

Acoustic correlates of initial and final stress in Udmurt

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- According to the descriptions, Udmurt (Uralic, Permic) has fixed **final** stress (Yemelyanov 1927; GSUJa I 1962; Denisov 1980; Winkler 2001)
- There are several types of morphologically motivated exceptions with **initial** stress: e.g., imperative verbs, negated verbs, etc.

This study

- Minimal pairs consisting of:

indicative verbs (PRS.3SG)

imperative verbs (IMP.2SG/PL)

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- What are the **acoustic correlates** of **final** and **initial** stress?

This study

- Minimal pairs consisting of:

indicative verbs (PRS.3SG)

final stress

imperative verbs (IMP.2SG/PL)

initial stress

- What are the **acoustic correlates** of **final** and **initial** stress?
- (What is the **phonological nature** of **final** and **initial** “stress”?)

Possible interpretations

Hypothesis 1:

Final stress is word stress, **initial** “stress” is a phrasal intonational phenomenon.

Hypothesis 2:

Initial stress is word stress, default **final** “stress” is absence of stress.

Hypothesis 3:

Both **initial** and **final** stresses represent word stress.

Outline

- 1 Background
- 2 Methods
- 3 Results
- 4 Inter-speaker variation
- 5 Conclusions & implications

Background

Traditional descriptions

- Udmurt has fixed **final** stress (Yemelyanov 1927; GSUJa I 1962; Denisov 1980; Winkler 2001)
 - e.g., indicative verbs: *valá* ‘understand.PRS.3SG’
- There are morphologically motivated exceptions with **initial** stress:
 - imperative verbs: *vála* ‘understand.IMP.2SG’
 - negated indicative verbs: *uz vála* ‘NEG.FUT.3SG understand’
 - etc.
- Dialectal variation

Acoustic correlates of stress

- **Duration:** stressed syllables/vowels may be greater in duration than unstressed ones
 - **Intensity:** stressed vowels typically have greater intensity than unstressed ones
 - **Pitch/ f_0 :** stressed vowels may have particular f_0 properties (high or low)
 - **Vowel quality:** there may be language-specific requirements for quality of stressed (or unstressed) vowels
- Most languages rely on **more than one** of these to cue stress.

Methods

Experimental items

- string-identical **minimal pairs** formed by **indicative** and **imperative** verbs (total n=172):
 - di- and trisyllabic
 - CV syllables
 - vowel height: low, mid, high+mid (for morphosyntactic reasons)
 - information structure: focused (F) vs. non-focused (non-F) (Roettger & Gordon 2017)
 - embedded in carrier sentences
- all items were collected from Kirillova's (2008) dictionary and checked by an Udmurt speaker who did not participate in the experiment.

Experimental contexts

- ① I [_{Foc} *vàla*] word said, but *gàža* word didn't. [F]
- ② I *vàla* word [_{Foc} quietly] said, but loudly didn't. [non-F]
- ③ I [_{Foc} *valà*] word said, but *gažà* word didn't. [F]
- ④ I *valà* word [_{Foc} slowly] said, but quickly didn't. [non-F]

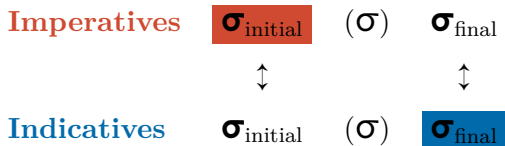
Experimental set-up & processing

- 6 native Udmurt speakers (5 f, 1 m; age range 20–40) took part in the study;
- Target sentences were displayed on the screen one at a time;
- The sound files were manually annotated in Praat (Boersma & Weenink 2021);
- **Duration**, **F1** and **F2** were measured for each vowel;
- **f₀** measurements were made at 10 fixed points per vowel.

Results

Results

- duration
- vowel quality (F1 and F2)
- f_0

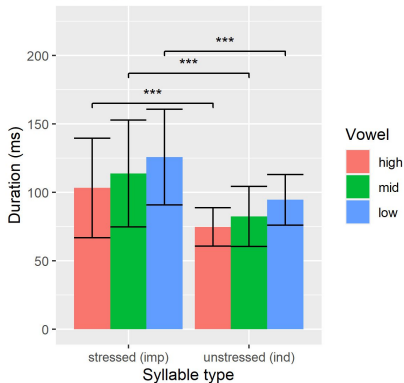


Results: vowel duration, initial syllables

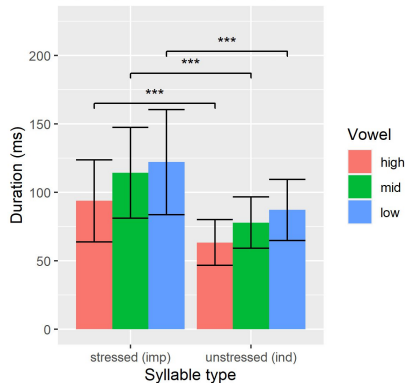
- **Initial** stress is systematically cued by vowel duration.
- This holds for both **di-** and **trisyllables**, both **focused** and **non-focused**.
- Vowel duration in **non-focused** verbs is **somewhat shorter** than that in their focused counterparts, in both disyllables and trisyllables (not statistically significant in most cases).

Results: vowel duration, initial syllables

(a) Disyllabic, 1st syllable, F



(c) Disyllabic, 1st syllable, non-F

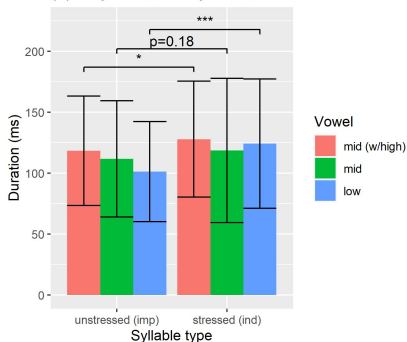


Results: vowel duration, final syllables

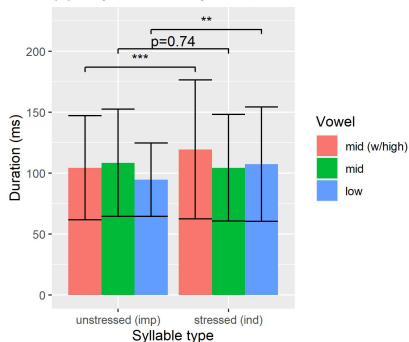
- **Final** stress is less consistently cued by vowel duration.
- This holds for both **di-** and **trisyllables**, both **focused** and **non-focused**.

Results: vowel duration, final syllables

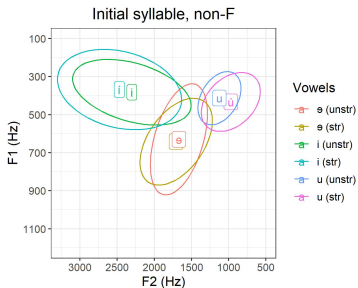
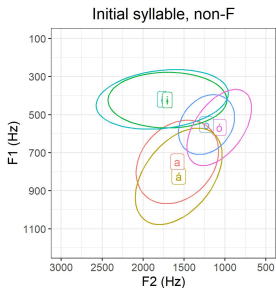
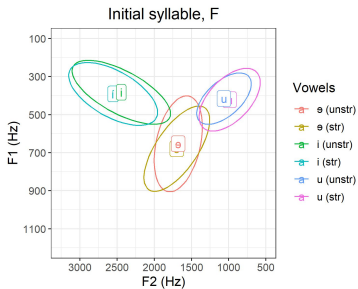
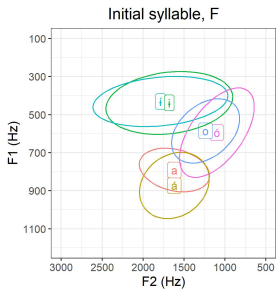
(b) Disyllabic, 2nd syllable, F



(d) Disyllabic, 2nd syllable, non-F



Results: vowel quality, initial syllables

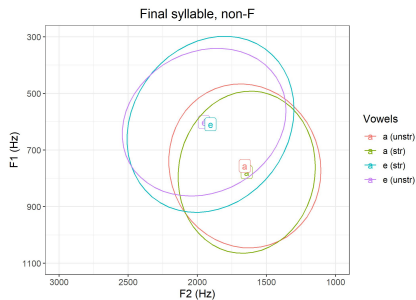
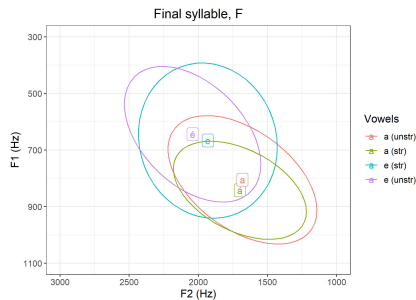


Results: vowel quality, initial syllables

- Stressed and unstressed vowels significantly differ from each other in **F1** and/or **F2** parameters;
- This is the case in both **focus** and **non-focus** conditions.

Vowel	F		non-F	
/a/	$p < 0.001^{***}$	(F1)	$p < 0.001^{***}$	(F1)
/ə/	$p < 0.05^*$	(F1)		
/i/	$p < 0.05^*$	(F2)	$p < 0.001^{***}$	(F2)
/ī/	$p < 0.01^{**}$	(F2)	$p < 0.05^*$	(F2)
/o/	$p < 0.001^{***}$	(F2)	$p < 0.001^{***}$	(F2)
/u/	$p < 0.01^{**}$	(F2)	$p < 0.05^*$	(F1)
			$p < 0.001^{***}$	(F2)

Results: vowel quality, final syllables

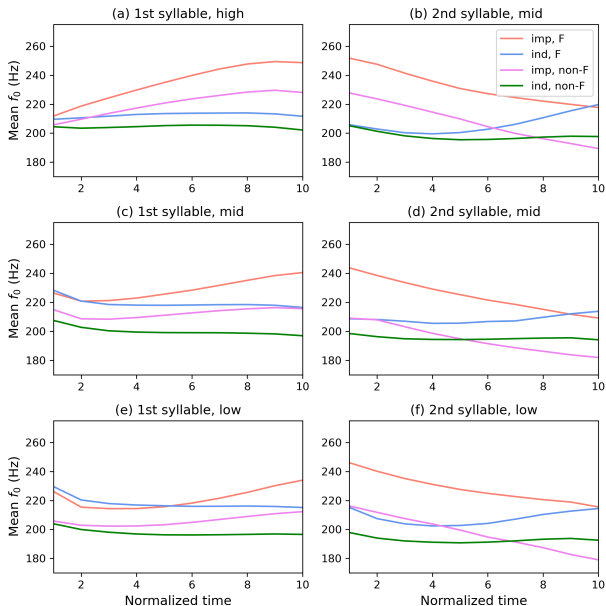


Results: vowel quality, final syllables

- There is a systematic difference between stressed and unstressed vowels in their **F1** and/or **F2** parameters, especially under **focus**;

Vowel	F		non-F	
/a/	$p < 0.001^{***}$	(F1)	$p < 0.001^{***}$	(F1)
/e/	$p < 0.01^{**}$	(F1)	$p < 0.01^{**}$	(F2)
	$p < 0.001^{***}$	(F2)		

Results: f_0



- **Imperatives** carry a **high** tone on the **initial** syllable, realized as a rise, with the peak reached at the juncture with the second syllable.
 - in Autosegmental-Metrical terms: tentatively, **H***.
- **Indicatives** have two realizations:
 - a **low** tone on the **final** syllable, which may be preceded by a higher plateau or a peak;
 - a **high** tone on the **final syllable**;
 - In Autosegmental-Metrical terms: tentatively, **(H+)L*** and **H***.
- Focused contexts have **higher overall f_0** values.

Interim summary

- What we know so far:

	vowel duration	vowel quality
initial stress	✓	✓
final stress	✓	✓

- Both types of stress are aligned with **intonational pitch accents**.

Inter-speaker variation

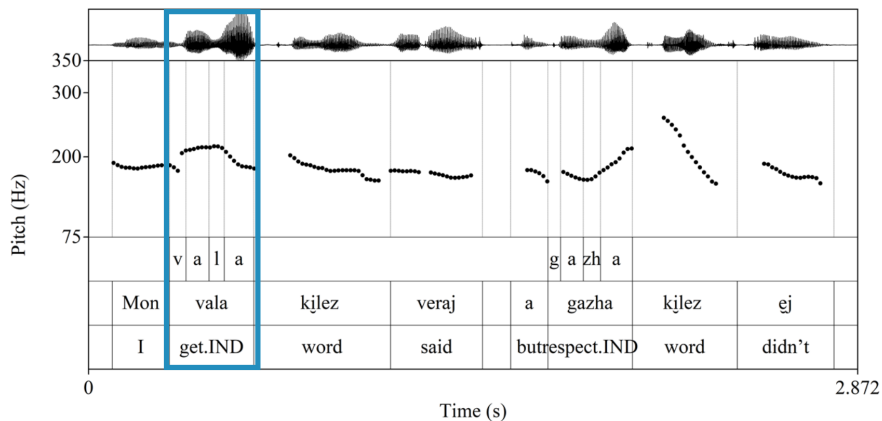
Results: inter-speaker variation

Individual speakers differed with respect to the **acoustic cues** that they used to mark stress, e.g.:

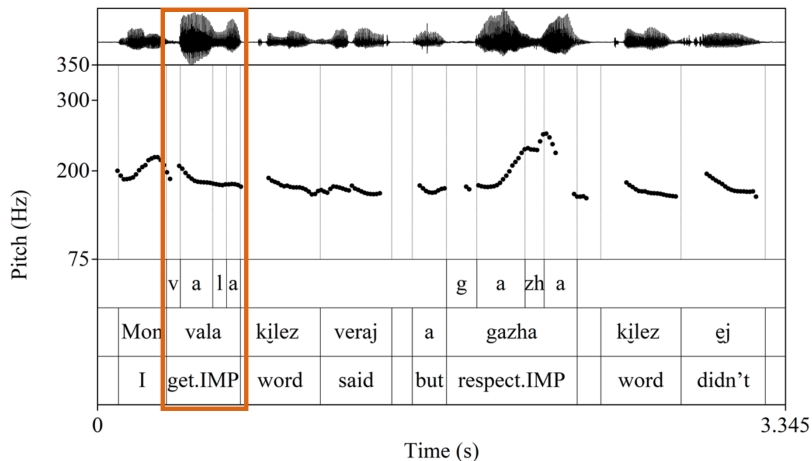
	stress		f_0 in IS contexts
	duration	vowel quality	
Speaker 5	✓	✗	✗ (F/non-F)
Speaker 6	✗	✓	✓

(To the best of our knowledge, the differences between speakers are not attributable to sociolinguistic, dialectal, age- or gender-related differences).

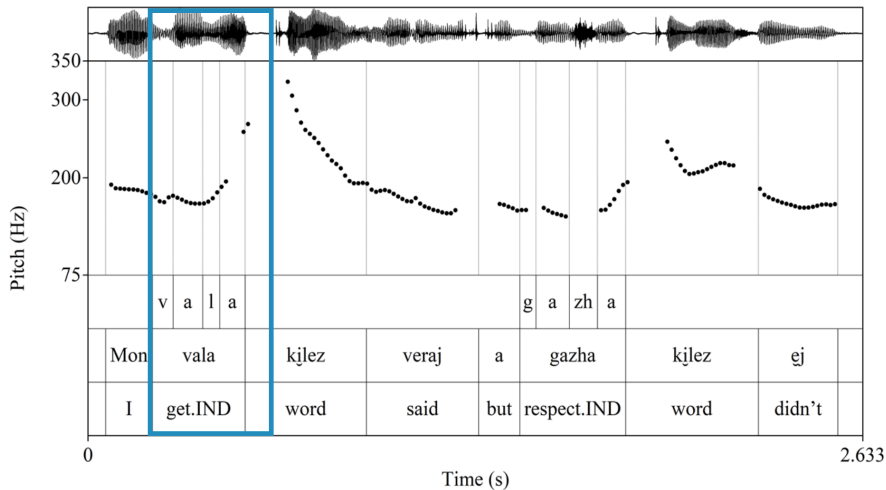
Speaker 5, indicative, F



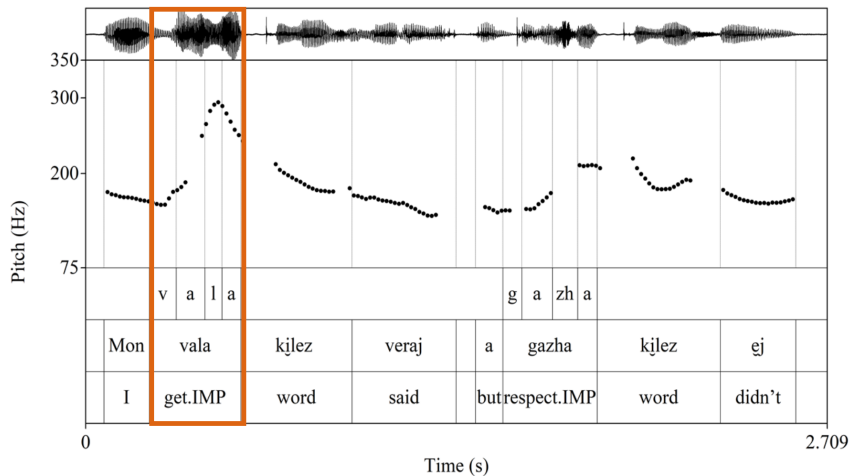
Speaker 5, imperative, F



Speaker 6, indicative, F



Speaker 6, imperative, F



Conclusions & implications

Main findings:

- **Initial** stress is systematically cued by **vowel duration**, **final** stress less so.
- Both **initial** and **final** stress is cued by **vowel quality**.
- Both **initial** and **final** stress is aligned with **pitch accents**:
 - **imperatives** typically carry a high pitch accent/**H*** on the initial syllable;
 - **indicatives** may carry a high pitch accent/**H*** or a low pitch accent/**(H+)L*** on the final syllable.
- **Focus** is cued by **vowel quality** and **f₀** – with a lot of **variation** between individual speakers.

Interpretation:

- **Vowel quality** cues both **initial** and **final** stress
⇒ would have been unexpected with just **intonational pitch targets** (in the absence of stress);
- **Vowel duration** cues stress regardless of the **type of intonational pitch target** that it is aligned with (i.e., H* & L*, nuclear & pre-nuclear)
⇒ would have been unexpected with just **intonational pitch targets** (in the absence of stress), especially for L* (?)

Hypothesis 1:

Final stress is word stress, **initial** “stress” is a phrasal intonational phenomenon.

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Inter-speaker variability: implications

- The **inter-speaker variation** raises interesting questions about the nature of phonetic-phonology interface;
- The Udmurt results align with the existing **neurolinguistic evidence**: speakers expect **varying individual acoustic cues** to be utilized in marking stress in a single language (Honbolygó & Csépe 2011).

Thank you for your attention!

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