# Stress-tone-weight interaction in poetic meter: South Slavic folk meter revisited

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Annual Meeting on Phonology 2025
University of California, Berkeley
September 26, 2025

# Epic decasyllable

- traditional verse of BCMS folk epic poetry
- trochaic pentameter: 10 syllables per line, caesura after fourth syllable

(Karadžić 1824, Jakobson 1966, Ružić 1975, Batinić 1975, Zec 2008)

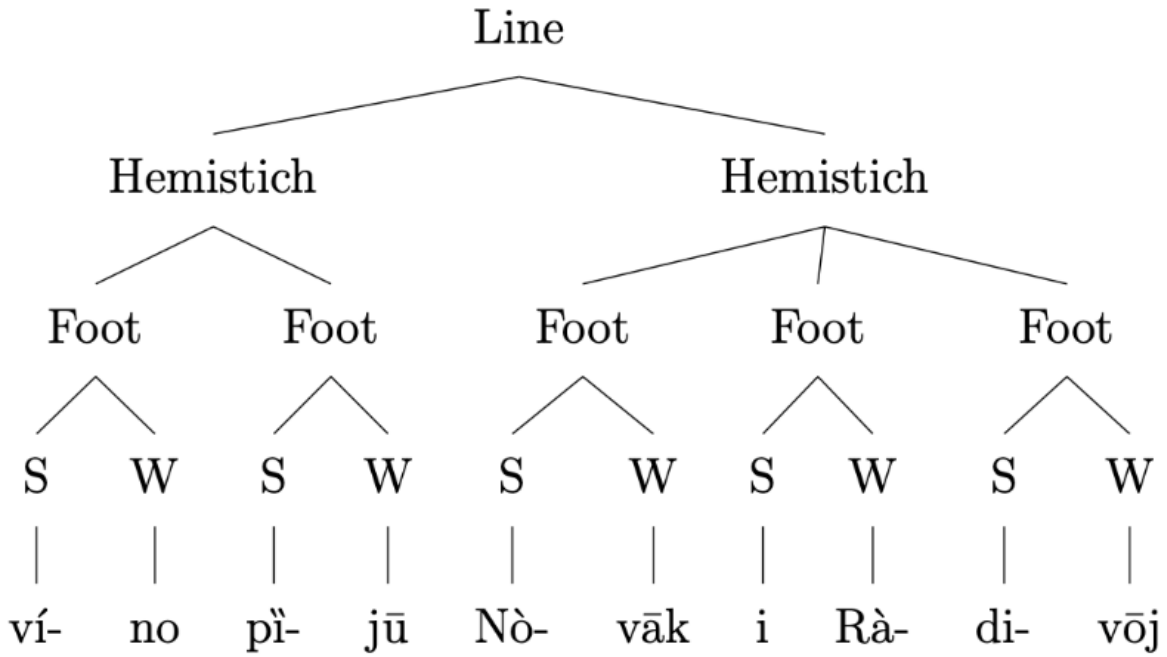
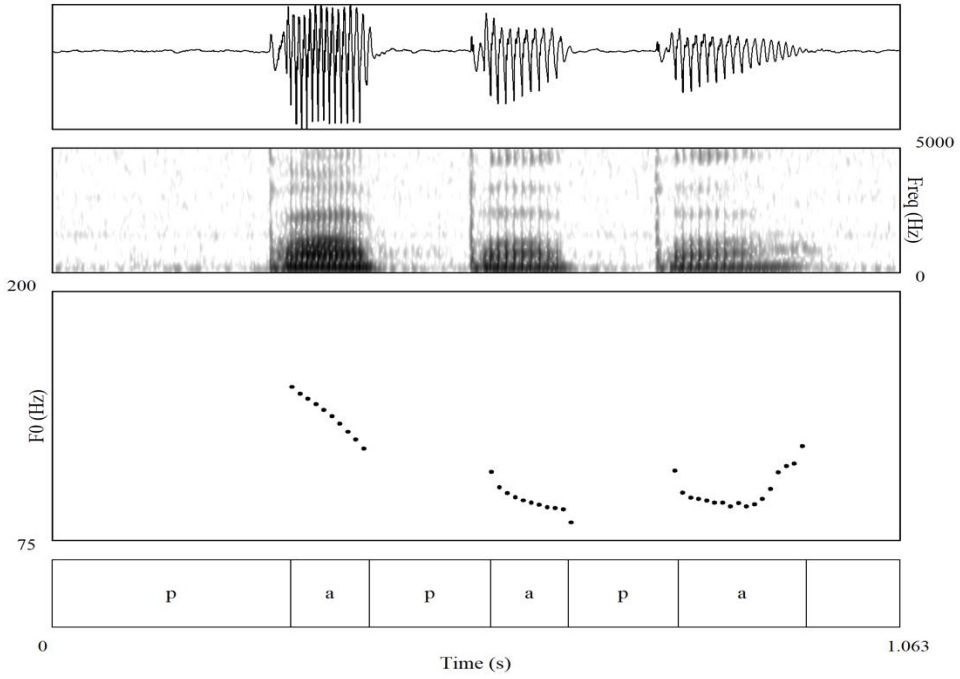
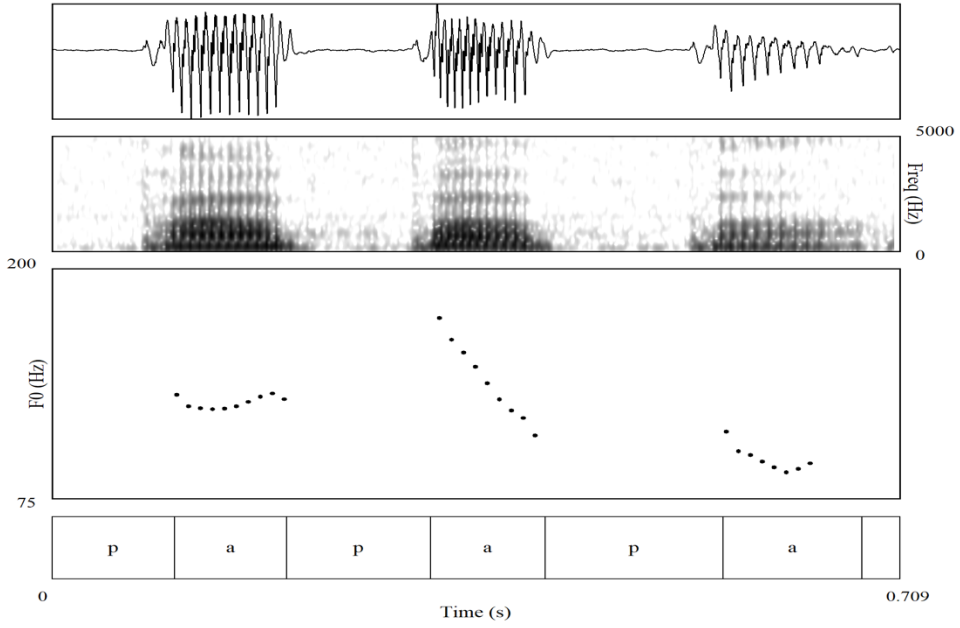



Figure 1: Epic decasyllable as trochaic pentameter

# BCMS pitch accents

- pitch accent: falling vs. rising
  (Lehiste & Ivić 1986; Zsiga & Zec 2013)
- pitch accent:
  stress (~duration, intensity) + tone (~F0):
- distributional constraints:
  - only falling in monosyllables;
  - falling restricted to polysyllable initials
  - rising allowed in all nonfinal syllables of polysyllables
- vowel length = syllable weight
  only CVV heavy
  (Zec 2000)



# Prominence hierarchy

Stress*tone*weight combinations

| Pitch accent | stress | High tone | vowel length |
|---|---|---|---|
| long falling | + | + | + |
| short falling | + | + | − |
| long rising | + | − | + |
| short rising | + | − | − |

# Today's talk

1. Which properties of BCMS syllables (if any) does the meter regulate?
2. Are regulation effects true metrical preferences or do they reflect extraneous factors (lexical statistics, distributional skews in ordinary-language prosody)?
3. Maxent model for the epic decasyllable

# Corpus survey

- 3,771 lines from books 1-4 of *Serbian Folk Poems* (1841-1862) compiled by Vuk Stefanović Karadžić
- Annotation automated when possible (e.g. syllabification)
- Manual annotation for pitch accent and vowel length

# Ordinary-language baselines

- To argue "the meter regulates X," one needs to show that the distribution of X is **specific to meter**, not a property of the general language

**1. Prose comparison ("Russian method")**

801 lines of decasyllable-like sentences from BCMS novels & short stories
(Tarlinskaja 1976, Bayley 1975, Gasparov 1980, 1987, Hayes & Schuh 2019)

**2. Permutation ("Rigged Veda method")**

Corpus is randomly scrambled, but word shape distribution is kept intact
(Janson 1975, Gunkel & Ryan 2011, Ryan 2017)

Real line: **sóva sjèdī || na bûkovu pánju** (I, 717:1)

Fake version 1: sûnce lètī || ka njínome grâdu

Fake version 2: národ pȁdā || sa mládijem dânom

Fake version 3: rûku òpēt || na pêndžere dáji

etc.

# Overall distribution of stress/tone/weight in epic vs. prose

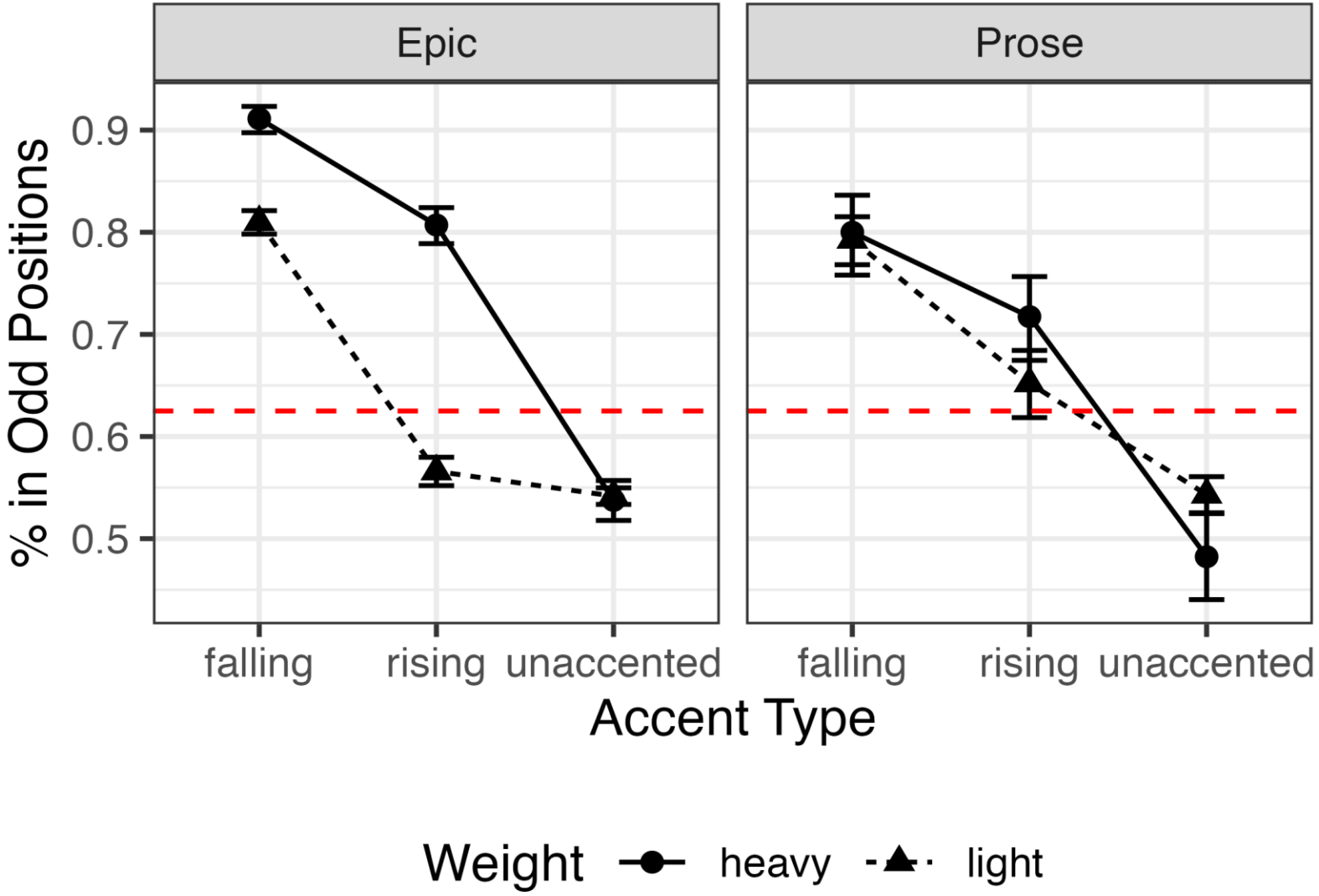
(excluding pre-pausal positions 4 and 10, which cannot bear pitch accent)

## 1. Weight

- Epic: heavy vs. light distinction in stressed syllables
- Prose: no distinction

## 2. Tone

- Falling vs. rising: bigger effect in epic

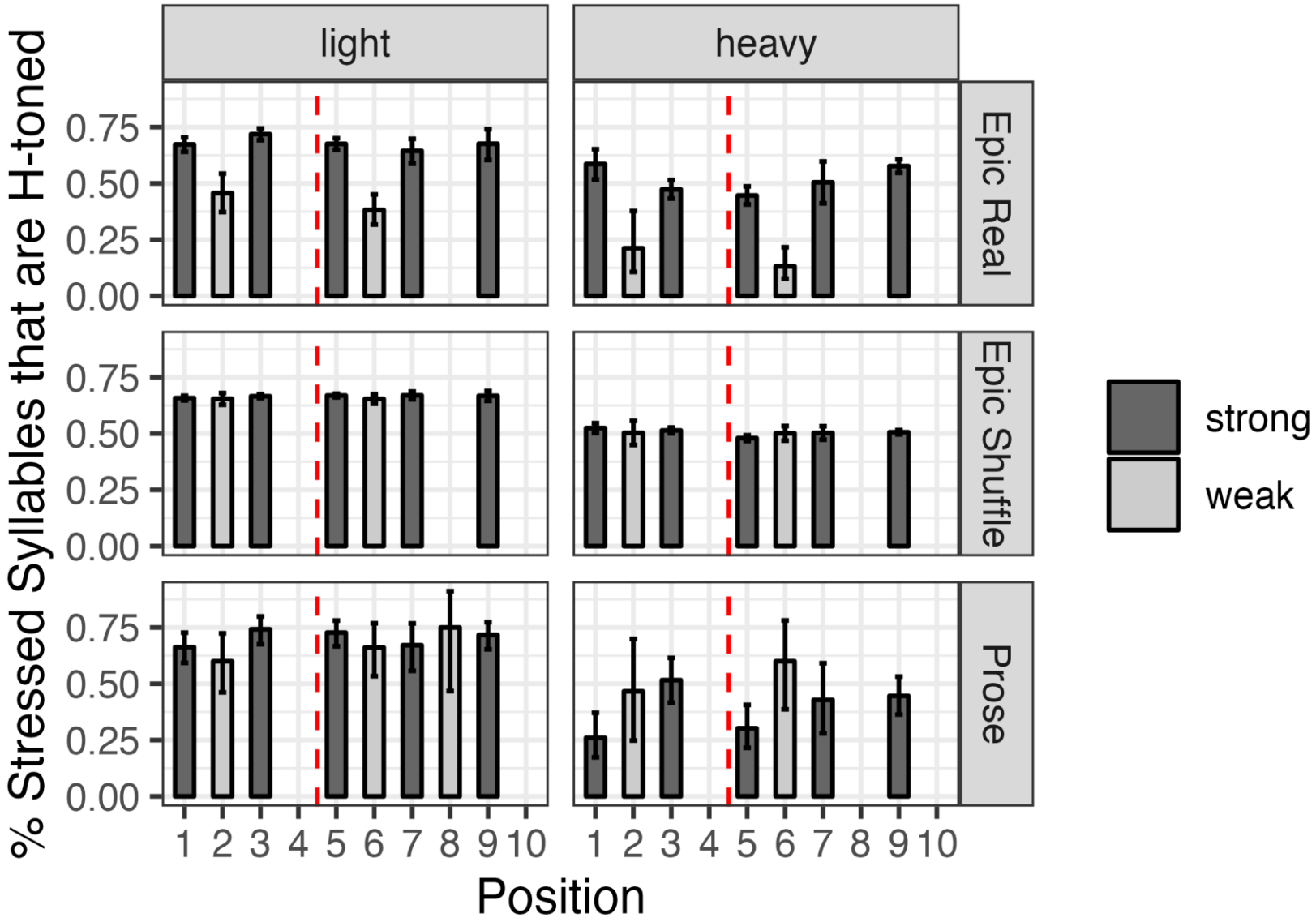


# Tone regulation

- Falling accents (stress + high) occur only word-initially
- Shorter words tend to be avoided line-finally (e.g. line-final monosyllables are categorically avoided)
  (Maretić 1901, 1907, Jakobson 1966, Foley 1993, Zec 2008)
- This might skew falling tones towards odd (strong) positions
- Solution: control for word shape; don't rely on the overall/raw distribution of tone

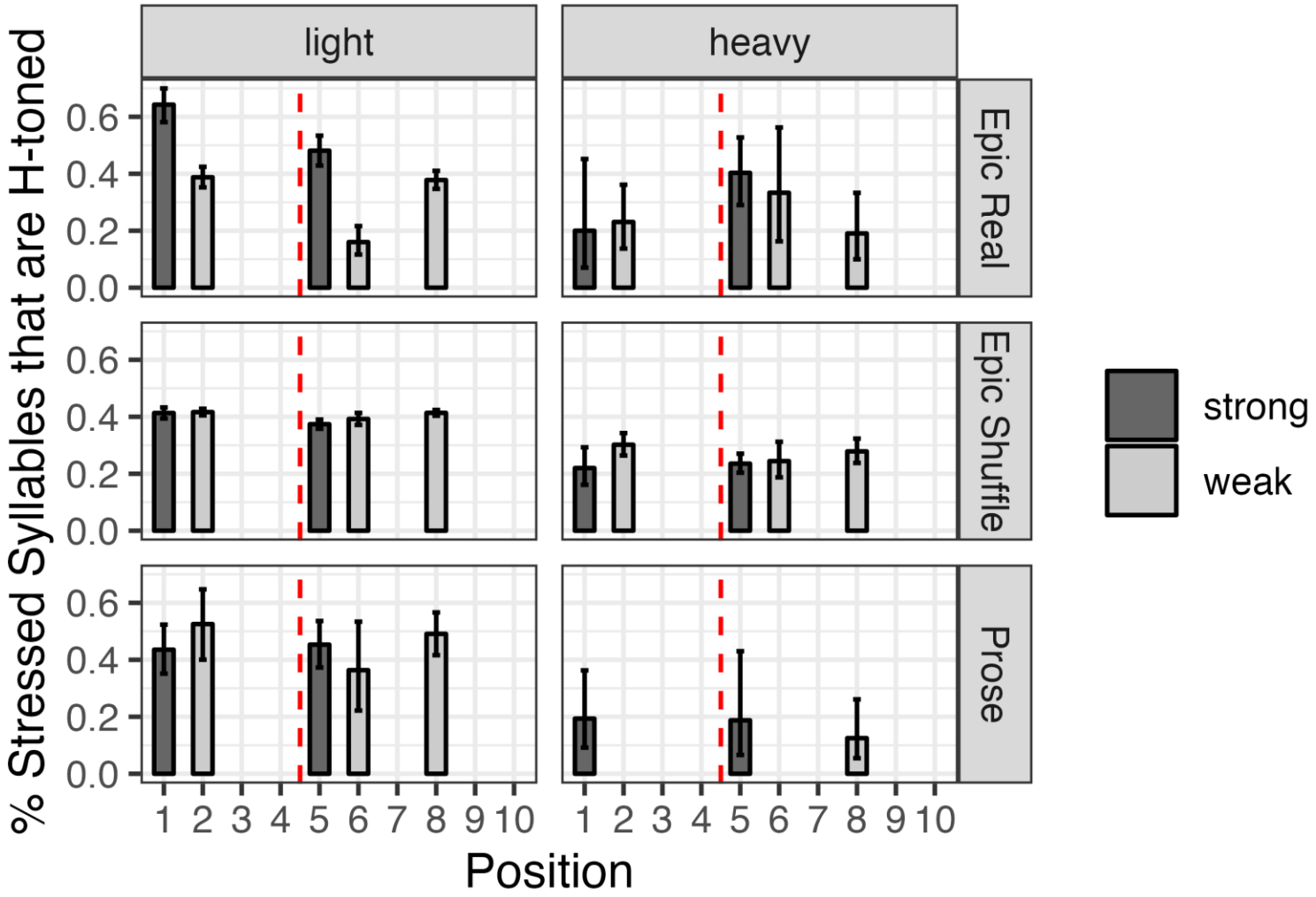
# Tone regulation: stressed, **disyllable** initials (e.g. sóva)

- y = % high (vs. toneless)
- Controlling for word shape, stress, and weight
- High tone is avoided in weak positions in epic
- But not in scramble or prose



# Tone regulation: stressed, **trisyllable** initials (e.g. bûkovu)

- More gaps because trisyllables can be localized in few positions
- High tone is avoided in weak positions in epic (but not baselines)



# Omnibus model: epic (prose)

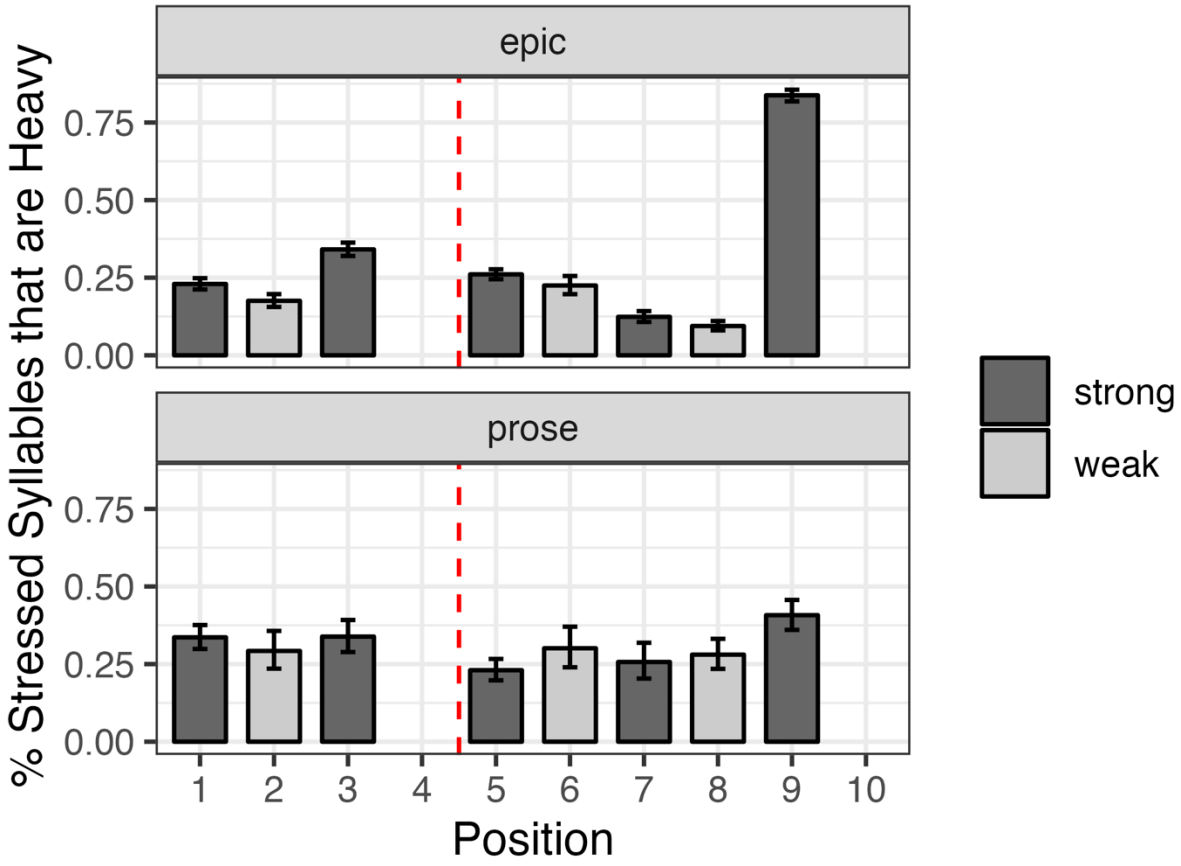
## Strong ~ Accent_Type * Weight + (1 | Shape)

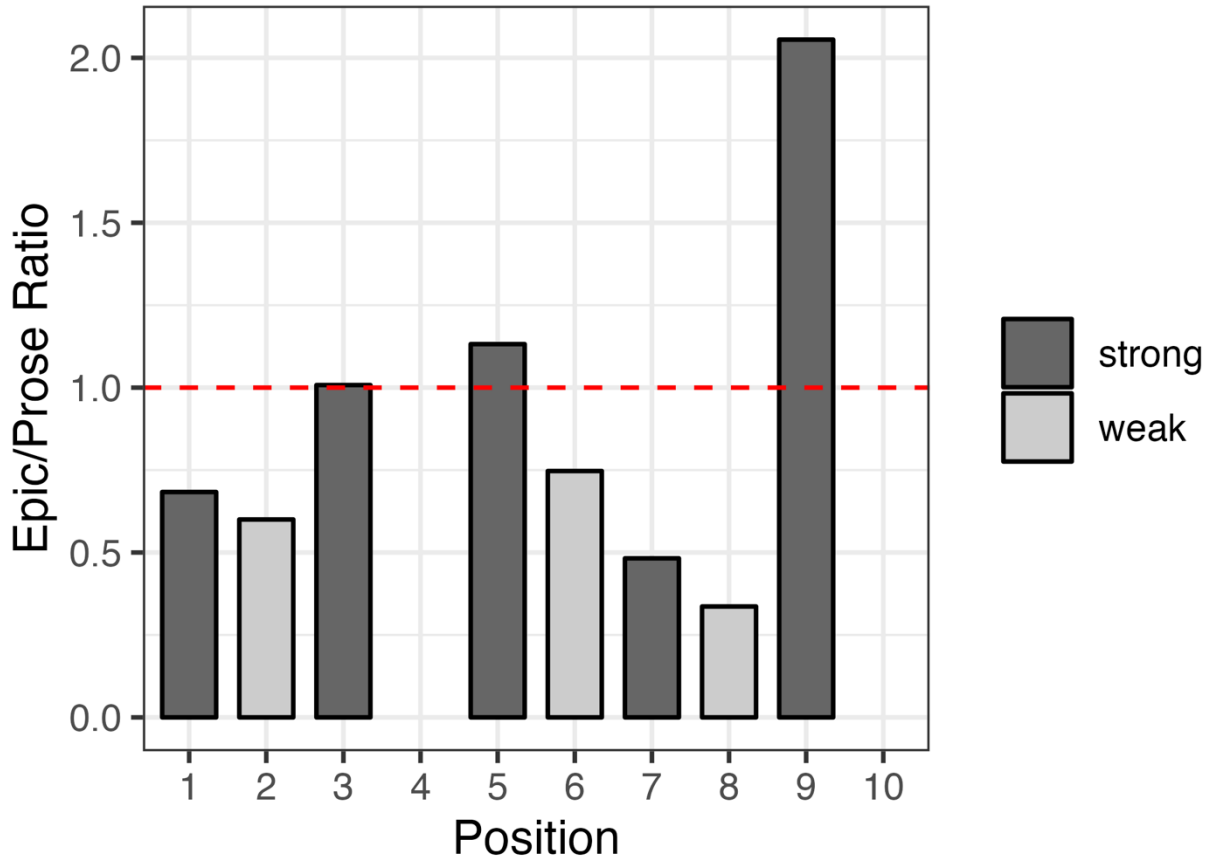
**Shape:** e.g. light-heavy-X-light, X-heavy, X, X-light-light-light (X = position of datum)

| *Random effects* | *Variance* | | *St. Dev.* | |
|---|---|---|---|---|
| Word shape (N = 68 (71)) | | | | |
| (Intercept) | 48.25 | (5.71) | 6.95 | (2.39) |

| *Fixed effects* | *β* | | *St. Error* | | *Wald z* | | *p* | |
|---|---|---|---|---|---|---|---|---|
| (Intercept) | .72 | (.6) | .79 | (.33) | .91 | (1.78) | .36 | (.07) |
| Accent type (difference coded) | | | | | | | | |
| Rising (vs. Unaccented) | .26 | (.06) | .06 | (.13) | 4.34 | (.47) | .000 *** | (.64) |
| Falling (vs. Rising) | .98 | (.18) | .07 | (.12) | 14.77 | (1.44) | .000 *** | (.15) |
| Weight (baseline: Light) | | | | | | | | |
| Heavy | .26 | (.21) | .05 | (.09) | 5.13 | (2.34) | .000 *** | (.02 *) |
| Accent type*Weight interaction | | | | | | | | |
| Rising (vs. Unaccented):Heavy | .69 | (.06) | .11 | (.21) | 6.15 | (.27) | .000 *** | (.79) |
| Falling (vs. Rising):Heavy | −.77 | (−.3) | .14 | (.23) | −5.57 | (−1.29) | .000 *** | (.2) |

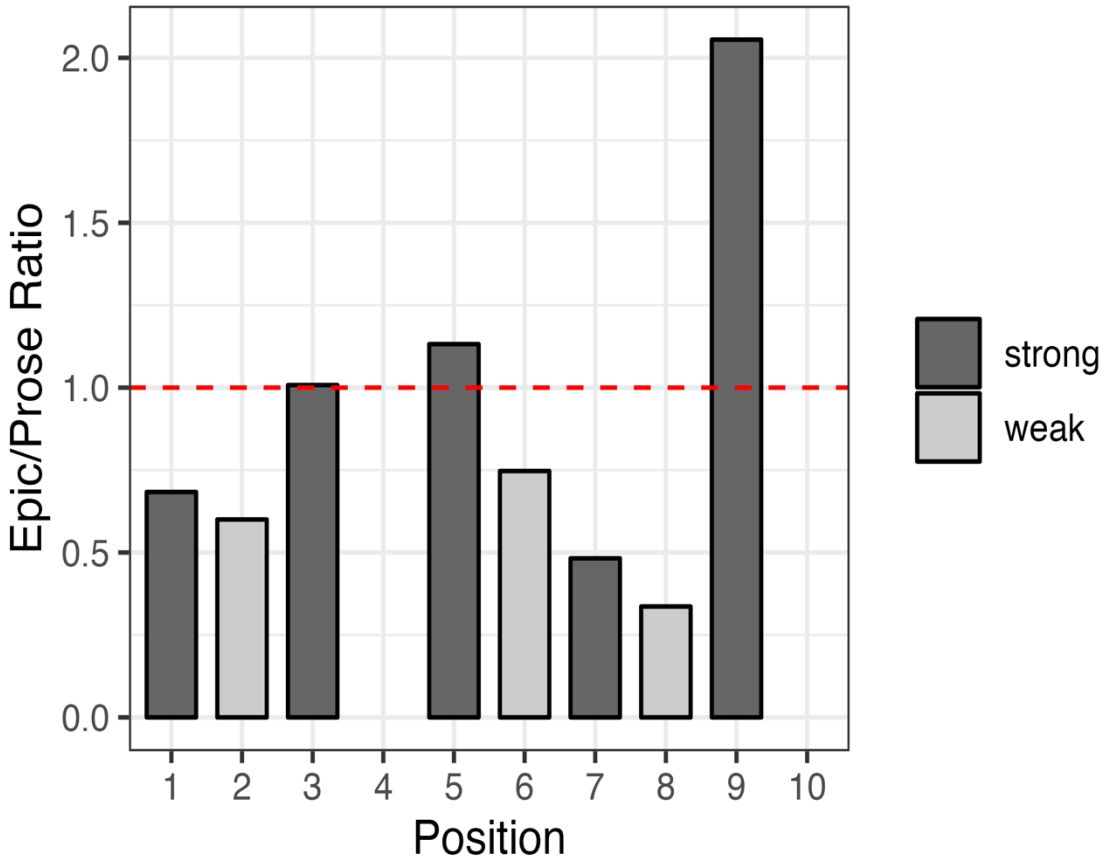
# Weight regulation (stressed syllables only)



# Weight regulation (stressed syllables only)

- Stressed heavies strongly preferred (> 80%) in $S_{cadence}$ (position 9) (Jakobson 1966)
- Elsewhere, stressed heavies are avoided in Weak
- (In Strong, they're closer to baseline)
- Why so few heavies in 1 and 7? The (esp. later) pre-cadence is depleted by the cadence



# Prominence-mapping constraints in meter

(Hanson & Kiparsky 1996, Ryan 2017)

- In Latin/Greek hexameter, strong positions must be heavy
  - STRONG ⇒ HEAVY (a.k.a. *LIGHT/STRONG)
- Multiple implication: In the Finnish Kalevala, strong positions must be heavy, but only if stressed
  - STRESS ⇒ (STRONG ⇒ HEAVY) (a.k.a. *STRESS/LIGHT/STRONG)
- Former is “quantitative meter”
- Latter is “stress-modulated quantitative meter” (Ryan 2017)

# Some mapping constraints for the BCMS epic
## (W = weak position, S = strong position)

- Weight and tone are relatively unregulated in unstressed syllables (plot above)
- A few clear constraints
  1. *Stress + heavy in W
     STRESS⇒(HEAVY⇒S)
  2. *Stress + high in W
     STRESS⇒(HIGH⇒S)
  3. *Stress + light in $S_{cadence}$ (position 9)
     STRESS⇒(S⇒HEAVY) $_{cadence}$

# MaxEnt analysis

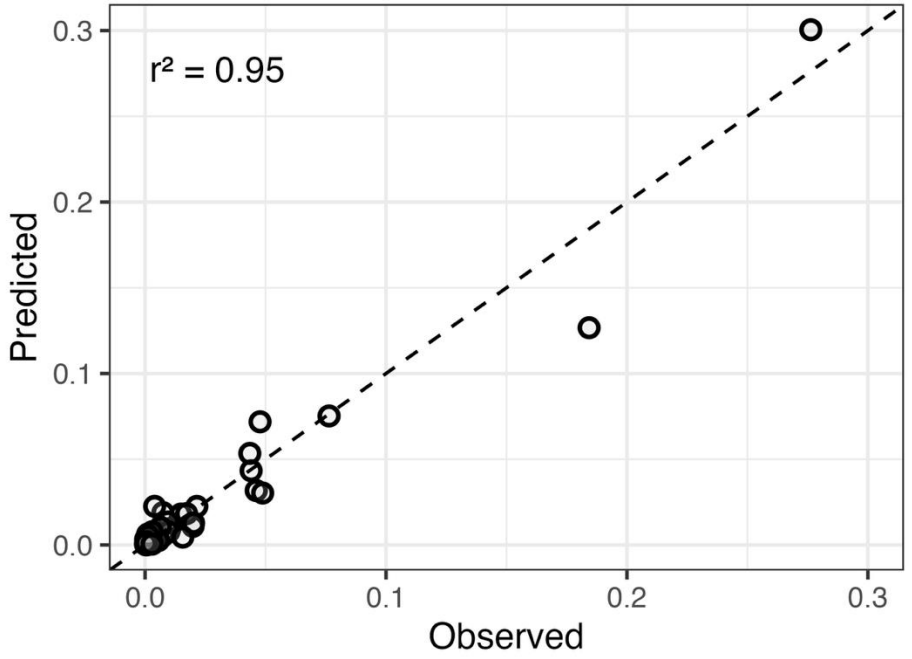
- Maximum Entropy (MaxEnt) Harmonic Grammar
  (Johnson & Goldwater 2003; Hayes & Wilson 2008)
- `maxent.ot` R package (Mayer et al. 2024)
- MaxEnt models for metrics:
  - metricality = Harmony (gradient!) → production frequency
    (cf. Halle & Keyser 1971's frequency hypothesis)
  - input-less models; grammar trained to match line type frequency (≈ Poisson regression)
    (Hayes & Wilson 2008; Hayes et al. 2012, Hayes & Schuh 2019)

# Model selection

- Initial constraint pool (13 constraints): which are useful?
- Stepwise forward model selection:
  start with null model, add constraints one at a time
  (Della Pietra et al. 1997, Hayes et al. 2012)
- information gain metrics:
  likelihood ratio test, AIC and BIC
- all metrics converged on the same final model

# Final model: weights and fit

| Constraint | Weight |
|---|---|
| HEAVY⇒STRONG | .86 |
| STRESS⇒(HIGH⇒STRONG) | 1.38 |
| STRESS⇒(STRONG⇒HEAVY)$_{\text{cadence}}$ | 2.59 |
| HEAVY⇒STRONG$_{\text{cadence}}$ | .57 |
| STRESS⇒(HEAVY⇒STRONG) | 1.07 |



# Maxent ≈ empirical findings

1. Epic decasyllable regulates W, not S (modulo cadence):
   - HEAVY⇒S useful; S⇒HEAVY useless
2. Interactive mapping: doubly-prominent syllables avoided in W
   - STRESS⇒(HEAVY⇒S) and STRESS⇒(HIGH⇒S) selected and relatively strong
3. stressed syllables in $S_{cadence}$ preferably heavy:
   - STRESS⇒(S⇒HEAVY)$_{cadence}$ selected and gets huge weight
4. Jakobson 1966: 75% of stressed syllables in S
   - STRESS⇒S still not selected: Jakobson's effect driven by other constraints

# Prose comparison

1. No ordinary-language baseline (cf. Hayes et al. 2012: 725):
   - True metrical preferences vs. ordinary-language phonology?
2. Prose comparison (Hayes & Schuh 2019): meter overrepresents desirable line types and underrepresents marked ones
   - Perfect lines: 28% of epic corpus, 12% of prose corpus
   - Individual violations:
   1. STRESS⇒(HEAVY⇒S): violated at least once in 32% of prose lines and 14% of epic lines
   2. STRESS⇒(HIGH⇒S): 44% of prose lines vs. 25% of epic lines
   3. STRESS⇒$(S⇒HEAVY)_{cadence}$: 29% prose vs. 6% epic

# Do metrical constraints contribute beyond their ordinary-language effects? (Henriksson 2022)

- Fit model to prose data; obtain **baseline weights**
- Re-fit model to epic data $K$ times ($K$ = N constraints) with baseline weights as constraint-specific Gaussian priors
- default prior: $\mu = 0, \sigma = 100 \rightarrow \mu = w_{\text{baseline}}, \sigma = .01$
- suppress constraints to their ordinary-language contribution
- Then compare each of $K$ models with the full epic model and compare them: ΔBIC (model with baseline priors - full model)

# Constraint contribution (meter vs. prose)

| Constraint | weight (epic) | weight (prose) | weight difference | ΔBIC (prose - epic) |
|---|---|---|---|---|
| HEAVY⇒S | .86 | .76 | .1 | 15.79 |
| STRESS⇒(HEAVY⇒S) | 1.07 | .18 | .89 | 390.99 |
| STRESS⇒(S⇒HEAVY)$_{\text{cadence}}$ | 2.59 | .77 | 1.82 | 1,131.4 |
| HEAVY⇒S$_{\text{cadence}}$ | .57 | .14 | .43 | 81.1 |
| STRESS⇒(HIGH⇒S) | 1.38 | .84 | .54 | 288.76 |

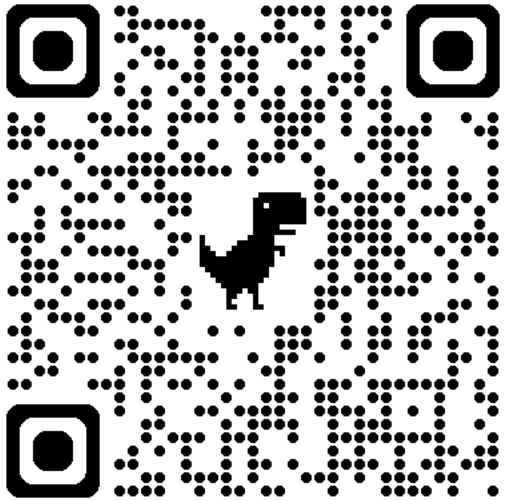
- suppressing any constraint to its baseline contribution leads to loss in model fit

# Conclusion

- Hybrid accentual/quantitative/tonal meter
- Primarily regulates doubly-prominent syllables
  - Stressed heavies
  - Stressed High-toned syllables
- Stress-modulated weight and tone regulation
  - Stress-weight interaction in Finnish, Tamil (Ryan 2017)
  - Stress-tone interaction previously undocumented
- Other Indo-European languages with pitch accent (stress+tone) ignore tone in meter (Greek, Sanskrit)!
- Real effects (not reducible to extraneous factors)

# Thank you!

Replication data:



# Appendix 1: constraints on independent mapping

| **Constraint** | **violation** |
|---|---|
| STRESS⇒S | * for each stressed syllable in W |
| HEAVY⇒S | * for each heavy syllable in W |
| HIGH⇒S | * for each High-toned syllable in W |
| S⇒STRESS | * for each S filled by unstressed syllable |
| S⇒HEAVY | * for each S filled by light syllable |
| S⇒HIGH | * for each S filled by toneless syllable |

# Appendix 2: constraints on interactive mapping

| **Constraint** | **violation** |
|---|---|
| STRESS⇒(HEAVY⇒S) | * for each stressed heavy in W |
| STRESS⇒(S⇒HEAVY) | * for each stressed light in S |
| STRESS⇒(HIGH⇒S) | * for each stressed High-toned syllable in W |
| STRESS⇒(S⇒HIGH) | * for each stressed toneless syllable in S |

# Appendix 3: constraints on cadence

| **Constraint** | **violation** |
|---|---|
| HEAVY⇒$S_{cadence}$ | * for each heavy syllable in $W_{cadence}$ |
| S⇒$HEAVY_{cadence}$ | * for each $S_{cadence}$ filled by a light syllable |
| STRESS⇒$(S⇒HEAVY)_{cadence}$ | * for each stressed light in $S_{cadence}$ |