. Sonority-driven stress, as well as prominence-driven stress in general, is therefore expected to be more limited than quantity-tracking stress, since it can access all mechanisms of stress assignment except for footing, i.e. "End rule, destressing, and extrametricality" (Hayes 1995: p. 272). So, prominence-dependent patterns cannot be foot-based, hence they are a priori more restricted than the quantity-based ones.

The work on sonority-driven stress has continued on the path of increasing restrictiveness with the introduction of the Universal sonority hierarchy (Kenstowicz 1997, de Lacy 2002), repeated below in example (13). Before that, little attention has been given to which factors actually contribute to prominence. There have of course been descriptions, albeit non-systematized and non-exhaustive, of possible factors contributing to prominence; for a more detailed summary, see Section 2 of Shih & de Lacy (2019).

(13) Universal sonority hierarchy (Kenstowicz 1997: p. 162, de Lacy 2002: p. 55)

low peripheral >	mid peripheral >	high peripheral >	mid central >	high central
a	e, o	i, u	ə	ɨ

The sonority hierarchy formalizes the intuition that has arisen before, for example, in chapter 7 of Hayes (1995), that the relationship between segmental features and prominence is not arbitrary: there are certain vowels that are more or less likely to attract stress. In particular, low and mid peripheral quality contributes to greater sonority, while high and/or central vowels are less prominent. In a system that abides by the sonority hierarchy, we do not expect schwas to be able to top the prominence scale, which would be completely licit within the grid theory of Halle & Vergnaud (1987).

Kenstowicz (1997) was followed by de Lacy (2002) et seq., who refined the hierarchy and integrated it into the framework of Optimality Theory (Prince & Smolensky 1993). de

Lacy (2002) introduced a family of constraints that penalize less sonorous foot heads and more sonorous non-heads (14), thus moving stress away from the less sonorous vowels to the more sonorous ones.

(14) Sonority constraints (as formulated by Shih 2016: p. 9)

a. $*\text{HD}_{\alpha}/v$
Assign a violation for every segment in Hdα that is [*w*F], where v is a substring of *w*.

b. $*\text{NON-HD}_{\alpha}/v$
Assign a violation for every segment in non-Hdα that is [*w*F], where v is a substring of *w*.

The sets of phonemes that the rules in example (14) refer to are shaped with respect to the sonority hierarchy. For instance, the definition of a constraint that punishes a non-head for being too sonorous should contain a continuous upper part of the hierarchy – all of the more sonorous vowels will be banned from the non-head positions (for an illustration, see a list of foot (non-)head constrains proposed by de Lacy (2002, 2004) in example (15).

(15) Sonority constraints (de Lacy 2004: p. 147)

$*\text{HD}_{\text{Ft}}$/*ɨ*	$*\text{NON-HD}_{\text{Ft}}$/*a*
$*\text{HD}_{\text{Ft}}$/*ɨ, ə*	$*\text{NON-HD}_{\text{Ft}}$/*a, e·o*
$*\text{HD}_{\text{Ft}}$/*ɨ, ə, i·u*	$*\text{NON-HD}_{\text{Ft}}$/*a, e·o, i·u*
$*\text{HD}_{\text{Ft}}$/*ɨ, ə, i·u, e·o*	$*\text{NON-HD}_{\text{Ft}}$/*a, e·o, i·u, ə*
$*\text{HD}_{\text{Ft}}$/*ɨ, ə, i·u, e·o, a*	$*\text{NON-HD}_{\text{Ft}}$/*a, e·o, i·u, ə, ɨ*

Note that de Lacy's (2002) approach is more permissive than Hayes' (1995) proposal about the irrelevance of prominence for foot construction. Head and non-head constraints can well penalize foot heads, therefore sonority can affect foot structure just like other weight factors. Still, the introduction of the sonority hierarchy has significantly helped to better delimit the class of possible sonority-dependent stress systems.

To return to the empirical problems described in the previous section, how do they fit into the overall tendency of increasing restriction of the influence of sonority on stress assignment? Shih (2016), apart from presenting an empirical argument against SDS in Gujarati, also raises some theoretical issues for the optimality-theoretic approach of de Lacy (2002).

If the empirical picture is such that stress can influence sonority but not vice versa, that is, for instance, vowel reduction in unstressed positions is possible, whereas genuine sonority-driven stress is not, then the constraints that link vowel sonority and (un)stressed syllables will have to work one way but not the other, which they cannot.

Consider the constraints proposed by de Lacy (2002, 2004, 2006) in example (14). The $*(\text{NON-})\text{HD}_{\alpha}/v$ constraints are able to capture any sonority-prosody interplay, since they are violated by mismatches between the properties of the vowel and its head/non-head position in the foot. These mismatches can arise for different reasons: it can be the absence of reduction in an unstressed position or a vowel at the top of the sonority hierarchy failing to receive stress. Therefore, it is not clear whether the *(NON-)HD$_\alpha$/ν constraints should or should not be included in the Con — the universal, innate set of constraints.

The path towards greater restriction has a terminal point where segmental features never affect prosody directly. Blumenfeld (2006) observes that segmental features in general are not a weight factor, however, he puts sonority, quantity and tone into the class of special features that *can* guide stress assignment. Still, he puts forward two arguments for considering sonority sensitivity similar to quantity sensitivity: (a) there are SDS systems that "can, and perhaps should, be reanalyzed in terms of quantity", that is, tense-lax and full-reduced contrasts contributing to weight are relatively easy to recast into quantitative terms; (b) "sonority never trumps quantity", meaning that sonority never takes precedence over the quantitative weight hierarchy (Blumenfeld 2006: p. 127). While Blumenfeld (2006) presents sonority sensitivity as an open issue with no conclusive evidence to resolve it, he appears to be on the skeptical side.

Rasin (2018) goes even further with the skepticism and defends the claim that stress cannot be sonority-driven at all, which he terms *The Stress-Encapsulation Universal* (16).

(16) The Stress-Encapsulation Universal (Rasin 2018: p. 13)
The distribution of stress is never conditioned by segmental features.

To support this universal, Rasin (2018) demonstrates that the cases of sonority-driven stress that are found in his sample of 400 languages can in fact be reanalyzed without reference to segmental features. Blumenfeld (2006) too has proposed an example reanalysis of a sonority-sensitive pattern in quantitative terms. Since I am going to propose one such reanalysis as well, I will now describe their proposals in more detail.

2.3.3 Recasting prominence as quantity

Both Blumenfeld (2006) and Rasin (2018) state that *some* of the SDS rules can be reformulated to exclude sonority, particularly the rules that distinguish between full and reduced vowels. The critique of the systems that draw the line between groups of peripheral vowels is rather factual than theoretical, arguing that such patterns are extremely rare or do not occur at all.

Consider several SDS patterns and how they can be reanalyzed. Blumenfeld (2006) uses Kara, and Austronesian language spoken in Papua New Guinea, as an example of such a pattern, after which other similar systems can be modelled, like "unstressable schwa" systems (those where schwa is light and all other vowels are heavy) and "stressed /a/" systems (those where all vowels but /a/ count as light).

Kara has a vowel inventory of 10 vowels (see Table 5), all of which form tense-lax pairs except schwa and /a/ (Blumenfeld 2006: p. 125; Schlie & Schlie 1993). Tense and lax mid vowels are in complementary distribution to each other, where tense variants occur in open syllables and the lax ones are restricted to closed syllables; not so for /a/ and schwa, which are contrasted in all syllables.

i	ɪ		ʊ	u
e ~ ɛ		ə		ɔ ~ o
		a		

Table 5: Kara vowel inventory.

Given this and the fact that /a/ and schwa do not participate in laxness harmony (17), where paired vowels become lax before other lax vowels, there are good reasons to treat /a/ and schwa as two distinct non-alternating vowels.

(17) Kara vowel harmony (Schlie & Schlie 1993: p. 104, Blumenfeld 2006: p. 126)

[ɛ] before [ɪ,ɛ]		[ɔ] before [ɔ]	
ɣalɛlɛɸ	'lightweight'	pʰɔɣɔʔ	'fall'
lɛlɛq	'run away to eat'	dɔɣɔt	'accompany'

The stress pattern of Kara singles out /a/ as a "heavy" vowel – see the pattern in example (18), as summarized by Blumenfeld (2006: p. 125), and example (19) from Schlie & Schlie (1993) for illustrations.

(18) Kara stress rule (Blumenfeld 2006: p. 125)

a. Rightmost syllable containing [a]

b. No [a] ⇒ rightmost closed syllable

c. No closed syllables or [a] ⇒ stem-initial

(19) Kara: stress rightmost /a/, else rightmost closed syllable, else initial (Schlie & Schlie 1993: p. 109)

Rightmost /a/		Rightmost closed		Initial default	
[ˈqʰa.pʰis]	'plant'	[ˌɣə.lə.ˈpʰʊŋ]	'a swallow'	[ˈpʰu.tʰə]	'pull out'
[mə.ˈtʰa]	'man'	[ˈmɛs.qʰə]	'muscle tissue'	[ˈɣi.lə]	'a parrot'
[ˌni.naŋ.ˈpʰap]	'stepmother'	[ˌmɛ.lə.ˈsʊɸ]	'meaning'	[ˈpʰi.sə.ˌne]	'tie it up'

If /a/ is represented as phonologically long, in contrast to schwa and all the paired vowels, both its unpaired status with respect to the tense-lax distinction and its contribution to weight are explained. This idea – endowing "heavy" vowels with underlying length – inspires my analysis of Moksha too.

Another example of a SDS system that can be reanalyzed in terms of quantity is that of Eastern Mari, for which Rasin (2018) proposes an analysis described below. In Eastern Mari, reduced vowels, i.e. schwa and its varieties produced by vowel harmony, count as light in stress assignment. The monomorphemic words in example (20) follow the weight-sensitive rule of stressing the rightmost full vowel.

(20) Eastern Mari: stress rightmost syllable with a full vowel (Rasin 2018: p. 37, Vaysman 2009: pp. 62–63)

koŋgá	'oven'	paréŋə	'potato'
sérəf	'letter'	pő̆rʃö — pő̆rʃə-m	'frost' — 'frost-ACC'
jóŋələs	'mistake'	ʃóʃo — ʃóʃə-m	'spring' — 'spring-ACC'

In words with no full vowels, stress is initial (21). Some of the words in this example contain schwas changed by vowel harmony and are followed by harmony-free forms.

(21) Eastern Mari: initial stress in schwa-only words

a. Vaysman (2009: p. 64)

βə́nər	'canvas'	tə́lzə	'moon, month'
ə́škəl	'step'	kə́zət	'now'
čə́rkə	'church'	lə́βə	'butterfly'

b. Saarinen (2022: p. 434)
ˈkə.ləm.dəʃ.tə.ʒe 'navel.INE.POSS.3SG'

This quality-sensitive stress rule can be rewritten without reference to quality. Reduced vowels in Mari are assumed by Rasin (2018) to correspond to empty timing slots in the underlying representation, as opposed to full vowels, which occupy filled slots. Empty slots do not count for weight and are only filled after stress is assigned. There is thus a quantitative difference between full and reduced vowels in the phonological computation, so stress does not have to track any segmental features. This analysis is especially suitable for the Eastern Mari data, since reduced vowels do not have any melodic content of their own. Schwa is the default choice, whereas its other variants are the result of vowel harmony.

2.4 Summary

The ostensible lack of strong evidence for SDS, as well as the growing number of alternative analyses, are accompanied by several proposals that explicitly prohibit quality from being a factor in stress assignment. The evidence against genuine SDS has been of two kinds: (a) empirical, i.e. factual critique and reassessment of the data on SDS systems, drawing attention to the unreliability of descriptions and the conflicting nature of data sources; (b) theoretical, which comprises all the alternative proposals for SDS that do not feature sonority as a direct influence on stress assignment.

In the present thesis, I am going to add to the latter — to the growing stack of sonority-free reanalyses of SDS. My choice of phonological framework in which to couch my analysis of Moksha SDS is guided by the same considerations that led Rasin (2018) to formulate the Stress-Encapsulation Universal — it should reflect the isolation of the stress algorithm from segmental features.

I find the approach to stress assignment that has been developed in Strict CV phonology (Lowenstamm 1996, Scheer 2004, 2012) to be particularly suitable. The two-tiered phonological representations of Strict CV, where melody and timing slots occupy separate tiers, help model the asymmetrical relationship between quality and prosody. With this autosegmental structure, the stress assignment process can only involve the syllabic tier. I will now introduce the key properties of this theory that are relevant to the issue of sonority-driven stress.

3 The framework: Strict CV

Strict CV is a lateral autosegmental approach to phonology (Lowenstamm 1996, Scheer 2004, 2012), meaning that it takes the representations to be multi-tiered but linear, unlike the tree-shaped representations of Prosodic Phonology (Selkirk 1981, Nespor & Vogel 1982 et seq).

This part of the thesis lays out the specifics of how Strict CV works and why it fits so well with the Stress-Encapsulation Universal and the dubious status of true SDS that scholars seem to converge on recently. Section 3.1 describes the history of the framework and how it is different from Government Phonology, from which it has evolved. Section 3.2 is dedicated to the representations, which are of great importance to Strict CV. Section 3.3 describes how phonological computation proceeds. Section 3.4 elaborates on how prosody and stress-induced segmental alternations are treated. Section 3.4.3 explains the concept of virtual length and how it can be applied to translate sonority sensitivity into quantitative terms.

3.1 A predecessor: Government Phonology

Strict CV has developed as an offshoot of Government Phonology (GP; Kaye, Lowenstamm & Vergnaud 1990). In GP, phonological representations are assumed to consist of onset-rhyme pairs, where rhymes contain nuclei. Rhymes, nuclei and onsets allow binary branching (see Figure 1).

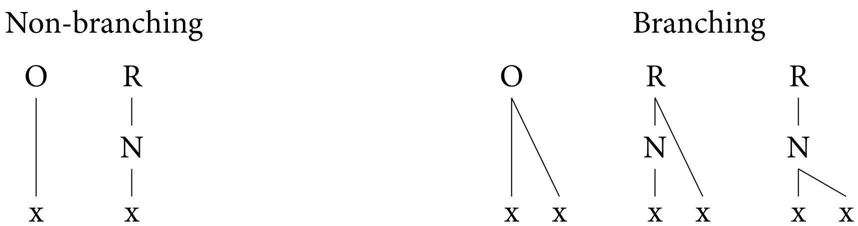


Figure 1: Onsets and rhymes in GP (Kaye, Lowenstamm & Vergnaud 1990: p. 199).

Government, from which the theory got its name, is an asymmetrical relation between constituent heads and their dependents. Government in GP is head-initial, i.e. nuclei govern the dependents of their rhymes, for example, codas. Given that government is strictly local and head-initial (Kaye, Lowenstamm & Vergnaud 1990: p. 198), a number of onset-rhyme configurations are ruled out as ill-formed, for instance, branching codas or superheavy syllables with CVVC shape (Figure 2). CVVC or CVCC structures presuppose that the governing domain comprises two dependents, only one of which can be governed, due to the strict locality condition on government.[5]

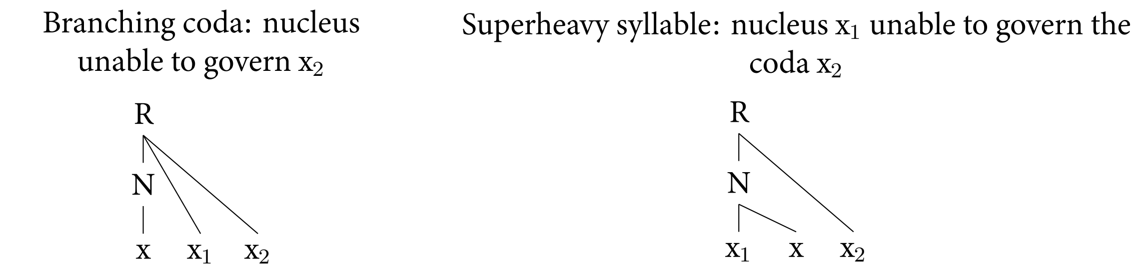


Figure 2: Onsets and rhymes in GP (Kaye, Lowenstamm & Vergnaud 1990: p. 199).

Note that codas are not granted a constituent status in GP, consequently, they are not allowed to branch. Kaye, Lowenstamm & Vergnaud (1990) also introduce proper government, which holds between constituents and is responsible for the distribution of empty categories; see the Empty Category Principle (ECP) in example (22) and an illustration in Figure 1.

(22) Empty Category principle
A position may be uninterpreted phonetically if it is properly governed
(Kaye, Lowenstamm & Vergnaud 1990: p. 219)

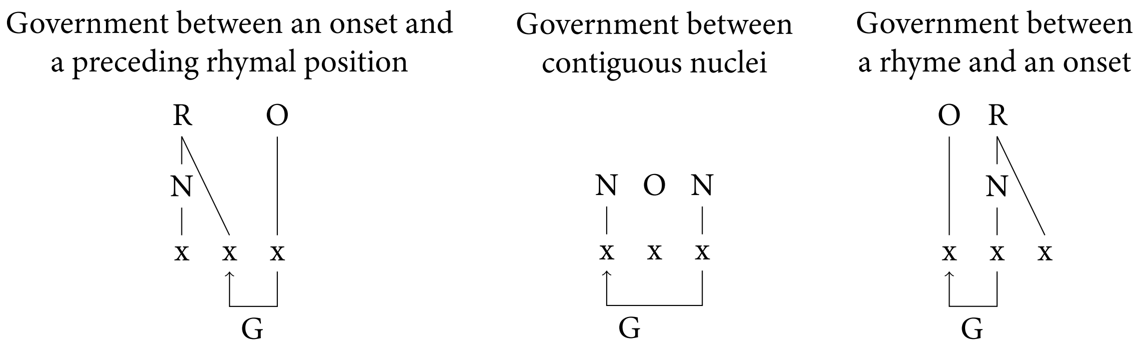


Figure 3: Onsets and rhymes in GP (Kaye, Lowenstamm & Vergnaud 1990: p. 199).

The central insight of GP is the way restrictions on possible syllables, like a ban on branching codas or superheavy syllables, as well as the occurrence of empty nuclei can be modelled with the notion of phonological constituents and asymmetrical relations within and between them. It also denies the constituent status to the syllable, which *is* a representational unit in standard syllabic theory, instead opting for an alternative structure, less intuitive but with greater explanatory power.

5. While Kaye, Lowenstamm & Vergnaud (1990) recognize that branching codas are attested, for instance, in English (in words like *part, carp, born*, etc), they still choose to deny constituence to codas, since metrics and "phonological processes which distinguish closed vs. open syllables" are not sensitive to whether the coda is branching or not. Since there is no such thing as a coda in GP, whether or not the structure is licit in any particular language will be regulated by the branching capabilities of the *rhyme*.

Strict CV has inherited from GP the idea of an alternative syllable structure, government as an asymmetrical local relationship between structural nodes, as well as the ECP. Nevertheless, a lot has changed. Constituents now have the CV shape, which stands for consonant-vowel, or onset-nucleus. The rhyme is obsolete: the coda is just an onset of a syllable whose nucleus is empty. Government domains, which used to be head-initial in GP, are head-final, since the nucleus is on the right of the CV constituent, not on the left of the rhyme. The next sections explain the shape of the Strict CV representations, as well as the intra- and inter-constituent relations in more detail.

3.2 Representations

Phonological representations of Strict CV, just like those of GP, are autosegmental, meaning that, apart from segments, there are higher order constituents. The constituents, again, similarly to GP, do not correspond to a traditional notion of a syllable – each so-called *syllabic unit* consists of a consonantal slot (C-slot) and a nucleus slot (V-slot). These units on the one hand, also referred to as the *skeleton*, and the segments on the other hand, exist on disjointed tiers, which are called the *syllabic tier* and the *melodic tier* respectively.

Melody is linked to the skeleton with *association lines.* Segments, i.e. bundles of phonological features, can only be pronounced if they are associated to the syllabic tier (for an illustration of how representations look, see example 23).

(23) Hypothetical word *karuti*

C	V	C	V	C	V
|	|	|	|	|	|
k	a	r	u	t	i

In example (23), all segments are associated, so all of them appear in the surface representation *karuti.* The consonants /k, r, t/ occupy consonantal positions (C-slots), while the vowels /a, u, i/ take up vocalic positions (V-slots).

Although some word forms do consist of filled nuclei only, like the simple toy example in (23), it is often the case that some skeletal slots are empty or that some melodic material remains unassociated. There are several mechanisms in Strict CV that control the appearance of empty slots and the formation of association lines; I will now explain how government and licensing work, as well as why they are needed.

3.3 Phonological computation

The range of possible representations is narrowed down when one considers the lateral relations that hold between skeletal slots. Government and licensing are two such relations.

3.3.1 Government

Skeletal slots, both consonantal (C-slots) and vocalic (V-slots) can remain empty (see examples 24–25).

(24) Empty C
Hypothetical word *araka*

```
C  V  C  V  C  V
   |  |  |  |  |
   a  r  a  k  a
```

(25) Empty V
Hypothetical word *keske*

```
C  V  C  V  C  V
|  |  |     |  |
k  e  s     k  e
```

In example (24), there is an initial empty C-slot in the made-up word *araka*. Since the syllabic tier is comprised of CV-units, every vowel-initial word contains an unoccupied onset. The hypothetical word *keske* in example (25) includes an empty vocalic position. Again, because of the structure of the skeleton, every coda is actually an onset followed by a vacant V-slot.

The occurrence of empty slots is restricted by the ECP, which is carried over from GP. The ECP states that an empty vowel must be properly governed in order to stay silent on the surface, that is, to be followed by a filled slot or a governing final empty nucleus (Kaye, Lowenstamm & Vergnaud 1990: p. 219). This brings us to the question of how government works in Strict CV.

The principles of proper government from GP, laid out by Kaye, Lowenstamm & Vergnaud (1990), apply to Strict CV as well, albeit with some changes. Filled nuclei are governors but are not themselves governed; empty nuclei can be governors under some conditions, and have to be governed to remain empty. Crucially, in Strict CV, governing domains, i.e. CV-slots, are *head-final*, unlike the head-initial domains in GP. Therefore, government proceeds right-to-left, and the start of the phonological computation is the domain-final nucleus.

(26) Principles of government in Strict CV

a. A filled V-slot can govern
b. An empty V-slot can only govern in special cases (final empty nucleus, infrasegmental government)
c. A filled V-slot cannot be governed
d. An empty V-slot can be governed (and must be governed to stay empty, by ECP)

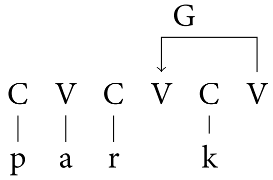
Consider example (25) repeated below in (27) with government relations made explicit. It is only because /e/ fills the final V-slot that the previous empty nucleus, trapped between two consonants, can stay unpronounced.

(27) Governed empty V
Hypothetical word *keske*

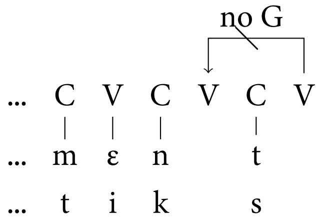
```
            G
         ┌─────┐
         ↓     |
C  V  C  V  C  V
|  |  |     |  |
k  e  s     k  e
```

While all filled nuclei are governors, final empty nuclei (FEN) are sometimes able to govern too. Since the computation starts with them, their status wrt. government and governing ability has to be predetermined. Scheer (2004: §§378, 540, 603) proposes to do this parametrically. So, in a language with governing FENs, final consonant clusters would be licit (English; 28), whereas if FENs are unable to govern, a final cluster would be resolved, for instance, via deletion (Turkish; 29).

(28) English: final clusters allowed
park [pɑɹk]



(29) Turkish: final clusters resolved in English loanwords (Beel & Felder 2013: p. 4)
apartment /əpɑɹtmənt/ ⟶ [ɑpɑɹtmɑn]
mathematics /mæθ(ə)mætɪks/ ⟶ [mʌtɛmʌtik]

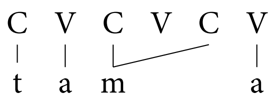


While government is mostly responsible for controlling the appearance of empty nuclei, licensing is in charge of those vowels that take up two nuclei.

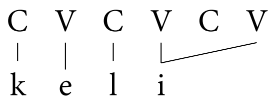
3.3.2 Licensing

Consonants and vowels can spread to occupy two slots (see example (30) for a geminate consonant and example (31) for a long bipositional vowel).

(30) Hypothetical word *tamma*



(31) Hypothetical word *kelii*



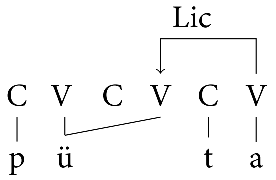
The occurrence of bipositional vowels, just like empty slots, needs to be restricted. There is a reason why some languages do not tolerate superheavy CVVC syllables in some or all positions in the word. Consider, for example, Votic (<Finnic<Uralic), where vowel length is phonologically contrastive and long vowels only occur word-finally in monosyllables (32). Word-internally, only CVV can be found.

(32) Votic: only final CVVC is allowed (Markus & Rožanskij 2017: p. 365)

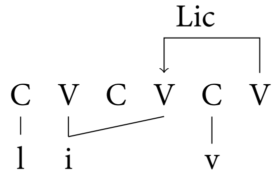
CVV		CVC.C		CVVC		CVV.CV	
puu	'tree'	kukk	'flower'	liiv	'sand'	püüta	'catch.INF'
müü	'we'	ʌajv	'ship'	kuuz	'fur'	ʌauʌu	'song'

The lateral relation that manages the distribution of long vowels is Licensing.[6] It is established from right to left. Filled (ungoverned) V-slots are licensors; FENs too can be parametrically endowed with licensing abilities. Vowel spreading, that is, the formation of a second association line from one piece of melody to connect it to a second V-slot, is only allowed into the nearest licensed V (Scheer 2004: §225). See examples (33–34) below for the representations of some Votic words from example (32).

(33) Licensing by filled nucleus
püüta 'catch.INF' (Votic)



(34) Licensing by FEN
liiv 'sand' (Votic)



Word-internal FENs in Votic cannot licence, therefore word-medial CVVC syllables are ruled out. So, length is traditionally represented as bipositionality, and the restrictions on positions where length can occur are due to which nuclei can license.

3.4 Prosody in Strict CV

GP and Strict CV are especially germane to the topic of sonority-driven stress because one of the key properties of both is *structuralized sonority*: onsets, rhymes and nuclei, as well as C- and V-slots, are just sonority projected to a higher tier, where it can be accessed by the stress algorithm. Sonority is thus written into the structure of representations and severed from other melodic features that are not relevant to stress (Scheer 2019). Vowels are more sonorous than consonants, they are more likely to become syllable nuclei — therefore, in Strict CV representations, vowels are associated with V-slots and consonants take the C-slots. Stress is computed with syllabic slots as input — all other melodic information is invisible. This property of the framework encodes the Stress Encapsulation Universal of Rasin (2018): segmental features are out, so the stress algorithm has to rely on what has been translated into quantity, i.e. on the sequence of empty and full skeletal slots.

Recall, however, that stress can indeed change segmental features, which, as I have mentioned in Section 2.3.2, is a problem for Optimality Theory. The constraints that penalize sonorous non-heads and non-sonorous heads fail to reflect the direction of the causation: the surface form where a non-head is low on the sonority scale may be produced

6. Licensing in GP used to comprise Government as a subtype and to be responsible for the appearance of empty nuclei, including the final ones, which are governed by nothing. In Strict CV, Licensing is a relation of its own (Scheer 2004: §135).

by a vowel reduction process (stress placement affects sonority), but it could also be a case where stress shifts away from a non-sonorous vowel (sonority affects stress placement).

The typological predictions made within Optimality Theory depend on the contents of the universal set of constraints (Con). Since Con is universal, and all variability between languages comes from different rankings, the set of systems generated by possible constraint rankings, or FACTORIAL TYPOLOGY, is what we expect to observe in the actual typology.

If we introduce into Con a constraint like *Non-Hd$_{Ft}$/*a, e·o* to reflect, for instance, a vowel reduction pattern where low and mid peripheral vowels have to be reduced in unstressed syllables, we expect to find possibly as many genuine SDS systems that prioritize those same vowels in stress assignment. However, this is not the case; the relationship between sonority and stress is not as symmetrical.

The relationship between the two tiers of Strict CV is asymmetrical, though. While segmental features are confined to the melodic tier unless projected upwards, the skeleton can condition the appearance of melody. Association lines, after all, are necessary for melody to be pronounced. So, in order to reflect the phonological effects of stress, one just has to find the right exponent for stress, which can be inserted on the syllabic tier and then produce the correct effect on the segmental level.

The task of modelling a stress system in Strict CV consists, therefore, of (a) finding the right stress exponent; (b) formulating a melody-agnostic stress placement rule. I explore stress exponence in Strict CV in Section 3.4.1 and approaches to stress placement in Section 3.4.2. Virtual length as a way to translate sonority into quantity is discussed in Section 3.4.3.

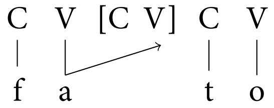
3.4.1 Stress exponents

The representation of stress as a syllabic unit, or a CV slot (Scheer & Szigetvári 2005), has been endorsed for Italian (Larsen 1998), Russian (Enguehard 2018), Old Norse (Enguehard 2015), Southern Saami (Enguehard 2014), Hawu (Ulfsbjorninn 2021), Hebrew (Faust 2021). A workable representation of stress is supposed to accurately capture the processes that take place in the vicinity of stress. Such processes include the lengthening of consonants and vowels, the preservation of contrast and the strengthening of stress-adjacent consonants (Giavazzi 2010). This set of stress-induced effects in the world's languages is limited but disjunctive. If stress is assumed to correspond to a syllabic unit, the lengthening and strengthening of segments follows from a single representation.[7]

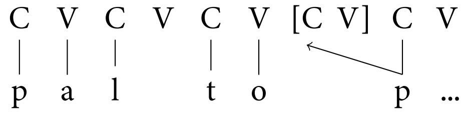
Consider an example from Italian, where non-final stressed vowels are lengthened. The vowel /a/ in *fato* 'destiny' receives an extra syllabic slot and spreads (35), as proposed by Larsen (1998). Final stressed vowels, however, cannot lengthen. The syllabic unit provided by stress is still taken up: the consonant to the right from the stressed final vowel is geminated (36).

7. The third part of the disjunction is preservation of contrast, which will be discussed later in Section 3.4.3 in relation to virtual length. In short, contrast tends to survive near stress because a greater amount of syllabic space is able to carry more segmental features.

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

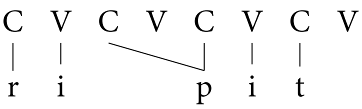


(36) *paltò pulito* [paltoppulito] 'clean coat' (Italian; Larsen 1998: p. 92)

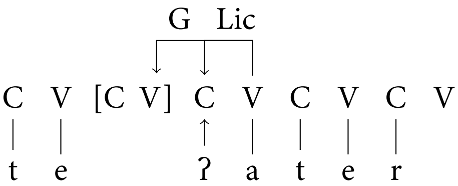


The addition of an empty syllabic unit can also strengthen the consonants next to stressed vowels. In English, for instance, onsets of stressed syllables are aspirated (37; example taken from Enguehard 2015, who takes the aspirated consonant to be a virtual geminate).[8] In German, the empty onset of a word-internal stressed syllable is filled with a glottal stop (38), because the onset of the stressed syllable undergoes fortition.[9]

(37) [rip^{h}i:t] (English)



(38) *The[ʔ]áter* 'theater' (stress CV parenthesized)
cf. *theatrálish* 'theatrical' (German)



Strengthening in the presence of an additional CV provided by stress is a consequence of Government and Licensing working together; see the literature on Coda Mirror for the details of how these two relations can deal with lenition and fortition (Ségéral & Scheer 2008).

With the CV-unit as a stress exponent, Strict CV is well-equipped to deal with quantity alternations frequently found in stressed syllables, such as tonic lengthening, compensatory gemination, as well as the qualitative ones, like onset fortition. I will now move on to the stress placement algorithm.

3.4.2 Stress placement

The approach to stress assignment developed in Strict CV builds on the same logic as standard moraic theory (SMT) or grid-based approaches to stress, where some suprasegmental units (moras and grid marks) project to the higher suprasegmental layer where they can be accessed by the stress algorithm; in Strict CV, such units are V-slots (Scheer & Szigetvári 2005).

8. See Section 3.4.3 on virtual length.

9. Fortition in this case is due to the C-slot being licensed and ungoverned; see Ségéral & Scheer (2008: p. 506) on fortition in pretonic environments.

All that is needed for stress assignment to work is already there: V-slots carry all the necessary information on weight. Weight by Position (Hayes 1989) — a parameter that determines whether codas contribute to weight — will rely on empty Vs, which always follow codas in the CVCV-skeleton. In the languages where codas are weightless, empty V-slots do not project; in those where CVC syllables are heavy, they will project. For example, in the stress pattern of Classical Latin, where a heavy penult can shift the stress from its default antepenultimate position, codas are heavy: CVC syllables are on par with CVV (see example (1) repeated in (39) below).

(39) Latin stress (Solopov & Antonec 2011: p. 29)

for.ˈtū.na	‘fate’
ma.ˈgis.ter	‘teacher’
ˈpo.pu.lus	‘nation’
ˈra.ti.ō	‘intellect, reason’

The empty V-slots of internal codas, as well as the extra vocalic positions of long vowels will be visible in stress assignment and able to determine the stressed position. Scheer & Szigetvári (2005) provide a detailed account of the Latin stress pattern where the rule is to stress the third nucleus from the right, also dealing with edge cases like final heavy syllables (e.g. ma.ˈgis.ter ‘teacher’) and the third nucleus from the right being empty (e.g. forø.mu.la).

Weight hierarchies in the world’s languages can be quite fine-grained; in order to handle a wide range of weights-sensitive systems, Strict CV Metrics – a more powerful framework – is being developed by Noam Faust and Shanti Ulfsbjorninn (Ulfsbjorninn 2014, Faust & Ulfsbjorninn 2018, Ulfsbjorninn 2022b, Faust 2023a). It combines the concept of a metrical grid with the skeleton built of CV-shaped syllabic units.

To begin with, all filled nuclei project to the second level (L2). For each language where weight is a stress factor, the projection capabilities of empty V-slots can be parametrized, so that some of them project to a higher level. For instance, if CVV syllables count as heavy, then the second nucleus of each long vowel will project to L1. The example comes from Selkup (<Samoyedic<Uralic), where stress falls on the rightmost heavy syllable and on the initial syllable in light-only words (40; Kuznecova et al. 2002).[10]

(40) Selkup: stress rightmost heavy syllable, else initial (Kuznecova et al. 2002: pp. 29–30)

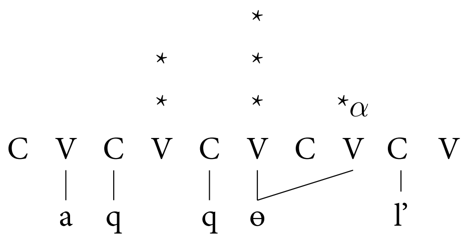
kó.ŋɨm.pɨ.qo	‘to speak’	tə̄n.tɨ.pṓ	‘table’
í.lak	‘I live’	aq.qə̄́l’	‘reins’

For the length-dependent stress pattern of Selkup to work in Strict CV Metrics, the nucleus hosting a long vowel has to project higher than those associated to short vowels. The second position of every long (bipositional) vowel will consume the grid mark of its second V-slot (41). Filled nuclei consume the projections of empty Vs via the process of Incorporation (Ulfsbjorninn 2014, Faust & Ulfsbjorninn 2018).

10. The transcription I use for Selkup is a loose correlate of the cyrillic script used by Kuznecova et al. (2002) and may not be accepted by other researchers of Selkup.

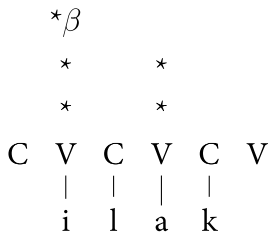
A nucleus of a long vowel in example (41) will project higher than that of a CV syllable by means of incorporating the grid mark of the empty V in its incorporation domain, i.e. on its right, no further than the next filled nucleus.[11]

(41) Selkup: second slot of a long vowel incorporated, CVVC wins over V
aqqө̄́l’ ‘reins’



In words with no long vowels and therefore no heavy syllables, there is a tie between several vowels projecting to L2, which is resolved by stressing the initial syllable (42). Similarly, in case of a tie between several heavy syllables projecting to L3, the rightmost syllable would win, like, for example, in *tө̄n.tɨ.pṓ* ‘table’.

(42) Selkup: tie resolved in favor of the initial syllable
ílak ‘I live’



It is not just the positions that long vowels spread into that can project and be incorporated. Post-coda empty nuclei, just like in the approach of Scheer & Szigetvári (2005), can be parametrized to project or not project, which would result in the heaviness or weightlessness of codas respectively.

For the purposes of my analysis of Moksha stress, the only weight factor that matters is length, so let me explain how sonority can be translated into virtual quantity.

3.4.3 Virtual length

The idea behind virtual length is that length in the phonology does not always correspond to duration in the phonetics. Virtual length appears in those cases where phonological length is expressed as anything other than duration.

In Strict CV, as mentioned in the previous section, long vowels and geminates are bipositional, that is, associated to two skeletal slots. There are a number of cases where bipositionality is phonologically apt but does not receive the “regular” phonetic expression. For instance, several analyses of vowel reduction have been proposed that assume

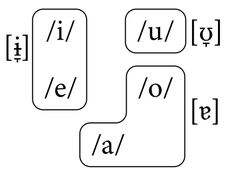
11. The direction of Incorporation — right-to-left — reflects the fact that entities representing potential weight factors (second vocalic positions or codas) are located on the right of the nucleus.

full vowels to be bipositional (long) and the reduced ones to be monopositional, or short (see Lowenstamm (1991, 2011) on Semitic, Ben Si Saïd (2011) on Kabyle Berber and Enguehard (2018) on Russian). Scheer (2014) provides a summary of other analyses that involve virtual length, featuring geminate consonants as well.

To demonstrate the way quality can be mapped onto quantity, I will present the case of unstressed vowel reduction in Russian. This process has been reanalyzed in terms of quantity by Crosswhite (2000) and later by Enguehard (2018). If stressed vowels are assumed to be phonologically long and therefore able to host more privative phonological features (elements of Element theory; Kaye, Lowenstamm & Vergnaud 1985), then vowel reduction follows from vowel shortening.

The Russian reduction pattern depends on the position of the unstressed syllable (pretonic vs. other), as well as on whether the onset of the said syllable is palatalized. For simplicity, I will focus on the non-palatalized pretonic context. The pattern is shown in (43), accompanied by some examples in (44).[12]

(43) Vowel inventory of Russian and the reduction pattern in pretonic non-palatalized contexts



(44) Russian vowel reduction (pretonic, non-palatalized)

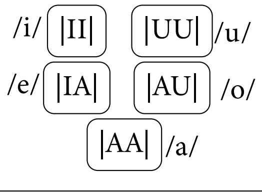
/i e/ ⟶ [ɨ̞]
rýba — r[ɨ̞]bák — ‘fisher — fish’
tréš — tr[ɨ̞]šóvyj — ‘trash — trashy’

/a o/ ⟶ [ɐ]
dál — d[ɐ]lá — ‘give.PST.M — give.PST.F’
pól — p[ɐ]lý — ‘floor — floor.PL’

/u/ ⟶ [ʊ̞]
kúst — k[ʊ̞]stý — ‘bush — bush.PL’

The difference in height between /i e/ and /a o/ is lost in reduction; this can be analyzed as loss of distinctive features. In Element Theory, three privative features, or *elements* — A, I, U — combine to produce vowels. The vowel inventory with elemental representations proposed by Enguehard (2018) for Russian is given in example (45).

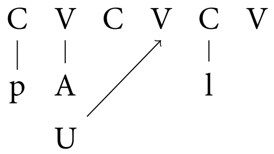
(45) Russian vowel inventory with elemental representations (Enguehard 2018)



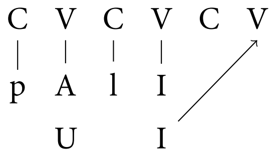
12. The source of the examples is my native competence in Russian, as well as the phonetic observations of Iosad (2012) and Enguehard (2018).

The full vowel inventory of five phonemes is reduced to just three contrastive vowels (|A| ⟶ [ɐ], |U| ⟶ [ʊ̞], |I| ⟶ [ɨ̞]); Enguehard (2018) suggests that in reduction, the second element is lost, resulting in the observed three-way vowel distinction in pretonic syllables with non-palatalized onsets. A long unreduced vowel can comprise two elements, whereas shortening results in the loss of one vocalic slot and with it, one contrastive feature (see examples (46–47) for an illustration).

(46) *pól* [pɔl] 'floor'



(47) *polý* [pɐlɨ] 'floor.PL'



To quote Enguehard (2018: p. 123), vowel reduction does not interact directly with the quality of vowels but with the "quantity of their distinctive properties". In the case of Russian vowel reduction, stress has an influence on vowel quality; in order to capture a reverse cause-and-effect relationship, one merely has to make virtual length a weight factor rather than a stress exponent. Such proposals have already been made for SDS: recall the analysis of Kara by Blumenfeld (2006), for example (see Section 2.3.3). I aim to do the same for the Moksha language, which is well-known for its sonority-driven stress rule.

4 Moksha

Moksha is a Mordvinic language that belongs to the Uralic language family and is spoken in the Republic of Mordovia, a region located in the European part of Russia, as well as in some neighboring regions. It is well-known for its sonority-dependent stress pattern and has been mentioned in several SDS-related sources I have examined in the literature review in Section 2 (Kenstowicz 1997, Rasin 2018, Shih & de Lacy 2019).

In what follows, I will provide a list of my sources of data and a sketch of the phonology and grammar of Moksha (Section 4.1), as well as a summary of existing analyses of the Moksha stress pattern (Section 4.2). Section 4.3 contains my proposal for a quantitative reanalysis of this pattern.

4.1 Grammar and phonology sketch

The primary sources of data for the present study are the Moksha corpus (Arkhangelskiy 2019), Kukhto's (2018) chapter on Moksha phonology and Kozlov & Kozlov's (2018) chapter on morphophonology in Toldova & Kholodilova (2018). The other sources I consulted about the history and dialectal variations in prosody can be found in Section 4.2. 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.

4.1.1 Phonetics and phonology

As described by Kukhto (2018), the vowel inventory of Moksha comprises 7 phonemes (see Figure 4 below).

i		(ɨ)	u
e	(ɘ)	ə	o
ɛ		a	

Figure 4: Vowel inventory of Moksha.

The low-mid front vowel /ɛ/ is commonly represented as /ä/ in the literature on Mordvinic langauges. [ɨ] is an allophone of /i/ that occurs after non-palatalized vowels and [ɘ] is an allophone of schwa that comes after palatalized consonants (48).[13]

(48) *ksti* [ɨ] 'berry' – *kšt'i* [i] 'dance.CN'
mol'əms [ɘ] 'to go'

The mid vowels /e o/ do not occur outside the initial syllable in native words (Kukhto 2018: p. 30). Although Kukhto (2018) provides an example of /o/ in a non-initial syllable — *oc'o* — a dialectal variant of the word *oc'u* 'big' typical for the dialect at hand, I will assume that /o/-final bases are extremely rare to nonexistent in Moksha.[14]. Other than as a lowered variant of /u/, /o/ is not found word-finally — Ivanova (2006: pp. 73–74) does not provide any examples with final /o/.

Like /o/, /u/ does not occur in open monosyllables, although it can occur in any other part of the word of any length. (Ivanova 2006: p. 77), again, does not cite any open monosyllables containing /u/. This vowel can, however, appear in monosyllabic verbal bases like *mu-* 'find' or *tu-* 'leave'.

Since an important part of this thesis deals with hiatus resolution, I will clarify, which vowels can occur word-finally. In open monosyllables, we can observe the vowels /a ɛ e i u/, as exemplified in Table 6 below.

Final vowel	**Word**	**Translation**
/a/	*šna*	processed leather
/ɛ/	*pr'ɛ*	head
/e/	*pe*	end
/i/	*ši*	day
/u/	*mu-*	to find

Table 6: Examples of vowel-final monosyllables.

In polysyllabics, the final position can contain /a ɛ i u ə/ (Table 7), since the mid vowels /e o/ are restricted to the initial syllable, except the lowered /u/.

13. /l'/ corresponds to a palatalized /l/ (see the IPA correspondence table in the Appendix).
14. This is an instance of /u/ lowering to [o] in an unstressed final position (Ivanova 2006: p. 29)

Final vowel	Word	Translation
/a/	*ava*	woman
/ɛ/	*s'ijɛ*	silver
/ə/	*kizə*	year
/u/	*kelu*	birch
/i/	*cil'əd'i*	cricket

Table 7: Examples of vowel-final bases.

The consonant inventory, which is characterized by contrastive palatalisation and voicing, can be found in Figure 5 below. The unvoiced velar fricative /x/ only occurs in Russian and Tatar loanwords. The digraph /šč/ corresponds to /щ/ in the Cyrillic Moksha alphabet and is pronounced as a fricative [ʃʲː] ([ʃt͡ʃ]).

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 5: Consonant inventory of Moksha.

The sonorants /j r r' l l'/ have unvoiced counterparts /j̊ r̥ r̥' l̥ l̥'/, which appear before suffixes that trigger regressive devoicing; the contrast only exists in the internal coda position (Kukhto 2018: p. 24). For minimal pairs, see example (49) below.

(49) Minimal pairs for voiceless sonorants /j̊ r̥ r̥' l̥ l̥'/ (Kukhto 2018: p. 23)

/l, l̥/

kal-n'ə — kal̥-n'ə — 'fish-1SG.POSS.PL — fish-DEF.PL'

/l', l̥'/

vajgɛl'-n'ə — vajgɛl̥'-n'ə — 'voice-1SG.POSS.PL — voice-DEF.PL'

/r, r̥/

mar-n'ə — mar̥-n'ə — 'pile-1SG.POSS.PL — pile-DEF.PL'

/r’, r̥’/
s’t’ər’-n’ə — s’t’ər̥’-n’ə 'girl-1SG.POSS.PL — girl-DEF.PL'

/j, j̊/
kuj-n’ə — kuj̊-n’ə 'snake-1SG.POSS.PL — snake-DEF.PL'

The Moksha language allows remarkably heavy syllables (Kukhto 2018: p. 31). There can be up to three consonants in the final coda in non-derived words (50) and up to four consonants in one cluster at morpheme boundaries (51).

(50) Complex codas in non-derived words

CC: *počf*	'flour'
CC: *traks*	'cow'
CCC: *ir̥’ks*	'rib'

(51) Final clusters on morpheme boundaries

CCC: *kstiks-t*	'berry garden-PL'
CCCC: *ir̥’ks-t*	'rib-PL'
CCCC: *bratksc’*	'fraternize.PST.3SG'

Initial clusters range from zero (e.g. *od* 'new') to three consonants (52).

(52) Complex onsets

CC: *kši*	'bread'
CC: *ftal*	'back, behind'
CCC: *ksti*	'berry'

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, or, in words without heavy syllables, by the leftmost light one (53). I will continue to refer to the vowels that constitute the nuclei of heavy and light syllables as heavy and light vowels respectively.

(53) Moksha stress pattern (Kukhto 2018: p. 34)

Initial heavy		Shift to the leftmost heavy (3rd/4th)	
ˈt’ɛ.d’ɛ	'mother'	kucəmá	'ladder'
ˈz’e.pə	'pocket'	putəmá	'lay.NZR'
ˈkoč.kas’	'gather.PST[3SG]'	t’ijəmá	'do.NZR'
ˈsa.ta.də	'go.3PL'	udəftəmá	'sleep.CAUS.NZR'
ˈjal.ga	'friend'		
ˈmo.l’ə.ma	'go.NZR'		

Shift to the leftmost heavy (2nd)		Default initial	
ku.ˈva.ka	'long'	ˈki.jə	'who'
u.ˈfaj	'blow.3SG'	ˈku.du	'house.LAT'
ər’.ˈvɛ	'wife'	ˈtər.nə.s’əms	'tremble.FREQ.INF'
i.ˈl’ɛt’	'evening'		

The phonetic correlates of stress, as mentioned by Kukhto (2018) and as shown in the acoustic study of the Central dialect of Moksha by Aasmäe et al. (2013), are vowel duration and quality. Stressed vowels are longer and better differentiated in the vowel space. Despite centralization, there is no neutralization of quality oppositions in unstressed syllables. F0 contours, according to Aasmäe et al. (2013: p. 72), are shaped by sentence prosody rather than word-level stress.

The stress rule is synchronically non-productive: consider late Russian loanwords in example (54), which defy the rule of stressing the leftmost heavy syllable.

(54) Loanwords as exceptions to the stress rule (Kukhto 2018: p. 34)
ˈkruš.ka 'cup'
ˈkni.ga 'book'

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.[15]

4.1.2 Morphophonology and grammar

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 8.

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 8: Examples of vowel-initial suffixes.

Base-final schwa of some bases alternates with zero (55). Whether the alternation happens or not is not predictable from the phonological appearance of the base, although the alternation-prone bases do tend to end in /p, k, g, x, c, c', č/ (Kozlov & Kozlov 2018: p. 48).

15. The examples in (54) cited by Kukhto (2018) may not be completely valid, since unstressed /a/ in non-pretonic positions is reduced to [ə] in Russian. Hence, it is possible that Moksha speakers actually interpret those words as *kruškə* and *knigə*; in this case, initial stress would not be exceptional. An example that unequivocally demonstrates the exceptional status of Russian loanwords is *s'el'išči* — a part of the toponym *vad s'el'išči* (i).

(i) *s'el'išči* [sʲɪˈlʲiɕːɪ] 'settlement' (Rus.) — s'i.ˈl'i.šči (Moksha) [source]

This example only contains light vowels and violates the Moksha stress rule: stress falls on the second light syllable instead of the leftmost one.

(55) Base-final schwa-zero alternations (Kozlov & Kozlov 2018: p. 48)

Disappearing schwa		Stable schwa	
z'epə	'pocket'	*stolbə*	'pillar'
z'ep-t	'pocket-PL'	*stolbə-t*	'pillar-PL'
z'epə-ška	'pocket-EQU'	*stolbə-ška*	'pillar'

As shown in example (56), the alternating schwa remains word-finally as well as before the equative suffix *škə* but disappears in other cases, e.g. before consonant-initial suffixes. Schwa in the suffixes is lost in hiatus with a full vowel (56).

(56) Schwa-zero alternations in suffixes (Kozlov & Kozlov 2018: p. 40)

Suffix-initial schwa		Suffix-final schwa	
mastər-ən'	'land-GEN'	*vir'-sə*	'forest-IN'
ava-n'	'woman-GEN'	*vir'-s-an*	'forest-IN-1SG'

The brief description of Moksha I have given so far pertains to the Central dialect. For a fuller picture of the phenomenon of sonority-driven stress, I will now review the historical development and dialectal variation of this pattern.

4.2 History and dialectal variation of Moksha SDS

Sonority-driven stress in Moksha is as old as the protolanguage of the Mordvinic subgroup, which comprises Moksha itself and the closely related Erzya language (Ivanova 2006: p. 48). In Proto-Mordvinic, the Proto-Uralic stress rule of initial primary stress changed to the contemporary Moksha pattern under what Ivanova (2006) considers to be Turkic influence.

The sonority-dependent stress pattern has been observed by many researchers who described and studied the Moksha language (Paasonen 1903, Lipatov 1969, Devaev 1963, 1975, Azrapkin 1966, Lomakina 1966). For a review of descriptive work, I refer the reader to Chapter 2 of the book by Aasmäe et al. (2013). I will outline the dialectal variation concerning the stress pattern.

Moksha stress is word-initial but it shifts from high (/u i/) and reduced (/ə/) vowels in initial syllables to the low ones (/a ɛ/) in non-initial syllables. While this pattern in found consistently in the South-Eastern and Central dialects, one South-Western dialect described by Devaev (1963, 1975) and Zirnask (2007), stress cannot shift to an open syllable with a low vowel, which normally does happen (57).

(57) Stress pattern in the Central and the South-Western dialects of Moksha (Aasmäe et al. 2013: p. 30)

Central: $CV_{[-high]} > CV_{[+high]}C$		South-Western: $CV_{[+high]}C > CV_{[-high]}$	
kud.ˈn'ɛ	'house.DIM'	ˈkud.n'e	'house.DIM'
tun.ˈda	'spring'	ˈtun.da	'spring'

An acoustic investigation by Zirnask (2007) of the Middle Vad dialect, which belongs to the South-Western group and has a divergent stress pattern sensitive to syllable structure, confirms the descriptions of Devaev (1963, 1975). Based on vowel duration, which Zirnask (2007) shows to be a correlate of stress, high and reduced vowels in initial closed syllables are almost as long as the vowels in the second syllables of disyllabic words (Zirnask 2007: pp. 39–40); compare the vowel duration ratios in $CuC.CV_{[-high]}/CəC.CV_{[-high]}$ and Ci.Cu (Table 9).

Word	V1/V2 duration ratio (2 speakers)	
	phrase-final	sentence-final
jalga 'friend'	1.37, 1.57	1.55, 1.56
viju 'strong' vid'u 'watery'	1.12, 1.43	1.36, 1.28
kutne 'these houses' kutce 'your house'	0.87, 1.06	1.09, 0.85
kərga 'cucumber'	1.01, 1.07	1.11, 0.92

Table 9: Vowel duration measurements in Middle Vad Moksha (Zirnask 2007: pp. 39–40).

Since in CV.CV words (e.g. *viju* 'strong') or in words with non-high non-reduced vowels (*jalga* 'friend') the V1/V2 duration ratio is approximately 15–50% greater than 1, a smaller ratio in $CuC.CV_{[-high]}/CəC.CV_{[-high]}$ words like *kutce* 'your house' suggests that stress is on the initial syllable.[16]

Vowel duration is the most prominent stress correlate for Moksha in general (Devaev & Cygankin 1970, Devaev 1975, Zirnask 2007, Aasmäe et al. 2013); stress is easy to perceive, compared, for example, to Erzya (Aasmäe et al. 2013: pp. 32–33). Despite shorter duration, there is no qualitative reduction in unstressed syllables, except for the South-Eastern (Insar) dialect described by Kabaeva (2014) and Čudaeva (1963).

Reduction of /u i/ to schwa in unstressed positions is a feature of the South-Eastern dialects and, to some extent, of some subgroups of central dialects (Levina 2015). In South-Eastern Moksha, high vowels in initial syllables are reduced to schwa (Table 10).

Central	South-Eastern	Translation
tumən'ɛ	təmən'e	'oak-DIM'
kudn'ɛ	kədn'e	'house-DIM'
numəln'ɛ	nəməln'e	'hare-DIM'
pikskɛ	pəkske	'rope-DIM'

Table 10: Reduction in South-Eastern Moksha, compared with the Central dialect (Kabaeva 2014: p. 41).

16. An example of a $Cu.CV_{[-high]}$ word, where stress is supposed to fall on V2 and the ratio is expected to be greater, would be really illustrative, however, Zirnask (2007) does not provide one.

There is further variability in which contexts allow vowel reduction: in the dialect of the Adashevo village, high vowels are preserved in initial syllables immediately preceding a syllable with a low vowel (Table 11; Kabaeva 2014).

Central, Adashevo	Translation
učá	'sheep'
urmá	'sickness'
urádəms	'kick the bucket'
is'ák	'yesterday'
il'ánas	'linen'
in'd'ž'á	'bug'

Table 11: Reduction in the Adashevo village dialect, compared with the Central dialect (Kabaeva 2014: p. 41).

In a derived environment, i.e. in a monosyllabic verbal base with a high vowel followed by a suffix containing a low vowel, reduction does occur (Table 12).

No stress shift		**Stress shift in a derived environment**		
Central, Adashevo	**Translation**	**Central**	**Adashevo**	**Translation**
údəms	'to sleep'	ud-án	əd-án	'sleep-1SG'
účəms	'to wait'	uč-án	əč-án	'wait-1SG'
íd'əms	'to save'	id'ə-sák	əd'ə-sák	'save-2SG>3SG'

Table 12: Reduction in the Adashevo village dialect in derived environments (Kabaeva 2014: p. 41).

In another South-Eastern dialect of Moksha — Old Pshenevo dialect — reduction targets any environment of the shape $CV_{[+high]}CV_{[+low]}$, regardless of whether it is derived or nor (Table 13; Čudaeva 1963).

Central, Adashevo	Old Pshenevo	Translation
učá	əčá	'sheep'
urmá	ərmá	'sickness'
urádəms	ərádəms	'kick the bucket'

Table 13: Reduction in the Old Pshenevo village dialect, compared with the Central and Adashevo village dialects (Kabaeva 2014: p. 41).

The dialect I focus my thesis on is the Central dialect, which is also the basis for the literary standard of Moksha. The prosody of the Central dialect has been studied acoustically by Aasmäe et al. (2013). Duration has been confirmed as a stress correlate (Aasmäe et al. 2013: p. 46). When it comes to sonority sensitivity, the intrinsic duration of high and low vowels has been found to diverge significantly: low vowels are longer in monosyllables than the high ones (Table 14).[17]

Vowel	Mean duration, ms		CV stimulus		CVC stimulus	
	phrase-final	sentence-final	word	translation	word	translation
/a/	156.8	165.9	va	'you see'	vaj	'butter'
/i/	124.1	135.7	ši	'day'	šit'	'in the day-time'

Table 14: Durations of /i/ and /a/ in monosyllables, Central Moksha (Aasmäe et al. 2013).

This means that it is possible for a stressed high vowel to be approximately as long as an unstressed low vowel. Aasmäe et al. (2013) illustrate this with the word *s'ijɛ* 'silver' that they found to have two variants — with initial and peninitial stress. When stress shifts to the second syllable, the duration of the second vowel is much greater, but if it does not, the vowel durations are almost equal (Table 15).

Word	Translation	Duration of /i/, ms	Duration of /ɛ/, ms	V1/V2 ratio
ˈsi.jɛ	'silver'	114.5	120.5	0.95
si.ˈjɛ		101.4	172.0	0.59

Table 15: Phrase-final vowel durations in *sijɛ* 'silver' with variable stress (Aasmäe et al. 2013: p. 41).

I take the acoustic and dialectal data presented above to constitute ancillary evidence for the analysis I suggest, if it fits the patterns found in other dialects with minimal adjustment. I do not, however, believe the duration data to be crucial to back up my analysis, since the length distinctions it relies on are *virtual*.

4.3 Moksha stress with virtual length

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

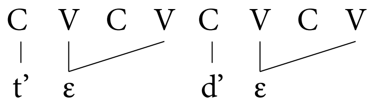
I claim that the heavy vowels /a o ɛ e/ and the stressed light vowels /u i ə/ are long; in Strict CV terms, they are associated to two V-slots. The stress falls on the leftmost long vowel, and where there are no long vowels, the initial syllable is stressed and its vowel is lengthened (58).

(58) **Moksha stress rule**
Stress the leftmost syllable with a long vowel; in the absence of long vowels, stress the initial vowel and lengthen it.

17. The measurements of CV and CVC stimuli are averaged together for both /a/ and /i/, that is, Aasmäe et al. (2013) do not provide data on the discrepancy between, for instance, *va* and *vaj* in terms of vowel duration. However, CV monosyllables across the board have slightly longer vowels than the CVC(C) ones (154.0 ms vs. 141.5 ms phrase-finally; Aasmäe et al. 2013: p. 43)

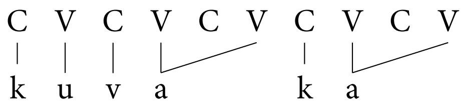
For this rule to work, all non-high peripheral vowels (/a o ɛ e/) will be represented as long. Below are several illustrations showing vowel quality as bipositionality. In *t'ɛd'ɛ* 'mother', for example, both vowels are heavy, that is, bipositional, and the leftmost one is stressed (59).

(59) ˈt'ɛ.d'ɛ 'mother'



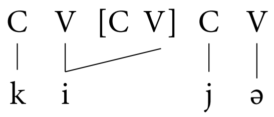
In *kuvaka* 'long', however, the first syllable contains a light vowel /u/, whereas the other two syllables have long vowels as nuclei. The /u/ in the initial syllable remains unstressed and hence phonologically short. The leftmost heavy vowel, which is in the second syllable, receives the stress (60).

(60) ku.ˈva.ka 'long'



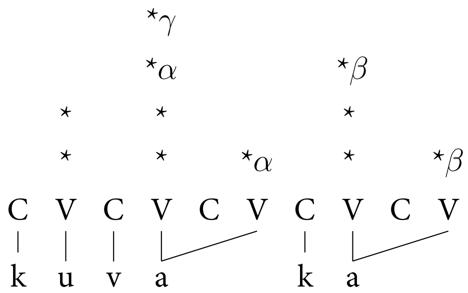
Finally, if there are no heavy vowels in the word, like in *kijə* 'who', the stress falls on the initial syllable. Since the vowel in the first syllable is light, it is lengthened by means of an inserted syllabic unit, put in square brackets in example (61).

(61) ˈki.jə 'who'

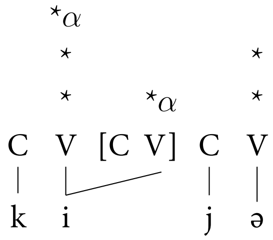


The stress rule I propose for Moksha is easy to formalize with Strict CV Metrics, as I did for a similar rule in Selkup in Section 3.4.2. Filled nuclei project to level 2; empty nuclei that belong to long vowels project to level 1. Stress falls on the leftmost vowel that projects to level 3, meaning that a stressed vowel has to incorporate an empty nucleus (62). So, if stress falls on a short vowel, which by itself can only reach L2, a CV unit is inserted in order to lengthen it (63).

(62) Stress the leftmost vowel reaching L3
kuvaka [ku'vaka] 'long'



(63) Lengthen stressed short vowels *kijə* ['kijə] 'who'



All in all, I contend that Moksha sonority-driven stress is actually a quantity-sensitive process. In order to corroborate the validity of such a reanalysis, I will demonstrate that virtual length helps predict the choice of hiatus resolution strategy.

5 Hiatus resolution and virtual length

I proceed to describe another part of Moksha morphophonology — suffixation and hiatus resolution on morpheme boundaries. After I lay out the data in detail in Section 5.1, I will provide a formal analysis in Section 5.2 that links these patterns to my proposal for Moksha stress (see Section 4.3).

5.1 Hiatus resolution

The Moksha language does not tolerate vowel hiatus (Kukhto 2018: p. 32). Since many bases end in vowels, and since there are a lot of vowel-initial suffixes, Moksha employs several different hiatus resolution strategies. I proceed to describe the facts, one suffix type at a time.

5.1.1 Schwa-initial suffixes

The first type is schwa-initial suffixes, some of which are shown in example (64).

(64) Examples of /ə/-initial suffixes

-ən' 'GEN/PST.1SG'	*-əms* 'INF'
-ən'd'i 'DAT'	*-əl'* 'IPF'

Suffix-initial schwa invariably appears after base-final consonants (65).

(65) /ə/-initial suffixes after C#

mastər-ən' 'land-GEN'
ruz-ən' 'Russian-GEN'
štraf-ən'd'i 'fine-DAT'

In hiatus with schwa or with non-high peripheral vowels (/a o e ɛ/), the suffixal schwa is deleted (66). In a /ə-ə/ hiatus, only one schwa survives; it does not matter on a descriptive level, whether it belongs to the base or to the suffix.

(66) Schwa deletion

pe + ən' → pe-n' 'end-GEN'
at'ɛ + ən' → at'ɛ-n' 'end-GEN'
ava + əl' → ava-l' '(3SG was a) woman-IPF'
kizə + ən' → kizə-n' 'year-GEN'

With high base-final vowels, the strategy is different — the schwa is not deleted. There is a rule that is described by Kozlov & Kozlov (2018) as a glide formation occurring after bases ending in /u/ or /i/ before vowel-initial suffixes. This can be characterized as a process of homorganic glide epenthesis: /v/ is inserted after /u/ and /j/ is inserted after /i/ (67).

(67) Homorganic glide formation (Kozlov & Kozlov 2018: p. 42)

jožu + əl' → jožuv-əl' '(3SG was) smart-IPF'
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/ (see Section 5.1.3 on glide-vowel alternations in suffixes). A curious proviso to the glide formation rule is that no epenthesis happens with monosyllabic bases (68).

(68) *ši + ən' → ši-n'* 'day-GEN'
mu + əms → mu-ms 'find-INF'
vi + əms → vi-ms 'bring-INF'

The behavior of glides in between /u i/ and suffixal schwa is summarized in Table 16 below. A# corresponds to the non-high vowels /a e ɛ/.

	C#	A#	u#	i#
monosyllabic	*ən'*	*n'*	*n'*	*n'*
polysyllabic	*ən'*	*n'*	*vən'*	*jən'*

Table 16: Suffix *ən'* 'GEN' with different kinds of bases.

All monosyllabic bases exhibit the same behavior — 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 homorganic glide formation 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 (69). 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'.

(69) *žuri* + *ən'* → *žuri-n'* 'jury-GEN'
soči + *ən'* → *soči-n'* 'Sochi-GEN'
li + *ən'* → *li-n'* 'Li-GEN' (online fieldwork)

Historically, high vowels in the first syllable came from the Proto-Uralic vowels *a, *ä, *e, *ē, *i, *ĭ/*ü, *ī, *ü, *o, mostly from the heightening of *e (Ivanova 2006: p. 53), whereas final high vowels in monosyllabics are only found in words that are originally morphologically complex, i.e. those vowels are suffixal (Ivanova, Žebratkina & Išaeva 2015: p. 15). This is evidenced by the appearance of their reflexes in the Erzya language (70).

(70) Final high vowels in Moksha correspond to vowel-glide sequences in Erzya (Aasmäe et al. 2013: p. 18)
M. *kelu* — E. *kil'ej* 'birch'
M. *kulu* — E. *kulov* 'ash'
M. *mac'i* — E. *mac'ej* 'goose'
M. *il'i* — E. *il'ej* 'rod'

In Erzya, the final high vowels of Moksha correspond to vowel-glide sequences. As Ivanova (2006: pp. 137–143) writes, these sequences merged into single vowels in Moksha but were preserved in Erzya. We have observed that in Moksha, these glides surface before vowel-initial suffixes.

5.1.2 /a/-initial suffixes

The only non-high peripheral vowel found in suffix-initial position is /a/, which, for example, occurs in the agreement markers *-an* '1SG' and *-at* '2SG'. These suffixes can appear on both verbal and nominal predicates (Kholodilova 2018, Toldova 2018). After base-final consonants, *-an*/*-at* always surface with a vowel (71).

(71) *-an*/*-at* after C# bases

van-an	'see-1SG'	*mašt-an*	'be able-1SG'
mɛr'g-at	'say-2SG'	*ruz-at*	'Russian-2SG'

After the vowels /a ɛ/, the surface realization depends on the syllable count of the base: with monosyllables, the hiatus in broken up with the glide /j/ (72), whereas with polysyllabics, the vowels of the base and the suffix coalesce to produce just one /a/ (73). The latter phenomenon is referred to by Kozlov & Kozlov (2018) as */a/-coalescence*.

(72) /j/-insertion in the /Ca_a/ context
sa + an → sajan ‘(I) come-1SG’
šna + an → šnajan ‘(I) praise-1SG’

(73) /j/-insertion in the /Ca_a/ context
jaka + at → jakat ‘(you) go-2SG’
at’ɛ + an → at’an ‘(I am an) old man-1SG’

Suffixes that begin with /a/ cause homorganic glide formation when attached to /u i/-final polysyllabic bases, as shown in examples (74). The vowels /u i/ are always unstressed in this environment, since they are followed by /a/ in the suffix.

(74) *jožu + an → jožuvan* ‘(I am) smart-1SG’
vidi + an → vidijan ‘(I am) a sower-1SG’

In monosyllabics ending in /u i/, however, /j/ is inserted at all times, similarly to /a ɛ/-final monosyllabics (75).

(75) *mu + an → mujan* ‘(I) find-1SG’
li + an → lijan ‘(I) fly-1SG’

The pattern is summarized in Table 17.

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

Table 17: Suffix *an* ‘NPST.1SG’ with different kinds of bases.

With /a/-initial suffixes, monosyllables once again behave similarly: final schwa disappears before them; /j/ is inserted both after the high vowels /u i/ and after non-high /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 formation.

5.1.3 Suffixes with high vowels

There are several suffixes in Moksha that start with a high vowel, for instance, *-i/j* ‘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, the lative case marker having an additional variant that appears after palatalized consonants. The distribution of these variants is similar: the glide comes after vowels, the vowel — after consonants; see example (76).

(76) Vowel-glide alternations (Kozlov & Kozlov 2018: p. 52)

-i/j ‘3SG’ *jaka-j* ‘go-3SG’
šam-i ‘empty-3SG’

	magazin-u	'shop-LAT'
-u/v/i 'LAT'	*vir'-i*	'forest-LAT'
	lavka-v	'shop-LAT'

The examples in (76) illustrate another hiatus avoidance strategy in Moksha, which is utilized with suffixes whose initial vowels alternate with consonants: they surface as homorganic glides.

5.1.4 Summary

To summarize the behavior 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 (77–79). First, hiatus resolution can involve vowel deletion (see example (77) below).

(77) Vowel deletion in hiatus

a. Full vowel coalescence:
/ɛ+a/ → /a/
at'ɛ + an → at'a-n '(I am) old man-1SG'
/a+a/ → /a/
ava + an → ava-n '(I am) woman-1SG'

b. Schwa deletion next to heavy vowels:
/ə+a/ → /a/
vir'-sə + an → vir'-s-an 'forest-IN-1SG' (Kozlov & Kozlov 2018: p. 40)
/a+ə/ → /a/
ava + ən' → ava-n' '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 in polysyllabics form a hiatus, it is avoided by deleting one of them: in an /aa/ sequence, just one vowel /a/ remains; /ɛa/ sequences coalesce into /a/ (77a). Vowel deletion in hiatus targets schwa whenever it is next to a heavy vowel or a stressed light one (77b–77c).

When suffixes starting with high vowels occur after vowel-final bases, they appear as homorganic glides (78).

(78) Vowel-glide alternation:
/a+i/ → /aj/
jaka + i → jaka-j 'go-3SG'
/a+u/ → /av/
lavka + u → lavka-v 'shop-LAT'

Another group of strategies involving glide formation comes in two types (79).

(79) a. Homorganic glide formation (polysyllabic bases only):
/uə/ → /uvə/
kelu + *ən* → *keluv-ən'* 'birch-GEN'
/iə/ → /ijə/
t'ɛči + *ən'* → *t'ɛčij-ən'* 'today-GEN'

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

First, homorganic glide formation targets polysyllabic bases that end with /u/ or /i/ and makes a glide appear in the middle of the hiatus (79a). 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 formation is not homorganic: it always involves /j/ and is restricted to monosyllabic bases (79b). It can take place only before the heavy vowel /a/.

I argue that the rules underpinning schwa deletion and homorganic glide formation come from the virtual length-dependent stress pattern: /u/ and /i/ can only spread when unstressed, due to a ban on ternary branching (Chekayri & Scheer 2004, Enguehard 2018, Faust & Ulfsbjorninn 2018, Balogné Bérces & Ulfsbjorninn 2023). Heavy vowels and stressed light vowels fall into the same natural class for schwa deletion because they are both long in the phonology. Since the surface realization 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.

5.2 Hiatus resolution is conditioned by stress

Let me explore the three hiatus resolution strategies of Moksha one by one: schwa deletion (Section 5.2.1), /a/-coalescence (Section 5.2.2), vowel-glide alternations (Section 5.2.3) and, finally, (non-)homorganic glide formation (Section 5.2.4).

5.2.1 Schwa deletion

Schwa is deleted in hiatus with any vowels that are phonologically long, i.e. heavy and light stressed vowels. The only exception is a hiatus of two schwas, both of which are short. The virtual length analysis of stress provides a natural class to the rule of schwa deletion: compare the rule with (80) and without the virtual length analysis of stress (81).

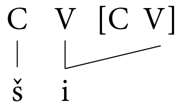
(80) **Schwa deletion rule (first attempt)**
ə ⟶ Ø / {a, ɛ, e, ə}_
ə ⟶ Ø / {u, i}_ (one σ)
ə elsewhere

(81) **Schwa deletion rule (revised with virtual length)**
ə ⟶ Ø / VV_
ə ⟶ Ø / ə_ or _ə (equivalent)
ə elsewhere

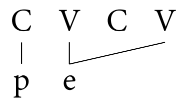
Unless stressed high vowels are long together with the non-high peripheral vowels, the rule has to explicitly refer to vowel quality, as well as to syllable count. However, as soon as virtual length is introduced into the analysis, the rule becomes simple: schwa is deleted in hiatus with long vowels and schwa.

As shown in examples (82–84), both final light vowels, like in *ši* 'day', and final heavy vowels, like in *pe* 'end' and *ava* 'woman', are phonologically long.[18]

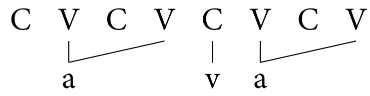
(82) *ši* [ˈši] 'day'



(83) *pe* [ˈpe] 'end'



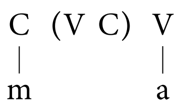
(84) *ava* [ˈava] 'woman'



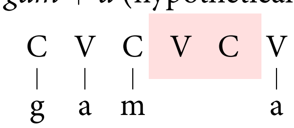
I suggest that the schwa disappears after long vowels due to VC deletion — a process that reduces empty VC sequences and has been introduced within Government Phonology by Vergnaud (1982) and Gussmann & Kaye (1993). VC deletion is common in Strict CV literature and is employed in analyses of various phenomena where some phonological interaction crosses a morpheme or word boundary (Faust, Lampitelli & Ulfsbjorninn 2018, Faust 2018, Beausoleil & Newell 2022, Ulfsbjorninn 2022a, Faust 2023b).

The motivation behind VC deletion is as follows. Word-internally, empty VCs do not occur. Although it is fully possible, they would make little sense for the surface realization: it does not matter for the output of the derivation, whether two filled slots are separated by two empty ones (85; optional VC in parentheses). So, empty VC sequences do not appear in underlying representations for the sake of fewer entities posited. On the boundary, however, an empty VC can easily be formed via juxtaposition of a consonant-final prefix and a vowel-initial suffix (86; empty VC shaded).

(85) Word-internally: VC or no VC
ma (hypothetical word)



(86) VC appears at the boundary
gam + *a* (hypothetical word form)



If something happens at C#V boundaries that would also happen, were the empty V- and C-slots not there, the empty VC is erased. Note that in the original definition of VC deletion (87), the empty onsets following empty nuclei are regarded as *pointless* — they are reduced, because the grammar does not care if they are there.

(87) Reduction (Gussmann & Kaye (1993: p. 433); emphasis mine)
An empty nucleus followed by a *pointless* onset are removed from any phonological representation in which they occur.

18. CV units in square parentheses are provided by stress.

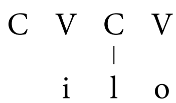
For an illustration of how VC deletion is applied, consider an example from Italian, where the definite article has three allomorphs in the masculine gender: *il*, *lo*, and *l* (88).

(88) Italian definite articule, masculine (Larsen 1998: pp. 93–94, Maiden & Robustelli 2007: p. 34)

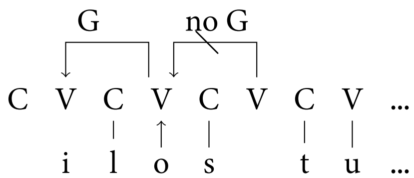
il allomorph		*lo* allomorph		*l* allomorph	
il parko	'the park'	*lo studio*	'the study'	*l'asino* [lazino]	'the donkey'
il libro	'the book'	*lo sbaglio*	'the error'	*l'infermiere*	'male nurse'
il sole	'the sun'	*lo sporco*	'the dirty (one)'	*l'uomo*	'man'

Larsen (1998) has proposed a single representation (89) from which both allomorphs can be derived based on which of its vocalic slots are governed. With a word that starts with an sC cluster, like *studio* 'study', where the empty V-slot trapped inside a cluster is unable to govern, *lo* will surface (90), since floating vowels only associate to ungoverned slots.[19] Similarly, if there is no initial cluster in the word, like in *sole* 'sun', then its first V-slot can govern, /o/ will not associate, but /i/ will (91).

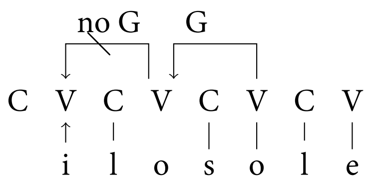
(89) Representation of *il/lo* (Larsen 1998, Faust, Lampitelli & Ulfsbjorninn 2018)



(90) *lo studio* 'the study' (after Larsen 1998: p. 99)



(91) *il sole* 'the sun' (after Larsen 1998: p. 99)

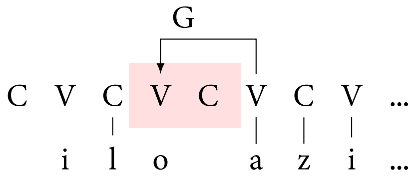


So, the definite article *il/lo* can have a unified underlying representation, where the two vowels /i, o/ are floating but only one is eventually associated. Faust, Lampitelli & Ulfsbjorninn (2018) take this proposal further by deriving all surface realizations of the definite article from a single representation, not only the masculine. Also, they discuss one corner case that Larsen (1998) does not address: with vowel-initial masculine nouns, the definite article appears as *l* (92).

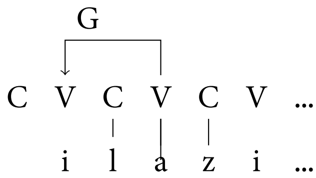
19. On the conditions on association of floating segments and vowel-zero alternations in Strict CV, see Scheer (1997, 2005), Ziková (2009), Scheer & Ziková (2010).

(92) *l'asino* 'the donkey' (Faust, Lampitelli & Ulfsbjorninn 2018: p. 11)

a. Stage 1: [ilazino]



b. Stage 2: [lazino]

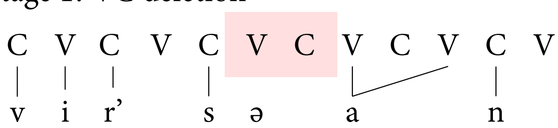


In Strict CV, all vowel-initial words begin with an empty onset; therefore, upon combining *<i>l<o>* and *azino* 'donkey', we would expect the unattested form **il azino*, based on just the government relations (92a). In order to rule this out, Faust, Lampitelli & Ulfsbjorninn (2018) suggest that with vowel-initial words, the empty VC sequence shaded in example (92a) is deleted. After that, the filled slot containing /a/ in *azino* can govern the slot with the floating /i/, thus deriving the correct surface form.

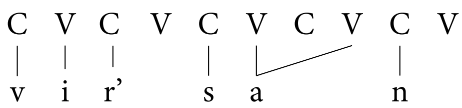
In the case of Moksha, VC deletion occurs when a long vowel is next to a schwa. Since schwas alternate with zero, both in hiatus and elsewhere (see Section 4.1.1), I assume that schwas are underlyingly floating. Hence, in the /ə-a/ sequence, there is an empty VC, which is reduced (93a). What remains is just the /a/ of the suffix (93b).

(93) *vir'sə* + *an* 'forest.IN-1SG'

a. Stage 1: VC deletion

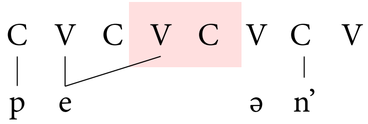


b. Stage 2: /ə/ not associated

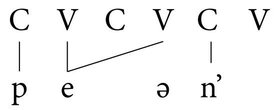


When a long vowel is followed by a schwa, the empty VC contains the second V-slot occupied by the long vowel and the initial empty onset of the suffix (94). When those are deleted, the long vowel remains, spreading to the V-slot of the suffix, to which the schwa can no longer be associated (95).

(94) *pe* + *ən’* (stage 1: VC deletion)

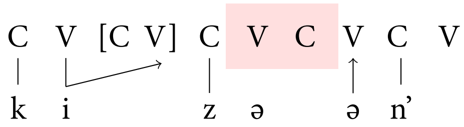


(95) *pe* + *ən’* (stage 2: /ə/ not associated)



Schwa deletion also happens in the /ə-ə/ hiatus, which the rule in example (80) does not resolve, since schwa is a short vowel and cannot be lengthened in the hiatus-initial position, since it is never found in monosyllables. However, VC deletion helps avoid /ə-ə/ hiatus as well: since both are floating and the empty VC at the base-suffix boundary is deleted, the remaining space is taken up by one of the schwas (96).

(96) *kizə* + *ən’* → *kizən’* ‘year.GEN’



So, VC deletion manages the disappearance of schwas after long vowels as well as other schwas. These contexts are united by the presence of a final empty V, which belongs to a long vowel or a floating schwa, and an initial “pointless” onset in the suffix.

5.2.2 /a/-coalescence

The context for /a/-coalescence is the hiatus of two long vowels, where the first one is in a non-initial syllable. While the initial syllable containing /a ɛ/ would always be stressed, I will show that /a/-coalescence cannot be stress-conditioned.

Let us tentatively suppose that /a/-coalescence only targets unstressed vowels. Final heavy vowels in polysyllabics can be stressed if all preceding syllables are light, like in example (97).

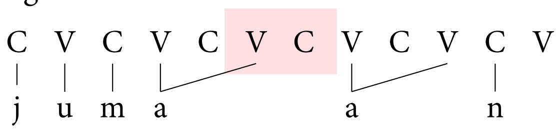
(97) *juma* + *an* → *jumán*
‘get lost-1SG’

In *juma-n* ‘get lost-1SG’, the final /a/ is stressed, since the initial syllable contains a light vowel /u/. Still, the /a/ of the suffix is deleted. I propose that /a/-coalescence is the default hiatus avoidance strategy that is chosen whenever glide formation is unavailable. In the more specific contexts, such as after a spreadable short vowel or a CV monosyllable, different strategies are at work (see Section 5.2.3).

Like the disappearance of schwas next to long vowels, /a/-coalescence can be handled by VC deletion. One of the contexts for schwa deletion that I mentioned — long vowel plus the empty onset of the suffix — is exactly what we find in the /a-a/ hiatus. Therefore. if VC deletion occurs in an /a-ə/ sequence, it should also work in the contexts for /a/-coalescence.

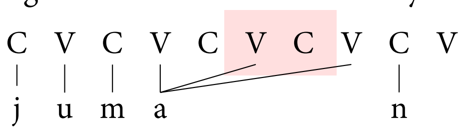
The derivation proceeds as follows: first, the VC at the boundary is erased (98).

(98) *juma + an* 'get lost-1sg'
Stage 1: VC deletion

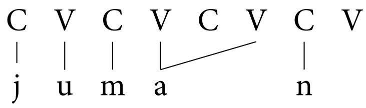


The result contains the segment /a/ associated to three V-slots in a row (99). Such a configuration is illicit due to violation of the Obligatory Contour Principle (OCP; McCarthy 1986: p. 208), which prohibits adjacent identical elements on the melodic tier.[20] Another VC is subsequently deleted, producing the final form shown in example (100).

(99) *juma + an* 'get lost-1sg'
Stage 2: OCP violation rescued by another VC reduction



(100) *juma + an* 'get lost-1sg'
Final result



Thus, even though schwa deletion and /a/-coalescence happen in different contexts, they are driven by the same process — empty VC deletion.

5.2.3 Vowel-glide alternations

The analysis of the suffixes that alternate between a vowel and a glide is simple: which skeletal slot, consonantal or vocalic, is taken by the suffix, determines its appearance. It also matters very little whether the underlying representation of the suffix is a vowel or a glide — for example, the suffix *i/j* '3sg' can consist of an element |I|, which is interpreted as /i/ in V-slots and as /j/ in C-slots. The representation is shown in example (101).

(101) Representation for the 3sg suffix *i/j*

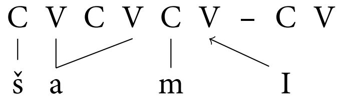
C V

I

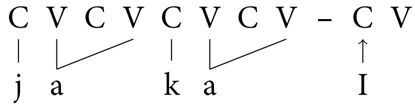
Below are the derivations of *šam-i* 'empty-3sg' (102) and *jaka-j* 'go-3sg' (103).

20. Since /a/-coalescence also applies to /ɛ-a/ sequences, I assume that /a/ and /ɛ/ share enough features to incur an OCP violation when associated to three slots in a row.

(102) *šam* + I → *šam-i* 'empty-3sg'



(103) *jaka* + I → *jaka-j* 'go-3sg'



The element of the suffix is floating and seeks to attach to the leftmost available position.[21] If the final vocalic position of the base is free, it is taken up by the suffix and it appears as the vowel /i/ (102). Otherwise, it has to associate the C-slot its own syllabic unit (103).

I now move on to another hiatus resolution strategy, which is the homorganic glide formation.

5.2.4 Glides in hiatus

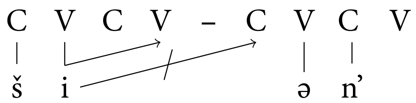
The virtual length analysis of stress is very pertinent to some hiatus resolution patterns. The vowels that can spread to produce homorganic epenthetic glides — both /u/ and /i/ — are light in the stress assignment algorithm. At the end of a polysyllabic word, where homorganic glide formation happens, a light vowel is always short, since it cannot be stressed. Schwa — another light vowel — does not produce a glide; rather, it is deleted.

As mentioned in the discussion of schwa deletion, the assumption that both stressed light vowels and heavy vowels are long makes those vowels that *do not* participate in the glide formation into a natural class: all final low vowels and stressed high vowels (i.e. base-final in monosyllables) share the property of being bipositional.

Only the short high vowels can spread. Long vowels are unable to 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, is widely attested (Chekayri & Scheer 2004, Enguehard 2018, Faust & Ulfsbjorninn 2018, Balogné Bérces & Ulfsbjorninn 2023; see also Shachmon & Faust (2023) for a counterexample Palestinian Arabic).

The mechanism of glide formation 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 (104) 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' (105).

(104) *ši* + *ən'* → *šin'* [šin']



21. I suppose that the search of an association site in Moksha proceeds fron left to right, meaning that the leftmost available slot will be taken; for a similar line of analysis, see, for instance, Ulfsbjorninn (2022).

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

```
C  V  C  V  C  V  –  C  V  C  V
|  |_____/   |  |_____>   |  |
t' ɛ         č  i         ə  n'
```

While base-final schwas uniformly disappear in hiatus with /a/ or /ə/, base-final high vowels spread to form homorganic glides. The exception to this pattern are monosyllables: after all monosyllabic bases, including those where the high vowel is unstressed and should be able to spread (106).

(106) All monosyllables are targets for /j/-insertion before /a/

ˈšnajan	'(I) praise-1SG'
muˈjan	'(I) find-1SG'
liˈjan	'fly-1SG'

I contend that the /j/ inserted after monosyllables has nothing to do with spreading or length. First, the glide /j/ is not homorganic, since it appears after /u/ as well, like in *mujan* 'find-1SG' (106). Next, it is inserted both after short vowels (unstressed /u i/ in monosyllables) and after the long ones (/a ɛ/ in monosyllables).

So, the generalization that best approximates the data about /j/ insertion is that it targets monosyllables. 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.[22] 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* 'old man-1SG'.

When it comes to high vowels, it is more difficult to explain why word minimality prevents spreading. Under the analysis I put forward, the expected outcome in the /i_#a/ and /u_#a/ contexts is homorganic glide formation: the /i, u/ are always unstressed in those contexts 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 expected derivation in example 107). Still, in *mujan* 'find.2SG', there is a non-homorganic /j/.

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

```
C  V  –  C  V  C  V  C  V
|  |_____>   |_____/  |
m  u         a        n
```

In order to account for the behavior of /a/-initial suffixes, I suggest that all vowel-final monosyllables with an /a/-initial suffix are a context for the insertion of /j/. Monosyllables with short high vowels are also a context for spreading; nevertheless, /j/-insertion takes precedence. I proceed to describe the order of the rules I have proposed.

22. For an example of another morphophonological process that does not target monosyllables, see Becker, Clemens & Nevins (2017) on the irregular *-al/aux* plurals in French, which are dispreferred in monosyllables due to the loss of the only vowel in the base.

5.2.5 Rule ordering

First, let me lay out the precedence relations that have to hold between rules in order for the analysis to converge on the correct outputs.

The outputs are summarized in Tables 18–19, where capitalization indicates length and /a/ stands for all non-high peripheral vowels found in any particular position.[23]

Monosyllables	**non-high peripheral**	**high**
non-high peripheral	a_a /j/-insertion	{u, i}_a /j/-insertion
high	a_u, a_i vowel-glide	{U, I}_{u, i} vowel-glide
central	a_ə VC deletion	{U, I}_ə VC deletion

Table 18: Hiatus resolution pattern in monosyllables.

Polysyllabics	**non-high peripheral**	**high**	**central**
non-high peripheral	a_a VC deletion	{u, i}_a homorganic glide	ə_a VC deletion
high	a_{u, i} vowel-glide	{u, i}_{u, i} vowel-glide	ə_{u, i} vowel-glide
central	a_ə VC deletion	{u, i}_ə homorganic glide	ə_ə VC deletion

Table 19: Hiatus resolution pattern in polysyllabic bases.

The insertion of /j/ has to precede the formation of homorganic glides, as discussed in the previous section. Also, /j/-insertion and vowel-glide alternations must apply before VC-deletion, since the boundary between a long vowel and a vowel-initial suffix contains an empty VC. Should VC deletion apply first in these contexts, it would bleed the aforementioned rules, which it does not. Finally, vowel-glide alternations must precede homorganic glide epenthesis, since in /u-u/, /i-i/, /i-u/ and /u-i/ hiatuses, the second vowel becomes a glide and no spreading of the first vowel occurs (108).[24]

23. Tables 18–19 are color-coded: /j/-insertion is marked with purple, vowel-glide alternations are marked with pink, homorganic glides are shaded with orange and all cases of VC deletion are shaded with green.
24. No data can be found on how /i/ manifests outside of monosyllabic bases, since there are no polysyllabic /i/-final verbal bases, so verbal suffixes cannot be tested (the agreement marker *-i/j* '3SG', the active participle suffix *i/j* 'PTCP.ACT' or the multiplicative *-ijə* 'MULT. In the nominal domain, the attributive markers *i/j, u/v* 'ATTR' cannot be used, since bases ending in high vowels are already produced by attributivization historically (see Section 4.2).'

(108) Hiatus of two high vowels

/u-u/ ⟶ /uv/
baku-v 'Baku-LAT'

/u-i/ ⟶ /uj/
mu-j 'find-3SG'
tu-j 'leave-PTCP'

/i-u/ ⟶ /iv/
soc'i-v 'Sochi-LAT'
tonaši-v 'underworld-LAT'

/i-i/ ⟶ /ij/
mi-j 'sell-3SG'

From the precedence relations gathered in example (55), I conclude that the rule ordering is as shown in Table 20.

(109) Precedence relations between rules
/j/-insertion ≫ homorganic glides
vowel-glide ≫ homorganic glides
/j/-insertion ≫ VC deletion
vowel-glide ≫ VC deletion

Order	Rule	Context
i.	/j/-insertion	(V)V_VV (one σ)
ii.	vowel-glide	(V)V_V$_{[+\text{high}]}$
iii.	homorganic glides	V_V(V)
iv.	VC deletion	VV_VV, ə_VV, VV_ə

Table 20: Rule ordering for hiatus resolution.

For example derivations, see Table 21.
The rules do not refer to vowel quality except for when spreading ability is concerned: high vowels can spread, the central vowel /ə/ cannot. Apart from that, the contexts are defined by the syllable count of the base (monosyllabic vs. polysyllabic) and vowel length.

6 Discussion

While my analysis of Moksha stress and hiatus resolution answers some questions, it leaves a number of other questions open. I have shown how to model quality-dependent stress without explicit reference to sonority, which is in line with the recent skepticism around SDS (see Section 2.3.2 for literature review), and how it helps explain the distribution of hiatus resolution strategies. Still, I have not discussed the dialectal variation in light of some insights from my analysis, which I will do in Section 6.1.

Also, the power of my argument from hiatus resolution for reanalyzing Moksha SDS with virtual length rests on the assumption that hiatus is avoided by using rules (e.g. glide formation) rather than by retrieving fixed forms stored in the lexicon. Given that the rule of glide formation is not extendable to recent borrowings, I feel the need to address the

Item / rule	**/j/-ins.**	**vowel-glide**	**hom. glides**	**VC del.**
sa + an VV_VV (one σ)	**sájan**	–	–	–
mu + an V_VV (one σ)	**muján**	–	–	–
škola + u VV_V[+high]	škólau	**škólav**	–	–
sóči + u V_V[+high]	sóčiu	**sóčiv**	–	–
kelu + ən' V[+high]_V	kéluən'	kéluən'	**kéluvən'**	–
jóžu + an V[+high]_VV	jóžuan	jóžuan	**jóžuvan**	–
áva + ən' VV_V	ávaən'	ávaən'	ávaən'	**ávan'**
tu + əms VV_V	túəms	túəms	túəms	**túms**
juma + an VV_VV	jumáan	jumáan	jumáan	**jumán**
kízə + ən' V_V	kízəən'	kízəən'	kízəən'	**kízən'**

Table 21: Example derivations: *sájan* 'go.1SG', *muján* 'find.1SG', *škólav* 'school.LAT', *sóčiv* 'Sochi.LAT', *kéluvən'* 'birch.GEN', *jóžuvan* 'smart.1SG', *ávan'* 'woman.GEN', *túms* 'do.INF', *jumán* 'get lost.1SG', *kízən'* 'year.GEN'.

issue of its alleged non-productivity using the Tolerance Principle (Yang 2016) in Section 6.2.

6.1 Accounting for the dialectal variation

The stress pattern is not uniform across the dialects of Moksha (see Section 4.2 for a survey of the data). The two deviations from the stress rule of Central Moksha that I would like to draw attention to are the following: (a) vowel reduction in the initial unstressed syllable (South-Eastern Moksha, Čudaeva 1963, Kabaeva 2014); (b) absence of stress shift from closed syllables with light vowels to open syllables with heavy vowels (South-Western Moksha, Devaev 1963, 1975, Zirnask 2007).

6.1.1 Vowel (non-)reduction

Unstressed vowel reduction in Moksha comes in two types: one neutralizes all unstressed high vowels in the initial syllable to schwa (Old Pshenevo dialect) and the other only neutralizes those vowels from which stress has shifted away in the course of the derivation (Adashevo dialect; see Table 22 for examples).

Central	Adashevo	Old Pshenevo	Translation
	Derived environment		
id’			‘child’
id’n’ɛ́z’ɛ	əd’n’éz’e		‘child.DIM.POSS.1SG’
údəms			‘sleep.INF’
udán	ədán		‘sleep.1SG’
	Non-derived environment		
urmá		ərmá	‘sickness’
učá		əčá	‘sheep’

Table 22: High vowel reduction in Old Pshenevo and Adashevo dialects, compared to Central Moksha.

What follows is a speculation and a program for an empirical study inspired by my research on Central Moksha rather than a robust analysis of vowel reduction in South-Eastern dialects.

The difference between the two reduction patterns — Old Pshenevo and Adashevo — is that the latter is sensitive to derived environments: either all unstressed high vowels in the first syllable are reduced, or they can only be reduced after stress has been assigned to a different vowel.

For the Adashevo dialect, where reduction is restricted to derived environments, I assume the underlying length distinction in vowels and the CV unit as the stress exponent, similarly to what I have proposed for Central Moksha. Reduction to schwa is the result of shortening of unstressed vowels, that is, all short vowels are pronounced as schwas.

Whether or not reduction implies actual loss of contrastive features may be seen, for example, by checking if reduction bleeds homorganic glide formation. If, for example, final reduced high vowels cannot spread, acting instead like schwas, reduction would have to involve feature loss — there would be nothing to spread. The word *jožu* 'smart' with a vowel-initial suffix would then look like *jožə + an ⟶ jožan* 'smart.1sg' in South-Eastern Moksha. If reduction implies merely phonetically interpreting all short vowels as schwas, then we expect spreading to occur: *jožə + an ⟶ jožəvan* 'smart.1sg'.

Let me return to the question of why non-derived contexts can be exempt from reduction. I suggest that this non-reduction should be relegated to exceptional lexical marking; reduction then is the norm rather than the exception. This is corroborated by the fact that /o/ is occasionally reduced as well (110) and that reduction has been observed to target recent loanwords from Russian (111). The reduction rule is actively extendable.

(110) Reduction of /o/ in Adashevo Moksha (Kabaeva 2014: p. 42)

kostə ∼ kəstə	'when'
kosə ∼ kəsə	'where'

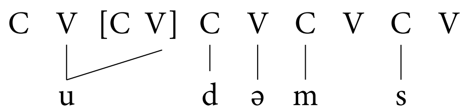
(111) Russian loanwords in Adashevo Moksha (Kabaeva 2014: pp. 41–42)

[kʊˈma] (Rus.) ⟶ kəmá	'godmother to one's child'
[rʲɪˈsˈpublʲɪkə] (Rus.) ⟶ r'əspúbl'əka	'republic'
[ˈɕːukə] (Rus. ščúka) ⟶ ščəká	'pike (fish)'
[tʲɪlʲɪˈfon] (Rus.) ⟶ t'əl'əfón	'telephone'

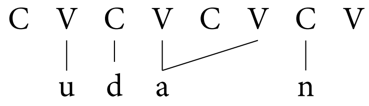
The difference between non-derived non-reduction and derived reduction, I suppose, is in the underlying representations: high vowels in initial pretonic syllables that resist reduction are underlyingly long. Given that stress falls on the leftmost heavy vowel, this would mean that in words like *uča* 'sheep' or *urma* 'sickness' the initial syllable would be stressed. As Aasmäe et al. (2013) have shown for the Central dialect, stressed high vowels can be shorter than unstressed non-high ones, which may influence the perception of stress in such words: it is possible for a stressed initial vowel to be perceived as unstressed. An acoustic study is in order to discover whether it is true for the Adashevo dialect; my hypothesis is that /u, i/ may actually be stressed in pretonic initial positions.

Reduction in derived environments, I suppose, is a more general process, where short vowels are neutralized to schwa. In the Adashevo dialect, a certain number of words then would have underlyingly long high vowels, which never become short; in other words, however, high vowels would have to receive stress, i.e. an additional skeletal slot, in order to keep their [+high] quality (see examples 112–113).

(112) Adashevo dialect: stressed high vowel is not reduced
udəms ['u.dəms] 'sleep.inf' /uː/ ⟷ [u]



(113) Adashevo dialect: reduced high vowel
udan [ə.ˈdan] ‘sleep.1SG’ /u/ ⟷ [ə]



In the Old Pshenevo dialect, however, no high vowels would be marked as long, leaving them completely at the mercy of the stress algorithm: they would surface as high only when stressed and reduced elsewhere.

While I am unable at the moment to definitively prove or disprove my conjectures about South-Eastern Moksha, the virtual length analysis of stress extended to this dialect is a fertile ground for future work. I have formed hypotheses about the lexical exceptionality of words with pretonic leftmost high vowels, as well as about the hiatus resolution rules.

6.1.2 Quantity and quality in syllable weight

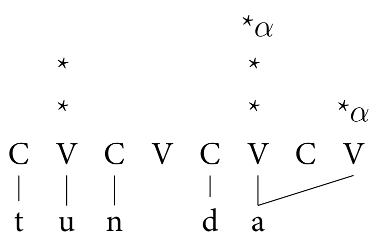
South-Western Moksha is of even greater interest in the discussion about SDS reanalyzed in terms of vowel quantity. In this dialect, codas contribute to syllable weight: a closed syllable with a high vowel can keep the stress, even though there is a heavy vowel in an open syllable on the right (see example (57) repeated in example (114) below).

(114) Stress pattern in the Central and the South-Western dialects of Moksha (Aasmäe et al. 2013: p. 30)

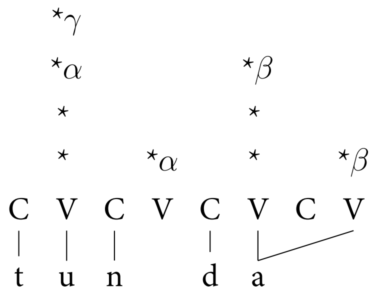
Central: $CV_{[-high]} > CV_{[+high]}C$		South-Western: $CV_{[+high]}C > CV_{[-high]}$	
kud.ˈn’ɛ	‘house.DIM’	ˈkud.n’e	‘house.DIM’
tun.ˈda	‘spring’	ˈtun.da	‘spring’

If light vowels are assumed to be short, as opposed to heavy vowels, which are long, the stress rule of the South-Western dialect is just one parameter away from Central Moksha: we merely have to add Weight-by-Position, that is, make codas metrically relevant. In Strict CV terms, this would mean that post-coda empty Vs project and are incorporated. This way, CVC syllables (i.e. closed syllables with light vowels) are equal in prominence to CVV syllables (open syllables with heavy vowels), so the leftmost one wins and stress does not shift to a heavy vowel. The difference between Central and South-Western Moksha can be seen in examples (115–116) respectively.

(115) Central: $CV_{[-high]} > CV_{[+high]}C$
Syllable with a non-high (long) vowel wins
tun.ˈda ‘spring’



(116) South-Western: $CV_{[+\text{high}]}C > CV_{[-\text{high}]}$
Tie resolved in favor of the leftmost heavy syllable
'tun.da 'spring'



The virtual length analysis of stress renders such dialectal differences quite expected: if the stress algorithm in fact tracks vowel quantity rather than quality, other quantitative factors like codas may be integrated naturally into the system.

I turn to the concern about the productivity of the glide formation rule, which I seek to dissolve by applying the Tolerance Principle.

6.2 Threshold for productivity: the Tolerance Principle

The Tolerance Principle as formulated by Yang (2016) provides a ceiling for the number of exceptions that a rule can tolerate (117).

(117) Tolerance Principle (Yang 2016: p. 64)
Let R be a rule applicable to N items, of which e are exceptions. R is productive if and only if $e \leq \theta_N$ where $\theta_N := \frac{N}{\ln N}$

The formula for θ follows from the Elsewhere Condition, also known as the Pāṇini principle, which states that the general productive "elsewhere" rule applies last, after exceptions are processed by more specific rules (Halle 1997, Halle & Marantz 1993, Kiparsky 1973, Anderson 1969). The results of applying any rule (plural formation, past tense, hiatus resolution, etc.) can be instantiated in the mind of the speaker either as a productive rule with a list of exceptions or as a list of arbitrary pairs of forms. Since exceptions are processed first, there is a cost to having a productive rule: in order to apply it, one has to traverse the list of exceptions.

If regular forms vastly outnumber exceptions, this cost is low: on average, going through a few exceptions is more time-effective than keeping all form pairs in a gigantic list. When exceptions become more numerous, however, there is a tipping point when the rule ceases to be productive. Tolerance Principle locates this tipping point at $\frac{N}{\ln N}$ exceptions maximum, where N is a number of contexts for the application of the rule.

Tolerance Principle, as Yang (2016) suggests, guides language acquisition — it is utilized as a criterion for the establishment of productive rules. I will use it as a criterion as well in order to show that the homorganic glide formation rule, despite not being extendable to recent loanwords, is likely still learned as a rule and not as a list of matching forms.

Vowel hiatus resolution in Moksha, in my analysis, is resolved by homorganic glide formation after polysyllabic bases ending in high vowels (118).

(118) Homorganic glide formation rule in Moksha

$$\mathrm{V}\begin{bmatrix}+\text{short}\\+\text{high}\\\alpha\text{back}\end{bmatrix} \rightarrow \mathrm{V}\begin{bmatrix}+\text{short}\\+\text{high}\\\alpha\text{back}\end{bmatrix}\mathrm{C}\begin{bmatrix}\alpha\text{back}\end{bmatrix} / \_\mathrm{V}\begin{bmatrix}-\text{high}\end{bmatrix}$$

This rule does not apply to recent loanwords: instead, we can observe vowel deletion (119), which is a more general rule in the rule ordering that I have proposed (see Table 20).[25] Some proper names like *mosku* 'Moscow' have been assimilated into the language and therefore sometimes conform to the glide formation rule (119).

(119) Proper names and loanwords are sometimes exceptional

Recent loanwords
t'el'ešóu + ən' ⟶ t'el'ešóun' 'TV show.GEN'
zómbi + ən' ⟶ zómbin' 'zombie-GEN' (online fieldwork)

Non-assimilated proper names
sóči + ən' ⟶ sóčin' 'Sochi.GEN'
číli + ən' ⟶ čílin' 'Chili.GEN'
tol'játt'i + ən' ⟶ tol'játt'in' 'Togliatti.GEN'

Assimilated proper name
mosku + ən' ⟶ moskuvən' ∼ moskun' 'Moscow.GEN'

I support my analysis of Moksha stress by modelling glide formation as vowel spreading. If, however, this rule turns out to be too expensive to maintain, that is, if the number of borrowed exceptions reaches the tipping point provided by Tolerance Principle, this argument will be untenable — I would no longer be able to suppose that glide formation is a rule. There is one way to check: count the words that can serve as input to the alleged rule, mark exceptions among them, calculate θ and compare it to the exception count.

The methodology I employ is far from perfect. First, there is no corpus of child-directed Moksha available, meaning that my estimate of input received by a Moksha learner will be based on literature, newspaper texts and, in the case of the social media corpus of Moksha, social media posts. Next, the number of loanwords in the corpus will inevitably be very conservative, compared to the present day situation where Moksha speakers likely interact very often with their primary contact language — Russian. Nevertheless, I take corpus data to be the best approximation available. On the bright side, a dictionary of words occurring in a corpus is closer to the real-life usage than a regular full dictionary.

6.2.1 Data sources and preprocessing

I use the Moksha corpus (Arkhangelskiy 2019), which has two subcorpora: (a) a corpus of literary Moksha containing 1.74 million tokens; (b) a corpus of Moksha social media posts with 14 000 tokens in Moksha and 166 000 tokens in Russian. For both of them,

25. In corpora or descriptions, I was unable to find examples featuring /a/-initial suffixes. The behavior of schwa-initial suffixes, however, is enough to demonstrate that the homorganic glide formation rule is not applicable to loanwords.

there is a full dictionary available with Russian translations, part-of-speech (POS) tags and frequencies.

I have downloaded the dictionaries and preprocessed them with rules that determined if a word is a proper name or borrowed and also marked words that the glide formation rule applies to.[26] Loanword/proper name status was granted if a word matched its Russian translation or was capitalized in the dictionary. Glide formation rule reacted to syllable count greater than one and to the final segment of the base. Words were additionally filtered by POS: only nouns and verbs were left.[27]

Cyrillic orthography of Moksha is a hindrance to such automatic dictionary processing, since schwa can be spelled as either *a, o* or *e*; also, borrowings occasionally have altered spelling (e.g. *международнай* from Russian *международный* 'international', *равноправия* from *равноправие* 'equality'), so it is not always correct to flag loanwords by matching them with their translations. These issues, however, do not bear too heavily on the recall of loanword recognition *among candidates for glide formation*: final /u, i/ are faithful to the original Russian spelling and syllable count can be calculated correctly regardless. In other words, we will not miss any loanwords that are contexts for the glide formation rule.

Loanwords were manually annotated in order to filter out words with final stress, which are not actually exceptions to the rule: stress lengthens the vowel, so it does not spread. This is true for native monosyllables (see Section 5.1.1), so it should be true for borrowings with final stressed /u, i/.

6.2.2 Results

The total number of extracted candidates, the tipping point and the number of exceptions are presented in Table 23.

Corpus	total	loanwords	exceptions	theta	productive
Literary Moksha corpus	218	52	38	40	$38 < 39$; yes
Moksha social media corpus	67	4	4	15	$4 < 15$; yes

Table 23: Exception counts in two corpora of Moksha confirm the productivity of the glide formation rule.

The results support my case: judging by the corpus data, the rule is productive. Notably, the number of exceptions is well below the threshold for the social media corpus, where extended use of loanwords is more expected, given the recency and the informal nature of the entries.

These results are not conclusive. Rather, my guess is that the hiatus resolution rule is on its way towards non-productivity. As more borrowed exceptions enter the language, it is plausible that they will overwhelm the native vocabulary and cause the rule to collapse.

26. Source code is available at https://github.com/thddbptnsndshs/tolerance_principle_moksha

27. Although native adjectives can be inflected with vowel-initial suffixes too, I left them out in an effort to stack the odds against my favor: adjectives borrowed from Russian are consonant-final, so the rule under examination would not apply to them anyway. The proportion of native words to which the rule applies would rise, should I include the adjectives, thus weakening the probability that the rule will be deemed unproductive.

At the moment, however, I assume I can maintain that in the Moksha language, there exists a rule of homorganic glide formation.

7 Conclusion

Sonority-dependent patterns have lately been subject to reevaluation, both empirical and theoretical (Blumenfeld 2006, Shih 2016, Shih & de Lacy 2019, Rasin 2018); I have taken up a theoretical examintaion of sonority-driven stress in the Moksha language. I have presented a novel argument for a reanalysis of Central Moksha stress with virtual length. I suggest that the stress algorithm does not distinguish between vowels of greater and lesser sonority but rather between long and short vowels. No segmental features participate in stress placement. The generalization that stress is unable to track segmental features is built into the framework I use for my formal analysis — Strict CV phonology (Lowenstamm 1996, Scheer 2004, 2012).

Virtual length manifests in another part of Moksha phonology — hiatus resolution. The assumption that the vowels treated as light in stress assignment are underlyingly short and lengthened by stress provides a natural class for schwa deletion in hiatus. Also, short high vowels are correctly predicted to form homorganic glides by spreading, as opposed to stressed high vowels that are unable to spread.

I have reviewed data from other Moksha dialects and suggested how my analysis can be extended to them with minimal modifications. Finally, I have demonstrated with corpus data and the Tolerance Principle (Yang 2016) that the rule I partially base my claim upon — homorganic glide formation — is productive, despite not applying to recent loanwords.

Appendix

IPA correspondence table for Moksha practical transcription

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’
ɬ̪	l̥
ɬ̪ʲ	l̥’
l̪	l
lʲ	l’
i	i
u	u
e	e
ə	ə
o	o
ɛ	ɛ
a	a

StressTyp2 query

The query lists all weight factor options that mention a particular vowel or a quality feature.

```
( stress bearing unit is '6' )
OR ( stress bearing unit is 'laxV' )
OR ( stress bearing unit is 'i' )
OR ( stress bearing unit is 'tenseV' )
OR ( stress bearing unit is 'highV' )
OR ( stress bearing unit is 'reducedV' )
OR ( stress bearing unit is 'non-highV' )
OR ( stress bearing unit is 'reducedVC' )
OR ( stress bearing unit is 'iN' )
OR ( stress bearing unit is 'fullV' )
```

List of glossing abbreviations

1 first person
2 second person
3 third person
ABL ablative
ACC accusative
ACT active voice
ATTR attributive
CAUS causative
CN connegative
DAT dative
DEF definite
DIM diminutive
EQU equative
F feminine
FREQ frequentative
GEN genitive
IN inessive case
INCL inclusive
INE inessive
INF infinitive
IPF imperfective
LAT lative case
LOC locative
M masculine
MULT multiplicative
NFIN non-finite
NPST non-past
NZR nominalizer
PF perfective
PL plural
POSS possessive
PST past
PTCP participle
SG singular

References

Aasmäe, Niina, Pärtel Lippus, Karl Pajusalu, Nele Salveste, Tatjana Zirnask & Viitso Tiit-Rein. 2013. *Moksha prosody*. Helsinki: Société Finno-Ougrienne.

Anderson, Stephen Robert. 1969. *West Scandinavian vowel systems and the ordering of phonological rules*. MIT dissertation.

Arkhangelskiy, Timofey. 2019. Corpora of social media in minority Uralic languages. In Tommi A. Pirinen, Heiki-Jaan Kaalep & Francis M. Tyers (eds.), *Proceedings of the 5th Workshop on Computational Linguistics for Uralic Languages*, 125–140. Tartu, Estonia: Association for Computational Linguistics.

Azrapkin, Ju. I. 1966. Kolopinskij govor mokša-mordovskogo jazyka [Kolopin dialect of the Moksha Mordvin language]. *Očerki mordovskix dialektov* 4. 251–280.

Balogné Bérces, Katalin & Shanti Ulfsbjorninn. 2023. Prevocalic Tenseness in English, Binarity and the Typology of Long Vowel Distributions. In Florian Breit, Yuko Yoshida & Connor Youngberg (eds.), *Elements, Government, and Licensing: Developments in phonology*, 77–88. London: UCL Press.

Beausoleil, Marie-Michèle & Heather Newell. 2022. Laurentian French Affrication in External Sandhi: The Facts, and a CVCV Analysis. In Noah Elkins, Bruce Hayes, Jinyoung Jo & Jian-Leat Siah (eds.), *Proceedings of the Annual Meetings on Phonology*. Washington, DC: Linguistic Society of America.

Becker, Michael, Lauren Eby Clemens & Andrew Nevins. 2017. Generalization of French and Portuguese plural alternations and initial syllable protection. *Natural Language & Linguistic Theory* 35(2). 299–345.

Beel, Rachel & Jennifer Felder. 2013. Phonological Adaptations of English Loanwords in Turkish. In *Proceedings of the Big South Undergraduate Research Symposium, High Point University*.

Ben Si Saïd, Samir. 2011. The interaction between structure and melody: The case of Kabyle nouns. In Kamila Dębowska-Kozłowska & Katarzyna Dziubalska-Kołaczyk (eds.), *On Words and Sounds: A Selection of Papers from the 40th PLM, 2009*, 37–48. Newcastle upon Tyne: Cambridge Scholars Publishing.

Blumenfeld, Lev. 2006. *Constraints on phonological interactions*. Stanford University dissertation.

Cardona, George. 1965. *A Gujarati reference grammar*. Philadelphia: The University of Pennsylvania Press.

Chekayri, Abdellah & Tobias Scheer. 2004. The appearance of glides in Classical Arabic defective verbs. *Folia Orientalia* (40). 7–33.

Crosswhite, Catherine M. 2000. Vowel reduction in Russian: A unified account of standard, dialectal, and 'dissimilative' patterns. In Catherine M. Crosswhite & Joyce McDonough (eds.), *University of Rochester Working Papers in the Language Sciences*, 107–171. Rochester, NY: University of Rochester.

Crowhurst, Megan J & Lev Michael. 2005. Iterative footing and prominence-driven stress in Nanti (Kampa). *Language* (81). 47–95.

Čudaeva, O. I. 1963. Staro-pšenevskij govor mokša-mordovskogo jazyka [Old Pshenevo dialect of the Moksha Mordvin language]. *Očerki mordovskix dialektov* 3. 27–48.

de Lacy, Paul. 2002. *The formal expression of markedness*. University of Massachusetts, Amherst dissertation.

de Lacy, Paul. 2004. Markedness conflation in Optimality Theory. *Phonology* 21(2). 145–199.

de Lacy, Paul. 2006. *Markedness: Reduction and preservation in phonology*. Cambridge University Press.

Devaev, S. Z. 1963. Sredne-vadskij dialekt mokša-mordovskogo jazyka [Middle Vad dialect of the Moksha Mordvin language]. *Očerki mordovskix dialektov* 2. 261–432.

Devaev, S. Z. 1975. Slovesnoe udarenie v mokša-mordovskom jazyke [Word stress in the Moksha Mordvin language]. *Congressus Tertius Internationalis Fenno-Ugristarum, 17.-23.VIII.1970. Pars I* 8. 481–483.

Devaev, S. Z. & D. V. Cygankin. 1970. *Fonetika mordovskix (èrzjanskogo i mokšanskogo) literaturnyx jazykov [Phonetics of Mordvin languages (Erzya and Moksha)]*. Saransk: Mordovskij gosudarstvennyj pedagogičeskij institut.
Doctor, Raimond. 2004. *A grammar of Gujarati*. Munich: Lincom.
Enguehard, Guillaume. 2014. Consonant Alternations, Weight Constraint and Stress in Southern Saami. In Eugeniusz Cyran & Jolanta Szpyra-Kozłowska (eds.), *Crossing phonetics-phonology lines*, 47–62. Newcastle upon Tyne: Cambridge Scholars Publishing.
Enguehard, Guillaume. 2015. Stress as a morphological edge. In Kate Bellamy, Elena Karvovskaya, Martin Kohlberger & George Saad (eds.), *Proceedings of console xxiii*, 472–492. Leiden: Leiden University Centre for Linguistics.
Enguehard, Guillaume. 2018. Strict CV without government. *Acta Linguistica Academica* 65(1). 29–45.
Faust, Noam. 2018. Bi-Morphemic Virtual Length in Yiddish. *Studia Linguistica* 72(3). 608–624.
Faust, Noam. 2021. The /aa/ moment in Modern Hebrew. In Gabi Danon (ed.), *Proceedings of IATL 35 (MITWPL 92)*, 43–58.
Faust, Noam. 2023a. Metrically-conditioned syncope in Strict CV metrics. *Glossa: a journal of general linguistics* 8(1). 1–29. https://doi.org/https://doi.org/10.16995/glossa.8764.
Faust, Noam. 2023b. The pronominal system of Saint-Pierre-le-Bost. *Isogloss. Open Journal of Romance Linguistics* 9(1). 1–16.
Faust, Noam, Nicola Lampitelli & Shanti Ulfsbjorninn. 2018. Articles of Italian unite! Italian definite articles without allomorphy. *Canadian Journal of Linguistics/Revue canadienne de linguistique* 63(3). 359–385.
Faust, Noam & Shanti Ulfsbjorninn. 2018. Arabic stress in Strict CV, with no moras, no syllables, no feet and no extrametricality. *The Linguistic Review* 35(4). 561–600.
Giavazzi, Maria. 2010. *The phonetics of metrical prominence and its consequences on segmental phonology*. MIT dissertation.
Goedemans, Rob, Jeffrey Heinz & Harry van der Hulst (eds.). 2014. *StressTyp2*. http://st2.ullet.net/?.
Goedemans, Rob & Harry van der Hulst. 2013. Weight factors in weight-sensitive stress systems (v2020.3). In Matthew S. Dryer & Martin Haspelmath (eds.), *The World Atlas of Language Structures Online*. Zenodo. https://doi.org/10.5281/zenodo.7385533.
Gussmann, Edmund & Jonathan Kaye. 1993. Polish notes from a Dubrovnik Café: I. The yers. *SOAS Working Papers in Linguistics and Phonetics* 3. 427–462.
Halle, Morris. 1997. Distributed morphology: Impoverishment and fission. *MIT Working Papers in Linguistics* 30. 425–449.
Halle, Morris & Alec Marantz. 1993. Distributed morphology and the pieces of inflection. In Kenneth Hale & Samuel Jay Keyser (eds.), *The view from Building 20: Essays in linguistics in honor of Sylvain Bromberger*, 111–176. Cambridge, MA: MIT Press.
Halle, Morris & Jean-Roger Vergnaud. 1987. Stress and the cycle. *Linguistic Inquiry* 18(1). 45–84.
Hayes, Bruce. 1989. Compensatory lengthening in moraic phonology. *Linguistic Inquiry* (20). 253–306.

Hayes, Bruce. 1995. *Metrical stress theory: Principles and case studies*. Chicago: University of Chicago Press.

Helimski, Eugene. 1998. Nganasan. In Daniel Abondolo (ed.), *The Uralic languages*, 480–515. London & New York: Routledge.

Herrfurth, Hans. 1964. *Lehrbuch des modernen Djawanisch*. Leipzig: Veb Verlag Enzyklopädie.

Iosad, Pavel. 2012. Vowel reduction in Russian: No phonetics in phonology. *Journal of linguistics* 48(3). 521–571.

Ivanova, Galina Sofronovna. 2006. *Sistema glasnyx v dialektax mokšanskogo jazyka v istoričeskom osveščenii [Moksha vowel system in the historical perspective]*. Saransk: Izdatel'stvovo Mordovskogo universiteta.

Ivanova, Galina Sofronovna, Irina Jakovlevna Žebratkina & Larisa Vasil'evna Išaeva. 2015. Distribucija glasnyx ne pervogo sloga v central'nom dialekte mokša-mordovskogo jazyka [Distribution of vowels in the initial syllable in the Central dialect of Moksha Mordvin]. *Finno-ugorskij mir* 4(25). 13–17.

Kabaeva, Nadežda Fëdorovna. 2014. Akcentuacija i redukcija glasnyx v dialektax mokšanskogo jazyka (na primere jugo-vostočnogo dialekta) [Accentuation and vowel reduction in Moksha dialects (on the example of the Eastern dialect)]. *Finno-ugorskij mir* 2(19). 40–42.

Kaksin, Andrej Danilovič. 2010. *Kazymskij dialekt xantyjskogo jazyka [The Kazym dialect of the Khanty language]*. Xanty-Mansijsk: Yugra State University.

Kaye, Jonathan, Jean Lowenstamm & Jean-Roger Vergnaud. 1985. The internal structure of phonological elements: a theory of charm and government. *Phonology* 2(1). 305–328.

Kaye, Jonathan, Jean Lowenstamm & Jean-Roger Vergnaud. 1990. Constituent structure and government in phonology. *Phonology* 7. 193–231.

Kenstowicz, Michael. 1997. Quality-sensitive stress. *Rivista di Linguistica* (9). 157–188.

Kholodilova, Maria. 2018. Imennaja predikacija [Nominal predication]. In Svetlana Toldova & Maria Kholodilova (eds.), *Èlementy mokšanskogo jazyka v tipologičeskom osveščenii [Elements of the Moksha language in a typological perspective]*, chap. 23, 616–632. Moscow: Buki Vedi.

Kholodilova, Maria & Jurij Borisovič Korjakov. 2018. Obščie svedenija o mokšanskom jazyke i issleduemom govore [General information on the Moksha language and the dialect under investigation]. In Svetlana Toldova & Maria Kholodilova (eds.), *Èlementy mokšanskogo jazyka v tipologičeskom osveščenii [Elements of the Moksha language in a typological perspective]*, chap. 2, 6–17. Moscow: Buki Vedi.

Kiparsky, Paul. 1973. Elsewhere in phonology. In Stephen Robert Anderson & Paul Kiparsky (eds.), *A festschrift for Morris Halle*, 93–106. New York: Holt, Rinehart & Winston.

Kozlov, Alexei & Lev Kozlov. 2018. Morfonologija [Morphophonology]. In Svetlana Toldova & Maria Kholodilova (eds.), *Èlementy mokšanskogo jazyka v tipologičeskom osveščenii [Elements of the Moksha language in a typological perspective]*, chap. 4, 38–62. Buki Vedi.

Krueger, John Richard. 1961. *Chuvash manual. Introduction, grammar, reader, and vocabulary*. Indiana University.

Kukhto, Anton. 2018. Fonologija [Phonology]. In Svetlana Toldova & Maria Kholodilova (eds.), *Èlementy mokšanskogo jazyka v tipologičeskom osveščenii [Elements of the Moksha language in a typological perspective]*, chap. 3, 19–37. Moscow: Buki Vedi.

Kuznecova, Ariadna Ivanovna, Ol'ga Anatol'evna Kazakevič, Evgenij Arnol'dovič Helimski & Elena Vladimirovna Grushkina. 2002. *Sel'kupskij jazyk: Učebnoe posobie dlja pedagogičeskix kolledžei i vysšix učebnyx zavedenij [Selkup language: a college textbook].* Saint Petersburg: Prosveščenie.

Larsen, Bergeton Uffe. 1998. Vowel length, Raddoppiamento Sintattico and the selection of the definite article in Italian. *Langues et grammaire II-III, phonologie*. 87–102.

Levina, Marija Zaxarovna. 2015. Iz istorii klassifikacii dialektov mokšanskogo jazyka [From the history of Moksha dialects]. *Finno-ugorskij mir* 3(24). 24–35.

Lipatov, S. I. 1969. Nekotorye fonetičeskie osobennosti ryb-kinsko-mamolaevskix govorov mokša-mordovskogo jazyka [Some features of the phonetics of Rybkin-Mamolaevo dialects of Moksha-Mordvin]. *Sovetskoe finno-ugrovedenie* 3(5). 175–183.

Lomakina, T. I. 1966. Gorodiščenskij dialekt mokša-mordovskogo jazyka [Gorodišči dialect of the Moksha Mordvin language]. *Očerki mordovskix dialektov* 4. 289–329.

Lowenstamm, Jean. 1991. Vocalic length and centralization in two branches of Semitic (Ethiopic and Arabic). In Alan S. Kaye (ed.), *Semitic Studies in honor of Wolf Leslau on the occasion of his eighty-fifth birthday*, 949–965. Wiesbaden: Harrassowitz.

Lowenstamm, Jean. 1996. CV as the only syllable type. In Jacques Durand & Bernard Laks (eds.), *Current trends in phonology, models and methods*, vol. 2, 419–443. Salford: European Studies Research Institute.

Lowenstamm, Jean. 2011. The phonological pattern of phi-features in the perfective paradigm of Moroccan Arabic. *Brill's Journal of Afroasiatic Languages and Linguistics* 3(1). 140–201.

Maiden, Martin & Cecilia Robustelli. 2007. *A reference grammar of modern Italian*. Abingdon & New York: Routledge.

Markus, Elena Borisovna & Fëdor Ivanovič Rožanskij. 2017. Sovremennyj vodskij jazyk: Teksty i grammatičeskij očerk [Modern Votic: grammar and texts].

McCarthy, John Joseph. 1986. OCP effects: Gemination and antigemination. *Linguistic Inquiry* 17(2). 207–263.

McCollum, Adam. 2019. Sonority-driven stress and vowel reduction in Uyghur. In Hyunah Baek, Chikako Takahashi & Alex Hong-Lun Yeung (eds.), *Proceedings of the Annual Meetings on Phonology*. Washington, DC: Linguistic Society of America.

Mistry, Purushottam Jivanji. 1997. Gujarati phonology. In Alan S. Kaye (ed.), *Phonologies of Asia and Africa (including the Caucasus)*, vol. 2, 653–673. Winona Lake, Ind.: Eisenbrauns.

Nespor, Marina & Irene Vogel. 1982. Prosodic domains of external sandhi rules. In Harry van der Hulst & Norval Smith (eds.), *The Structure of Phonological Representations*, vol. 1, 224–255. Dordrecht: Foris.

Paasonen, Heikki. 1903. Mordvinische Lautlehre. In *Mémoires de la Société Finno-Ougrienne XXII*. Helsinki: Société Finno-Ougrienne.

Pajusalu, Karl. 2022. Prosody. In Marianne Bakró-Nagy, Johanna Laakso & Elena Skribnik (eds.), *The Oxford Guide to the Uralic Languages*, 868–878. Oxford: Oxford University Press.

Prince, Alan & Paul Smolensky. 1993. Optimality Theory. Constraint Interaction in Generative Grammar, Ms, Rutgers University, University of Colorado.
Rasin, Ezer. 2018. *Modular interactions in phonology*. MIT dissertation.
Saarinen, Sirkka. 2022. Mari. In Marianne Bakró-Nagy, Johanna Laakso & Elena Skribnik (eds.), *The Oxford Guide to the Uralic Languages*. Oxford: Oxford University Press.
Scheer, Tobias. 1997. Vowel-zero alternations and their support for a theory of consonantal interaction. In David Michaels, Pier-Marco Bertinetto, L. Gaeta & Georgi Jecev (eds.) (eds.), *Certamen Phonologicum III*, 67–88. Rosenberg & Sellier.
Scheer, Tobias. 2004. *A Lateral Theory of Phonology. Vol 1: What is CVCV, and why should it be?* Berlin: De Gruyter Mouton.
Scheer, Tobias. 2005. Slavic vowel-zero alternations and Government Phonology: Two approaches, one solution. In Steven Franks, Frank Gladney & Mila Tasseva-Kurktchieva (eds.), *Formal Approaches to Slavic Linguistics. The South Carolina Meeting*, vol. 13, 300–311. Ann Arbor: Michigan Slavic Publications.
Scheer, Tobias. 2012. *A Lateral Theory of phonology*. Vol. 2: *Direct Interface and One-Channel Translation*. Berlin: De Gruyter Mouton.
Scheer, Tobias. 2014. Spell-Out, Post-Phonological. In Eugeniusz Cyran & Jolanta Szpyra-Kozlowska (eds.), *Crossing phonetics-phonology lines*, 255–275. Newcastle upon Tyne: Cambridge Scholars.
Scheer, Tobias. 2019. Phonetic arbitrariness: a cartography. *Phonological Studies (Japan)* (22). 105–118.
Scheer, Tobias & Péter Szigetvári. 2005. Unified representations for stress and the syllable. *Phonology* 22(1). 37–75.
Scheer, Tobias & Markéta Ziková. 2010. The Havlík Pattern and Directional Lower. In Draga Zec & Wayles Browne (eds.), *Formal Approaches to Slavic Linguistics. The Second Cornell Meeting, 2009*, 471–486. Ann Arbor: Michigan Slavic Publications.
Schlie, Perry & Ginny Schlie. 1993. A Kara phonology. *Data papers on New Guinea linguistics: Phonologies of Austronesian languages* 2. 99–130.
Ségéral, Philippe & Tobias Scheer. 2008. The Coda Mirror, stress and positional parameters. In Joaquim Brandaõ de Carvalho, Tobias Scheer & Philippe Ségéral (eds.), *Lenition and fortition*, 483–518. Berlin: Mouton de Gruyter.
Selkirk, Elisabeth. 1981. On the nature of phonological representation. In John Anderson, John Laver & Tim Myers (eds.), *The cognitive representation of speech*, 379–388. Amsterdam: North Holland.
Shachmon, Ori & Noam Faust. 2023. The loss of suffixal /h/ in Galilee: Graduality and Universal Markedness. *International Journal of Arabic Linguistics* 9. 188–211.
Shih, Shu-hao. 2016. Sonority-driven stress does not exist. In Gunnar Ólafur Hansson, Ashley Farris-Trimble, Kevin McMullin & Douglas Pulleyblank (eds.), *Proceedings of the 2015 Annual Meetings on Phonology*. Washington, DC: Linguistic Society of America.
Shih, Shu-hao & Paul de Lacy. 2019. Evidence for sonority-driven stress. *Catalan Journal of Linguistics* 18. 9–40.
Solopov, Aleksej Ivanovič & Ekaterina Vladimirovna Antonec. 2011. *Latinskij jazyk [The Latin Language]*. Moscow: Izdatel′stvo JuRAJT.
Tjutjunnikova, Varvara. 2022. Udarenie v kazymskom xantyjskom [Stress in Kazym Khanty] [Ms.]

Toldova, Svetlana. 2018. Predikacii s glagol'nym skazuemym [Clauses with verbal predicates]. In Svetlana Toldova & Maria Kholodilova (eds.), *Èlementy mokšanskogo jazyka v tipologičeskom osveščenii [Elements of the Moksha language in a typological perspective]*, chap. 22, 546–615. Moscow: Buki Vedi.

Toldova, Svetlana & Maria Kholodilova (eds.). 2018. *Èlementy mokšanskogo jazyka v tipologičeskom osveščenii [Elements of the Moksha language in a typological perspective]*. Moscow: Buki Vedi.

Ulfsbjorninn, Shanti. 2014. *A field theory of stress: the role of empty nuclei in stress systems*. SOAS, University of London dissertation.

Ulfsbjorninn, Shanti. 2021. Lenition and Metathesis in Hawu: a quantity-sensitive language. *SOAS Working Papers in Linguistics* (20). 1–25.

Ulfsbjorninn, Shanti. 2022a. Pseudo-Allomorphy of Articles and Articulated Prepositions in Llanito. *Linx. Revue des linguistes de l'université Paris X Nanterre* (84).

Ulfsbjorninn, Shanti. 2022b. Towards Eradicating Class Driven Allomorphy: Nominal Suffixes in Afar. https://ling.auf.net/lingbuzz/003533.

Vaysman, Olga. 2009. *Segmental alternations and metrical theory*. MIT dissertation.

Vergnaud, Jean-Roger. 1982. On the theoretical bases of phonology. Paper presented at the 1982 GLOW colloquium in Paris.

Yang, Charles. 2016. *The price of linguistic productivity: How children learn to break the rules of language*. Cambridge, MA: MIT Press.

Ziková, Markéta. 2009. Vowel-zero Alternations in Czech Double Diminutives: From the Havlík Pattern to the Lower Pattern. In Mojmír & Markéta Ziková Dočekal (ed.), *Czech in Formal Grammar*, 237–250. München: Lincom. http://ling.auf.net/lingbuzz/@ntJppgDIYlbupZRC/FKvzNGsm?8.

Zirnask, Tatiana. 2007. *Rõhk ja kestus mokša keele Kesk-Vadi murdes*. Tartu Ülikool. Uurali keelte õppetool MA thesis.