Solving Chuvash stress with sonority-sensitive feet

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Question: How are prominence and stress motivated phonologically in Chuvash?

- Phonetically, every word begins with a pitch peak (↗) on the initial syllable.
- Stress (greater vocalic duration/intensity) falls on rightmost strong (/i y u e ɑ/)[1] vowel.
- Words without these vowels (only weak /ɔ ø/) have no stress. (Dobrovolsky 1999)

(1) Final stress:	↗ju.lɑ.ˈnut, ↗χɔ. ˈmɑ	‘horse (for riding)’, ‘beaver’
(2) Penultimate stress:	↗ɕy.ˈle.vøɕ, ↗ʉj.ˈtul.lɔ	‘lynx’, ‘question (adj.)’
(3) Initial stress:	↗ˈmɑ.kɔ.rɔtʲ, ↗ˈpu.lɔ	‘moo (3sg)’, ‘fish’
(4) Without stress:	↗ɔ.rɔm.ɕɔ, ↗t͡ɕø.pø	‘sorcerer’, ‘chick’

NEW SONORITY-SENSITIVE ACCOUNT	PREVIOUS QUANTITY-SENSITIVE ACCOUNTS
• Accounts for stress (word-level stress) and initial pitch peak (word-level prominence) as separate phenomena	• Conflates initial pitch peak and stress so that words in (4) have initial stress (default-to-opposite)
• Motivates stress patterns by distinguishing peripheral ((/i y u e ɑ/) and central (/ʉ ø ɔ/) vowels	• Motivates stress patterns by distinguishing full (/i y ʉ u e ɑ/) and reduced (/ø ɔ/) vowels
• Uses sonority-sensitive feet	• Uses quantity-sensitive feet

Goal of this talk:

1. illustrate a sonority-driven stress analysis that better accounts for new Chuvash data,
2. compare this account with an alternative quality-sensitive account (Kenstowicz 1996) and
3. show how this analysis can be reordered to account for other dialects of Chuvash.

New data under consideration:

1. phonetic fieldwork recordings (Dobrovolsky 1999, Lindsey 2014),
2. an electronic list of all Chuvash words (Zheltov *et al.* 2008),
3. an electronic dictionary corpus (Skvortsov 1982; Alekseev & Plotnikov 2011)

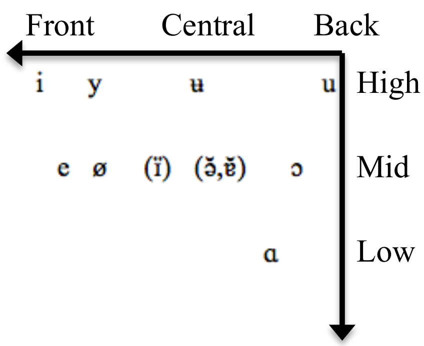
[1] There are eight vowels in Chuvash - /ɑ e i u y ø ɔ and ʉ/. Previous analyses have grouped ʉ with the vowels that take rightmost stress. However, /ʉ/ is only rarely found non-initially. Of the five words in the lexicon (n=31,403), where /ʉ/ is found non-initially, only two predict /ʉ/ to carry rightmost stress. In these two words, the dictionary lists /ɔ/ as variants for /ʉ/, suggesting rightmost stress also skips over this vowel. Moreover, /ʉ/ patterns with /ø/ and /ɔ/ in minimal word patterns. In my analysis, I consider /ʉ/ a weak-sonority vowel with /ø/ and /ɔ/.

1 Distinguishing vowel classes

Question: What are the phonetic properties of the Chuvash vowels and what is the simplest distinction between those vowels that carry rightmost stress (ɑ e i u y) and those that only carry initial prominence (ʉ ø ɔ)?

- I ran a controlled production experiment with 20 speakers to determine the height, backness, rounding and length of all the vowels.
- There is not a significant length distinction between the two classes of vowels that influence stress, but there is a backness/frontness (F2) distinction.
- Weak vowels /ʉ ø ɔ/ occupy the most central position of the phonetic vowel space when prominent and are fully central (/ø/ → /ĭ/, /ɔ/ → /ǝ̆, ɐ̆/) when non-prominent (Andreev 2002, Degtjarjov 2012).

(5) Phonetic vowel space



(6) Vowel length measurements

Vowel	Normalized Vowel Length*
/ɑ/	.749
/ʉ/	.747
/y/	.735
/e/	.655
/u/	.641
/ø/	.599
/ɔ/	.590
/i/	.572

*Calculated by dividing vowel length by length of preceding /s/.

(7) Phonological vowel features

	Front		Central	Back	
	-Round	+Round	+Round	-Round	+Round
High	/i/	/y/	**/ʉ/**		/u/
Mid	/e/	**/ø/**			**/ɔ/**
Low				/ɑ/	

- This differentiation between peripheral and central vowels is indicative of a sonority-sensitive system.

Chuvash sonority hierarchy: central > peripheral   ʉ, ø (ɪ), ɔ (ə, ɐ) > ɑ, e, i, u, y

(8) UNIVERSAL VOWEL SONORITY SCALE

Language-specific divisions: **A** (e.g. Chuvash) **B** (e.g. Gujarati)

a.	high central vowels	>	mid central vowels	> |	high peripheral vowels	>	mid-high peripheral vowels	>	mid-low peripheral vowels	> |	low peripheral vowels
b.	ɨ ʉ	>	ɘ ɵ ə ɚ	> |	i y ɯ u	>	e ø ɤ o	>	ɛ œ ʌ ɔ	> |	æ a ɶ ɑ ɒ

- **Summary**: it seems that the relevant distinction is quality-*sensitive* and quantity-*insensitive*.

- HOWEVER, strong and weak vowels also pattern differently in minimal words, suggesting quantity-sensitivity elsewhere in the phonology:

(9) A minimal word consists of at least one strong vowel or a weak vowel and coda.
✓ /ʃɑ/ 'end' ✗ /ʃɔ/ ✓ /ʃɔn/ 'frost'

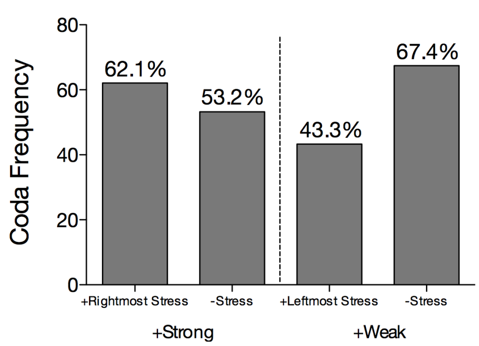
2 Distinguishing stress and prominence

- Rightmost stress and leftmost prominence have distinctive phonetic realisations: increase in vocalic duration/intensity and increase in pitch, respectively.
- Speakers judge the leftmost prominence as "weaker" and "harder to hear" (Ashmarin 1898).

Question: do rightmost stress and leftmost prominence differ phonologically as well?
Data: The Zheltov *et al*. (2008) lexicon (the most complete Chuvash collection, n=31,403)

- A distribution analysis of the Zheltov *et al.* (2008) lexicon reveals that stressed strong syllables are more likely to have a coda than unstressed syllables and weak syllables in leftmost stress position are even less likely to have codas.

(10) CODA FREQUENCY ACROSS SYLLABLE TYPES



		Count	Coda Frequency
Strong	Stressed	19,290	62.1%
	Unstressed	19,539	53.2%
Weak	Stressed	1,827	43.3%
	Unstressed	20,586	67.4%

- A logistic regression of 61,242 syllables with coda presence as the dependent variable and syllable position (initial or final) and vowel strength (weak and strong) controlled for revealed that coda presence is preferred on stressed strong vowels (β = 0.0943, $p < 0.005$), but dispreferred on "stressed" weak vowels (β = -0.2618, $p < 0.005$)[2].
- This model shows that rightmost stress is a predictor of coda presence, but leftmost stress is an even stronger predictor for coda absence.
- This is a good indication that rightmost stress and leftmost prominence are distinct.

[2] The logistic regression coefficients (β) are positive when they predict the probability of the dependent variable (coda presence) and deviations further from zero indicate more predictive power.

3 A sonority-sensitive analysis

- Word-level stress is primarily motivated by ALIGN-RIGHT (STRESS, PROSODICWORD) and CULMINATIVITY.

(11) ALIGN-R (STR, PWD): Stress must be aligned with the right edge of the prosodic word.
(12) CULMINATIVITY: Every word must have at least one stressed syllable.

- Stringency Hierarchy sonority constraints (de Lacy 2002, 2004; Kiparsky 1994) ensure that stress never prefers syllables with marked vowels over less marked vowels (universal) but that conflation occurs between the relevant sonority classes (language-specific).

(13) *HEAD$_{\text{FOOT}}$/CENTRAL: No central vowels in head position.
(14) *NON-HEAD$_{\text{FOOT}}$/PERIPHERAL: No peripheral vowels in non-head position.

- The sonority constraints in (13-14) are ranked higher than FOOTBINARITY.

(15) FOOTBINARITY: Every foot is binary at the syllabic or moraic level.

- These constraints, ranked as in (16), motivate a footing where syllables with strong-sonority vowels are heads of feet, and those with weak-sonority vowels are unfooted (extra-metrical).

(1') Final stress:	↗(ju).(lɑ).(ˈnut), ↗χɔ.(ˈmɑ)	'horse (for riding)', 'beaver'
(2') Penultimate stress:	↗(ɕy).(ˈle).vøɕ, ↗ʉj.(ˈtul).lɔ	'lynx', 'question (adj.)'
(3') Initial stress:	↗(ˈmɑ).kɔ.rɔtʲ, ↗(ˈpu).lɔ	'moo (3sg)', 'fish'
(4') Without stress:	↗ɔ.rɔm.ɕɔ, ↗t͡ɕø.pø	'sorcerer', 'chick'

- This constraint ranking correctly motivates primary stress falling on the rightmost foot of every word and words without strong-sonority vowels not having stress.
- Finally, the constraint INITIALPROMINENCE accounts for word-initial boundary tones.

(16) INITIALPROMINENCE: The beginning of every prosodic word must have a boundary tone.

(17) OPTIMALITY THEORY TABLEAU FOR WORDS WITH PENULTIMATE STRESS AND NO STRESS

/pulɑslɔχ/ 'future'	INITIALPROM	*HD$_{\text{FT}}$/CEN	*NON-HD$_{\text{FT}}$/PER	ALIGN-R (STR, PWD)	CULM
☞ a. ↗(pu).(ˈlɑs).lɔχ				*	
b. (pu).(ˈlɑs).lɔχ	* W			*	
c. ↗(ˈpu).(lɑs).lɔχ				** W	
d. ↗(pu).(lɑs).(ˈlɔχ)		* W	* W	L	
/nørsørløχ/ 'abnormality'					
☞ e. ↗nør.sør.løχ					*
f. nør.sør.løχ	* W				*
g. (ˈnør).sør.løχ		* W		** W	L

4 An unbounded foot analysis

- The only alternative approach that is both quantity-insensitive and quality-sensitive is Kenstowicz' 1996 analysis of Mari, neighboring but unrelated to Chuvash.
- In this analysis, there is only one foot per word. This foot is anchored to the right edge of the word and extends leftward to encompass the first syllable with a strong-sonority vowel.

(18) a. $\sigma\ \sigma\ _s\sigma\ _s\sigma\ \sigma\ (^{ˈ}\sigma\ )$ suboptimal
b. $\sigma\ \sigma\ _s\sigma\ _s\sigma\ (^{ˈ}\sigma\ \sigma\ )$ suboptimal
c. $\sigma\ \sigma\ _s\sigma\ (^{ˈ}{}_s\sigma\ \sigma\ \sigma\ )$ optimal
d. $\sigma\ \sigma\ (^{ˈ}{}_s\sigma\ _s\sigma\ \sigma\ \sigma\ )$ suboptimal

- If a word lacks syllables with strong-sonority vowels, the unbounded foot simply encompasses the entire word, and stress falls on the leftmost syllable.

(18) e. $(^{ˈ}\sigma\ \sigma\ \sigma\ \sigma\ \sigma\ \sigma\ )$ optimal

5 Different feet make different predictions

- The foot structure assumed in the unbounded foot model and the sonority-sensitive foot model are different and consequently indicate different predictions for other segmental phenomena, e.g. vowel elision.
- First, an unbounded foot model predicts distinction between the word-initial syllables in (19), whereas the sonority-sensitive foot model predicts them to be the same.

(19) **Unbounded Foot Model**		**Sonority-Sensitive Foot Model**	
a. <u>nør</u>.len.(ˈse)	'become beautiful'	c. ↗nør.(len).(ˈse)	'become beautiful'
b. (ˈ<u>nør</u>.sør.løχ)	'abnormality'	d. ↗nør.sør.løχ	'abnormality'

- We know from phonetic experiments that they realized in the same way (Dobrovolsky 1999).
- Second, the models predict a phonological distinction between footed and unfooted vowels.

(20)	**Unbounded Foot Model**	**Sonority-Sensitive Foot Model**
Footed	syllables to the right of stress	syllables w/strong-sonority vowels
Unfooted	syllables to the left of stress	syllables w/weak-sonority vowels

- Vowel deletion (apocope) is more prevalent in unfooted syllables (Kager 1997, Anttila 2006).
- Chuvash exhibits stylistic vowel deletion, documented in Skvortzov's dictionary (1982)

(21) **Unbounded Foot Model**	**Sonority-Sensitive Foot Model**	**Results**
1. The word-medial syllables in ʂɑ.rɑ.(ˈtɑ) 'meadow' and ʂy.pø.(ˈle) 'to argue' should have SIMILAR susceptibility to deletion.	1. The word-medial syllables in (ʂɑ).(rɑ).(ˈtɑ) 'meadow' and (ʂy).pø.(ˈle) 'to argue' should have DIFFERENT susceptibility to deletion.	**DIFFERENT** Footed .rɑ. will not delete; unfooted .pø. may delete.

2. The word-initial syllables in (ˈɔ.nɔʂ.sɔr) 'loser' and ɔ.nɔʂ.(tɑr) 'adjust' should have DIFFERENT susceptibility to deletion.	2. The word-initial syllables in ɔ.nɔʂ.sɔr 'loser' and ɔ.nɔʂ.(tɑr) 'adjust' should have SIMILAR susceptibility to deletion.	**SIMILAR** Neither word-initial syllable will delete.
3. Word-final weak syllables SHOULD NOT BE susceptible to elision, as they are always footed.	3. Word-final weak syllables SHOULD BE susceptible to elision, as they are never footed.	**SUSCEPTIBLE** Word-final weak syllables are the most frequent cases of vowel deletion.

5 Conclusion

A sonority sensitive foot model accounts for:

- Rightmost stress and leftmost prominence
- Distribution of codas on stressed syllables
- Minimal word patterns
- Stylistic vowel deletion

Moreover, a reordering of the constraint rankings in (16) produces eight possible languages, five of which are attested as dialects of Chuvash.

(17) FACTORIAL TYPOLOGY (OT-Help software (Staubs *et al.* 2010))

	Language	**Behavior**		**Ranking**
		Stress	Prominence	
1.	Standard Chuvash	rightmost strong, else none	initial	*HD$_{FT}$/CEN, INITIALPROM, *NON-HD$_{FT}$/PER >> ALIGN-R (STR, PWD), FINALPROM, CULM
2.	middle Chuvash dialect	rightmost strong, else none (or else rightmost weak)	final	STRESS-TO-SONORITY, FINALPROM, CULM >> *HD$_{FT}$/CEN, INITIALPROMINENCE, ALIGN-R (STR, PWD)
3.				*HD$_{FT}$/CEN, *NON-HD$_{FT}$/PER, FINALPROM >> INITIALPROM, ALIGN-R (STR, PWD), CULM
4.	lower Chuvash dialect	rightmost syllable if strong, else none (or else rightmost weak)	final	ALIGN-R (STR, PWD), FINALPROM, CULM >> *HD$_{FT}$/CEN, INITIALPROM, *NON-HD$_{FT}$/PER
5.				*HD$_{FT}$/CEN, ALIGN-R (STR, PWD), FINALPROM >> INITIALPROM, *NON-HD$_{FT}$/PER, CULM
6.	?	rightmost syllable	initial	INITIALPROM, ALIGN-R (STR, PWD), CULM >> *HD$_{FT}$/CEN, *NON-HD$_{FT}$/PER, FINALPROM
7.	?	rightmost strong, else rightmost weak	initial	INITIALPROM, *NON-HD$_{FT}$/PER, CULM >> *HD$_{FT}$/CEN, ALIGN-R (STR, PWD), FINALPROM
8.	?	rightmost syllable if strong, else none	initial	*HD$_{FT}$/CEN, INITIALPROM, ALIGN-R (STR, PWD) >> *NON-HD$_{FT}$/PER, FINALPROM, CULM

6 Future directions

This model does not yet account for:

- Lack of secondary stress (as an unbounded foot model does)
- Quality reduction of weak-sonority vowels in non-initial position
- Quantity-sensitivity in minimal words (it explains the distinction but not the behavior)

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