The syntax–phonology interface in poetic meter: Phonologically conditioned syntactic variation in South Slavic oral folk meter

Abstract

This article analyzes patterned word-order alternations in South Slavic folk meter. Syntactic variation is conditioned by phonological factors such as syllable count, weight, and stress. The results support an interactionist model in which phonological information is directly accessible to syntax. Building on previous work in generative metrics, the article proposes the PROBABILISTIC INTERLEAVING MODEL of the syntax–phonology interface in meter, whose main tenets are: (i) syntactic and phonological factors interact directly in a parallelist system, and (ii) the grammar governing word-order choice is stochastic rather than deterministic. Whereas parallel interactionist models have been previously entertained for meter, they have not been shown empirically to make superior predictions to their non-interactionist alternatives. South Slavic folk meter makes it possible to directly evaluate key predictions of these competing models. Approaches maintaining the feed-forward architecture are shown to make flawed predictions for poetic meter. Contrary to the filtering theory, which holds that phonology may only select between word orders that are equally syntactically well-formed, the data show that phonological constraints trigger deviations from syntactically determined default orders. Moreover, approaches that derive variable word order via post-syntactic movement of prosodic constituents are inconsistent with the observation that in meter, phonology directly references syntactic categories, not strictly their prosodic counterparts.

1 Introduction

Phonological factors can modulate various aspects of sentence structure, including word order (Hetzron, 1972; Zec and Inkelas, 1990; Harford and Demuth, 1999; Wasow, 2002; Rosenbach, 2014; Shih et al., 2015; Shih, 2017b; Shih and Zuraw, 2018; Anttila, 2016; Szmrecsanyi et al., 2017; Ryan, 2019b; Breiss and Hayes, 2020). Coordinate constructions (or binomials) are a prime environment for phonologically conditioned word-order alternations. When semantic factors are controlled for, binomial order is robustly affected by the conjuncts' phonological properties, such as syllable count (Wright et al., 2002, 2005; Benor and Levy, 2006; Morgan and Levy, 2016; Ryan, 2019a). The syllable count effect is illustrated in (1): The binomial order in (1a), with the longer, trisyllabic *sciences* following monosyllabic *arts*, is preferred (per Google Books Ngram data) to its transposition in (1b).

(1) Syllable count effect in coordinate constructions: (1a) > (1b)
  a. arts and sciences
  b. sciences and arts

Phonological markedness constraints may trigger deviation from the canonical order in some syntactic constructions. One such case is German intensifier inversion (Kentner, 2018). Intensifiers like *ganz* 'quite' usually follow the article, but may undergo inversion for rhythmic reasons. In (2), the canonical order (2a) produces a stress clash. Inversion (2b) separates the primary stressed syllables by moving the article *ein* between them. In (3), the canonical order (3a) does not result in a stress clash, rendering inversion (3b) rhythmically unmotivated and therefore ungrammatical. Moreover, the non-canonical order of (3b) brings about a lapse and is more rhythmically marked than (3a). (Relevant stressed syllables are underlined.)

(2) *Inversion possible when canonical order results in stress clash*
  a. Canonical order
    ein ganz junger Mann
    a quite young man

b. Inversion

ganz ein junger Mann
quite a young man
‘a quite young man’ [Kentner, 2018: 126; ex. (3b)]

(3) *Inversion impossible when canonical order is unmarked*

a. Canonical order

ein gänzlich junger Kerl
a quite young lad

b. Inversion

*gänzlich ein junger Kerl
quite a young lad
‘a quite young lad’ [Kentner, 2018: 126; ex. (5a)]

Similar cases of phonologically conditioned syntactic variation include variable adjective–noun order in Tagalog (Shih and Zuraw, 2017) and French (Abeillé and Godard, 1999; Thuilier, 2012), English genitive (Shih et al., 2015; Szmrecsanyi et al., 2017) and dative alternations (Wasow, 2002; Anttila et al., 2010), *to*-optionality in English infinitives (Wasow et al., 2015), and many others.

Poetic meter offers a unique window into phonological effects on word order. Meter tends to maximize phonological well-formedness, allowing phonological constraints to override syntax under certain conditions. Thus, some ill-formed syntactic configurations become available in meter by way of reducing phonological markedness (Kiparsky, 1975; Youmans, 1983, 1989; Fitzgerald, 2003, 2007; Gunkel and Ryan, 2011; Hayes et al., 2012). Consider the Shakespearian line in (4b). The canonical order (*should be blunter*; 4a) maps a trochaic word (*blunter*) onto an iambic template, resulting in the so-called inverted foot (Kiparsky, 1975; boxed below). This mismatch is readily avoided by the non-canonical order of (4b).

(4) a. Canonical order: *should be blunter*

*	W	S	W	S	W	S	W	S	W	S	[unmetrical]
	|	|	|	|	|	|	|	|	|	|	
	Thy	édge	should	bé	blún-	ter	than	áp-	pe-	-títe	

b. Inversion: *should blunter be* (Fitzgerald, 2007, 207)

W	S	W	S	W	S	W	S	W	S	[Son 56.2]
|	|	|	|	|	|	|	|	|	|	
Thy	édge	should	blún-	ter	bé	than	áp-	pe-	-títe	

This article examines variable binomial, adjective–noun, possessive–noun, and verb–object order in the Bosnian/Croatian/Montenegrin/Serbian (BCMS) folk epic. The key demonstration is that this oral tradition’s highly variable word order is fully predictable from a range of phonological factors such as relative word size, syllable weight, and stress.

What distinguishes the present study from other similar studies is its holistic, statistically grounded approach: I analyze all instances of multiple construction types in parallel, in thousands of verse lines, rather than in isolated, highly controlled environments restricted to individual construction types. This makes it possible to provide a comprehensive model of poetic word order and establish with quantitative rigor the precise conditions under which phonological markedness overrides baseline linearization preferences.

The results support an interactionist model (Fitzgerald, 2007; Shih and Zuraw, 2018) in which phonological and syntactic constraints are evaluated together in a parallel constraint grammar. Unlike Fitzgerald (2007), who uses deterministic Optimality Theory (OT; Prince and Smolensky, 1993/2004), I adopt Maximum Entropy (MaxEnt; Goldwater and Johnson, 2003; Hayes and Wilson, 2008), a probabilistic variant of Harmonic Grammar (HG; Legendre et al., 1990), as a model of poetic grammar. MaxEnt accommodates the variable and gradient nature of the phonological effects on poetic word order, and is shown here to outperform rival frameworks: Stochastic OT (StOT; Boersma and Hayes, 2001) and Noisy HG (NHG; Boersma and Pater, 2016). The article contributes to the ongoing debate between stochastic constraint-based frameworks (Zuraw and Hayes, 2017; Smith and Pater, 2020; Flemming, 2021; Hayes, 2022).

Models that assume direct interaction between modules have been entertained for natural language (Shih and Zuraw, 2018; Bruening, 2019; Breiss and Hayes, 2020) and are commonly assumed for meter (e.g. Fitzgerald, 2007). However, to my knowledge, no study has explicitly shown that interactionist models make better predictions for meter than their non-interactionist alternatives. The South Slavic data discussed herein allow us to empirically evaluate some divergent predictions of interactionist and non-interactionist models. Non-interactionist accounts are shown to run into severe problems.

The article is organized as follows. §2 provides background on BCMS word order and folk meter, and introduces the metrical corpus. §3 outlines the phonological factors driving syntactic variation in meter. §4 provides a MaxEnt model of poetic word order. §5 discusses competing models of the syntax–phonology interface in meter. §6 concludes.

2 Background

2.1 Word order in BCMS

The default, unmarked word order in BCMS is SVO (Progovac, 2005; Urošević et al., 1986), as in (5a). Word order is relatively free in the language (modulo clitics; Schütze, 1994; Bošković, 2001), in that permutations of the default SVO order are possible, as in (5b), though these are associated with particular interpretations (e.g. focus and topic).

(5) Default head-initiality in BCMS VPs: *Oni pišu knjigu.* ‘They are writing the book.’

a. Unmarked order (VO)
ɔ.ni piː.ʃuː kɲi.gu
3PL.NOM write.PRS.3PL book.ACC.SG
‘They are writing the book.’

b. Marked order (OV)
ɔ.ni kɲi.gu piː.ʃuː
3PL.NOM book.ACC.SG write.PRS.3PL
‘They are WRITING the book.’

In NPs, word order is less flexible. BCMS adjectival modifiers are prenominal by default, as (6a) shows. The noncanonical order (noun–modifier), shown in (6b), has a high degree of expressivity, being effectively unavailable in most registers. Exceptions include poetry, persuasive speech, and ecclesiastical texts, which occasionally allow the noun–modifier order.

(6) Adjectival modifiers are prenominal: *ljuta guja* ‘angry snake’

a. Unmarked order (modifier–noun)

ʎuː.ta gu:.ja
angry.NOM.SG.F snake.NOM.SG

b. Marked order (noun–modifier)
?? guː.ja ʎuː.ta
snake.NOM.SG angry.NOM.SG.F

‘angry snake’

Possessive pronouns such as *moj-* [mɔj-] ‘my’ pattern with regular adjectives, being invariably prenominal in most registers (7a). Postnominal possessives are highly expressive (7b).

(7) Possessive pronouns are prenominal: *moja knjiga* ‘my book’

a. Unmarked order (modifier–noun)
mɔ.ja kɲi.ga
my.NOM.SG.F book.NOM.SG

b. Marked order (noun–modifier)
?? kɲi.ga mɔ.ja
book.NOM.SG my.NOM.SG.F

‘my book’

2.2 BCMS folk meter

BCMS has a rich oral folk tradition that can be traced back to Common Slavic and, more distantly, Indo-European antiquity (Loma, 2002). The tradition has been abundantly documented since the late 18th century. I focus on the epic decasyllable, the most extensively studied verse form of BCMS oral folk tradition (particularly in Western scholarship).

The epic decasyllable is a trochaic meter in which each line consists of ten syllables. In scansion, these are organized into five trochaic feet, such that odd positions are strong and even positions are weak. A caesura, or break, divides the line into two hemistichs. The first hemistich comprises the initial two feet, while the remaining three feet form the second hemistich (see Figure 1). Hemistich edges are invariably crisp: Prosodic words may not span hemistich boundaries (Karadžić, 1824; Maretić, 1907; Lord, 1960; Jakobson, 1966; Batinić, 1975; Zec, 2008).

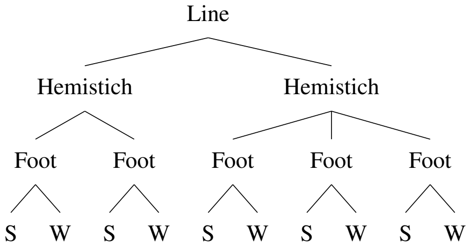

Figure 1: Epic decasyllable as trochaic pentameter.

Monosyllabic prosodic words are generally prohibited in weak (even-numbered) positions (Zec, 2008). Given this independent distributional constraints, I exclude monosyllables from the present survey. Further, the analysis is restricted to word-order variation in the second hemistich, since phonologically conditioned syntactic variation is primarily observed line-finally (Maretić, 1907).

2.3 Metrical corpus

The data for this study include all poems composed in the epic decasyllable from the second edition of Vuk Karadžić's (hereafter Vuk, per BCMS tradition) collection of BCMS folk poetry (1841–1862), that is, the entirety of books 2–4 and some poems from book 1. I built the corpus using the Sketch Engine (Kilgarriff et al., 2004), which automated the annotation process. Annotation included tokenization, lemmatization, and morphological tagging. The annotated corpus (and all supplementary materials for the study) can be accessed in an anonymous OSF repository: https://osf.io/fn9ph/overview?view_only=38b0cbe04000465abb5614b55500f703.

Morphological annotation was implemented using a pre-trained part-of-speech tagger, which assigned to each token a part-of-speech label and a bundle of contextual morphosyntactic features. For nominals, these include case, number, and (where applicable) gender. For verbs, tense and agreement features (person, number, and gender where relevant) are provided.

Once the corpus was constructed, I retrieved via regular expressions all instances of line-final NPs, VPs, and coordinate constructions. The data were processed using a combination of manual annotation and R scripts (R Core Team, 2023). I excluded tokens that were false hits (i.e. tagging errors), and noun–adjective sequences involving secondary predication.[1] The final corpus consists of 15,397 NPs, VPs, and binomials.

Syllable count was added for each token using an R script. I manually coded prosodic information (vowel length and stress position) following Vuk's *Serbian Dictionary* (1852).[2] I then re-imported the dataset into R for statistical analysis and computational modeling.

3 Variable word order in BCMS folk meter

This section examines variable word order in BCMS folk meter. NPs and VPs vacillate between canonical and non-canonical order, as illustrated in (8–9). The syntactic variants in (8–9) do not convey different meanings in the folk epic.

(8) Variable NP order: *careve dvore* [ˈʦa.rɛ.ʋɛ ˈdʋɔː.rɛ] 'tsar's palace'

a. Canonical order: Adj N

ɔd.nɛː.ʨu	=ga	‖	u=	ˈʦa.rɛ.ʋɛ	ˈdʋɔː.rɛ
carry.FUT.1SG	3SG.M.ACC		in	tsar's	palace.ACC.PL

'I will carry him to tsar's palace.' (II; 29:118)

b. Noncanonical order: N Adj

ɔd.nɛ.sɛ	=ga	‖	u=	ˈdʋɔː.rɛ	ˈʦa.rɛ.ʋɛ
carry.AOR.3SG	3SG.M.ACC		in	palace.ACC.PL	tsar's

'He carried him to tsar's palace.' (II; 29:163)

(9) Variable VP order: *izgubiti glavu* [iz.ˈgu.bi.ti ˈglaː.ʋu] 'lose (one's) head'

a. Canonical order: VO

jaː	=ʨu	sʋɔ.ju	‖	iz.ˈgu.bi.ti	ˈglaː.ʋu
1SG.NOM	will.1SG	self's		lose.INF	head.ACC

'I will lose my head (i.e. die).' (IV, 57: 559)

b. Noncanonical order: OV

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[1] Because the annotation is limited to morphological information, it was not possible to algorithmically filter out secondary predicate configurations at the query stage.

[2] For background on BCMS word prosody, see Lehiste and Ivić, 1986; Inkelas and Zec, 1988.

da=	tɕɛ=	a.ɡi	‖	ˈɡlaː.ʋu	iz.ˈɡu.bi.ti
that	will.3PL	agha.DAT		head.ACC	lose.INF

‘That they will lose the agha’s head (i.e. kill him).’ (IV, 57: 74)

Since Vuk collected folk poetry from different regional varieties of BCMS and from many folk poets, one might wonder whether the observed word-order variation is a by-product of aggregating data across different near-categorical (regional or individual) poetic grammars. The data like (8–9) argue against the view that individual grammars are invariably deterministic. Both line pairs display syntactic variation in the same poem and, moreover, with the same lexical items, suggesting that variation is speaker-internal and the metrical grammar is stochastic.

The data for this study include 15,397 NPs, VPs, and binomials from the corpus described in §2.3. NPs constitute the largest portion of the data. Adjective–noun and possessive–noun bigrams are analyzed separately, given that the two constructions show different word-order preferences in meter despite their identical patterning in modern BCMS. Figure 2 plots aggregate rates of word-order options by construction type. The binomial bar is hatched, since binomials do not have a syntactically determined canonical order (though phonology and semantics may skew binomial order; see §3.2.2).

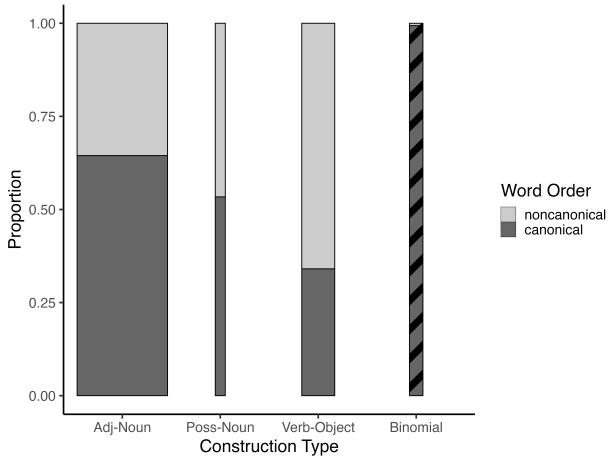

Figure 2: Word-order distribution by construction type. Bar thickness is proportional to sample size.

An important demonstration of the corpus study is that, while construction types have their own syntactic baselines, the phonological factors that shape word order are largely consistent across construction types. Thus, taking into account construction-specific baseline word-order distributions, all construction types are governed by a unified set of phonological constraints.

The discussion in this section proceeds as follows. In §3.1, I introduce the markedness constraints that affect word order in folk meter using adjective–noun data, in which, thanks to the sample size, all phonological environments are populated with ample data. In §3.2, I demonstrate that word-order variation in other construction types follows the same set of phonological regularities as in NPs with adjectival modifiers. In §3.3, I analyze the corpus data using mixed effects logistic regression.

3.1 Adjective–noun order

Adjectival modifiers are prenominal in BCMS, as *ljuta guja* ‘angry snake’ in (6a) shows. In folk meter, NPs may undergo inversion, placing the modifier after the head noun: *guja ljuta* ‘snake angry.’ Deviations from canonical order are not random. First, non-canonical order (noun–modifier) is positionally restricted, being available only in line-final NPs. Inversion rarely, if ever, targets line-internal NPs. Second, folk poets employ the syntactically marked noun-initial order to satisfy phonological markedness constraints. Inversion is therefore phonologically motivated.

When phonological factors are held constant, the canonical order (adjective–noun) is strongly preferred to noun–adjective. I formalize the syntactic pressure to preserve the canonical order as a violable constraint, which I define in (10).

(10) ADJECTIVEFIRST
Adjectival modifiers are prenominal. Assign a violation for every postnominal adjective.

The probability that the modifier follows the head noun depends on the prosodic properties of the two constituents, such as thir relative size, their prosodic weight,[3] and stress position. All relevant prosodic factors have precedents in the literature. For instance, the effect of weight on word order in the epic decasyllable was first observed by Maretić (1907) and has since been discussed extensively (Jakobson, 1966; Batinić, 1975; Ružić, 1975; Foley, 1993; Zec, 2008). The effect of word size has likewise received some attention (e.g., Foley, 1993, 99).

Figure 3 visualizes inversion propensity, that is, the proportion of NPs with a postnominal modifier (as in *guja ljuta* 'snake angry'), as a function of their size (here, syllable count) and weight profile. For the latter effect, the meter tracks only the weight of penultimate syllables (Maretić, 1907; Zec, 2008). For reasons discussed below, the meter prefers to place words with a heavy penult in line-final position. Inversion is therefore most likely when the modifier's penult is heavy and the head's is light (top-right panel), since this satisfies the weight-mapping constraint. The reverse configuration (bottom-left) resists inversion more than any other weight condition. The weight factor is moot in the top-left and bottom-right panels, since the modifier and the head have the same penult weight.

The second hemistich consists of six metrical positions. The head noun and the modifier may therefore occupy six positions at most in aggregate. Empty cells in Figure 3 correspond to metrically impossible word combinations, which exceed the six-syllable limit. Monosyllables are excluded, so each NP member can be minimally disyllabic and maximally quadrisyllabic. Disyllables freely combine with all other admissible word sizes, trisyllables pair with disyllables and trisyllables, and quadrisyllables only pair with disyllables.

3.1.1 End-Weight

The effect of word size is consistent across all weight profiles. The likelihood of the non-canonical, modifier-final order is inversely correlated with the head noun size, and directly correlated with the modifier size. Within each weight profile in Figure 3, inversion rates are highest in the upper-left region, where the modifier is syllabically longer than the head ($4\sigma \times 2\sigma$),[4] as in *bijeloga grada* 'white city' (12b). As head size increases (moving rightward along the horizontal axis), the rates of modifier-finality gradually decrease, reaching their lowest points in the lower-right region, where the head is longer than the modifier ($2\sigma \times 4\sigma$), as in *dragi gospodaru* 'dear master' (12c). Along the diagonal of each panel, the relative size effect is moot, since both NP members are of equal size. I address the differences between the $2\sigma \times 2\sigma$ and $3\sigma \times 3\sigma$ in §3.1.4.

The word-size effect on adjective–noun order is an instantiation of PROSODIC END-WEIGHT (Quirk, 1972; Ryan, 2019a), a preference for longer words to occupy final positions in larger phrasal domains (here, lines). Cross-linguistically, end-weight effects show sensitivity to a range of factors, such as syllable count, vowel length and sonority, and margin complexity. In BCMS folk meter, the only factor contributing to end-weight propensity is a word's syllable count, as formalized in (11).

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[3] Codas do not contribute weight in BCMS; only CVV syllables are heavy (Zec, 2000).

[4] Hereon, in $x\sigma \times y\sigma$, $x\sigma$ is the syllable count of the dependent, and $y\sigma$ is the syllable count of the head.

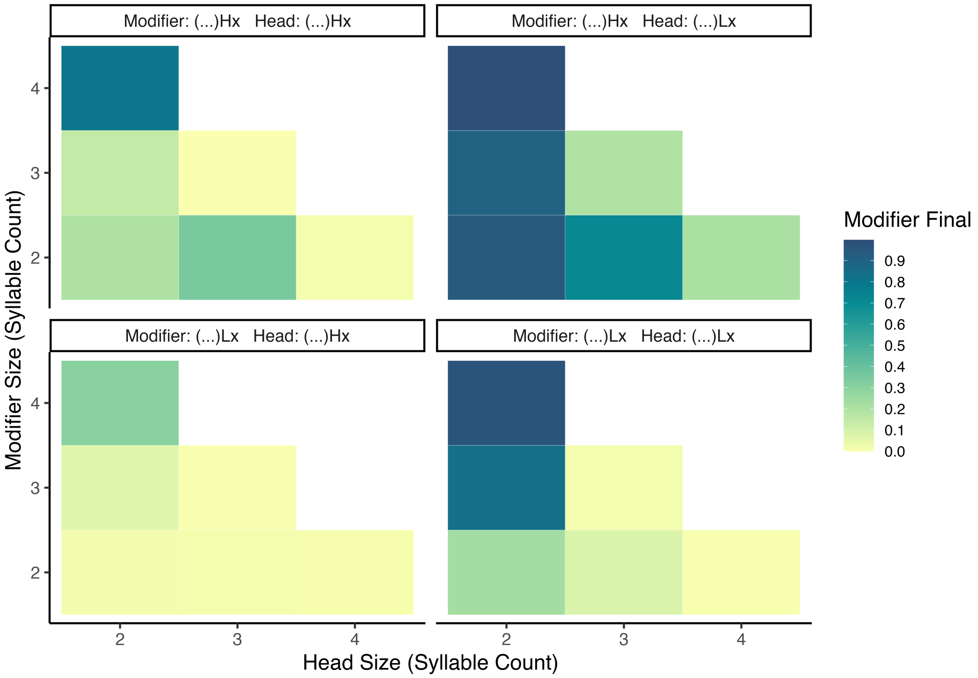

Figure 3: Proportion of NPs that exhibit non-canonical (noun–modifier) order by head size (horizontal axis), modifier size (vertical axis), and weight profile (facets; H = heavy penult, L = light penult, x = final syllable (any weight)). Darker colors indicate higher inversion rates. Empty cells correspond to metrically impossible word size combinations.

(11) END-WEIGHT
Assign a violation for every line whose final prosodic word is preceded by a syllabically longer prosodic word within the second hemistich.

Effectively, END-WEIGHT tracks the syllable count of the line-final prosodic word and compares it to the syllable counts of other prosodic words in the second hemistich (in practice, one or two preceding prosodic words). The constraint penalizes a line-final word that is shorter than a preceding word, but does not require it to be longer than the preceding word(s). END-WEIGHT is defined here as a categorical constraint (in the sense of McCarthy, 2003), primarily for simplicity. The gradient nature of end-weight effects in Figure 3 can be attributed to an independent alignment constraint (§3.1.3).

Much of the variation observed in Figure 3 can be attributed to prosodic end-weight, whose role in the meter is immense (the regression and MaxEnt analyses further bear this out). The data in tableau (12a) provide a baseline for word-order distribution in meter, isolating the effect of syntax (ADJFIRST). With syllable count and penultimate weight both controlled for, the meter strongly prefers the canonical order (adjective–noun) to inversion. When the adjective is longer than the head noun, as in (12b), inversion is preferred, that is, ADJFIRST gives way to END-WEIGHT. Conversely, when the head noun is longer than the modifier, as in (12c), ADJFIRST and END-WEIGHT jointly favor the canonical order, which, being violation-free, approaches the ceiling. (Throughout, the proportions reported in tableaux represent observed candidate frequencies from the corpus.)

(12) a. *ljuta guja* [ˈʎuː.ta ˈguː.ja] ‘angry snake’

	End-W	AdjFirst	p
Adj N ˈʎuː.ta ˈguː.ja			0.80
N Adj ˈguː.ja ˈʎuː.ta		−1	0.20

b. *bijeloga grada* [ˈbi.jɛ.lɔː.ga ˈgraː.da] ‘white city.GEN’

	End-W	AdjFirst	p
Adj N ˈbi.jɛ.lɔː.ga ˈgraː.da	−1		0.20
N Adj ˈgraː.da ˈbi.jɛ.lɔː.ga		−1	0.80

c. *dragi gospodaru* [ˈdraː.giː ˈgɔ.spɔ.daː.ru] ‘dear master.VOC’

	End-W	AdjFirst	p
Adj N ˈdraː.giː ˈgɔ.spɔ.daː.ru			0.98
N Adj ˈgɔ.spɔ.daː.ru ˈdraː.giː	−1	−1	0.02

3.1.2 Weight mapping in the final foot

Another factor at play in Figure 3 is weight mapping. The ninth position of the line (the final strong position; see Figure 1) is preferably assigned a heavy syllable (Figure 4). Accordingly, the meter favors word orders that place a heavy syllable in the ninth position. Because monosyllables are banned from the tenth position (Zec, 2008), the ninth position is always occupied by the penultimate syllable of the line-final word. This explains why the weight mapping effect tracks only the weight of penults.

The attraction of heavy syllables to the final strong position is driven by the constraint in (13). This is a variant of the weight-mapping constraint *Light/Strong, known from Classical quantitative meters, which penalizes light syllables in strong positions (Hanson and Kiparsky, 1996; Ryan, 2017; Kiparsky, 2020). In BCMS folk meter, weight is regulated only in the ninth position (Jakobson, 1966; Zec, 2008; further substantiated by Figure 4). *Light/Strong is therefore restricted to the line-final foot.

(13) *Light/FinalStrong (*L/FinS)
Assess a violation for every light syllable assigned to the final strong position.

The tableaux in (14) show *L/FinS at work (unconfounded by end-weight, which is inactive throughout). Tableau (14a), repeated from (12a), is the baseline: Both NP members have heavy penults, meaning that *L/FinS is uniformly satisfied. In (14b), *L/FinS favors inversion over canonical order, which results in a high inversion propensity.[5] Tableau (14c) shows the opposite of (14b): Placing the modifier after the head is less metrical than the canonical order. Syntax and phonology therefore jointly militate against inversion, which is almost categorically inhibited.

(14) a. *ljuta guja* [ˈʎuː.ta ˈguː.ja] ‘angry snake’

	*L/FinS	AdjFirst	p
Adj N ˈʎuː.ta ˈguː.ja			0.80
N Adj ˈguː.ja ˈʎuː.ta		−1	0.20

b. *ravno polje* [ˈraːʋ.nɔ ˈpɔ.ʎɛ] ‘flat field’

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[5] *L/FinS is not the sole driving force behind inversion in (14b); another contributing factor is avoidance of stressed lights in position 9 (§3.1.5).

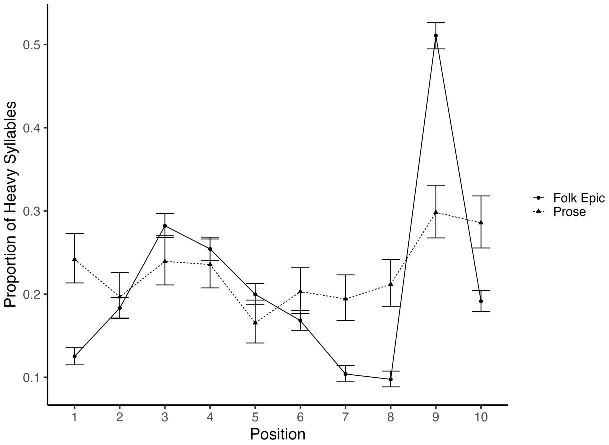

Figure 4: BCMS folk meter regulates weight in the final strong position (position 9), but not elsewhere in the line. The plot shows the proportion of heavy syllables (vertical axis) by position (horizontal axis) in the epic decasyllable (3,771 randomly selected lines; solid line) against a prose sample (dashed line); error bars represent Wilson confidence intervals. In quantitative meters, one expects a zigzag pattern throughout the line, with peaks in strong and dips in weak positions.

	*L/FinS	AdjFirst	p
Adj N ˈraːʋ.nɔ ˈpɔ.ʎɛ	−1		0.06
N Adj ˈpɔ.ʎɛ ˈraːʋ.nɔ		−1	0.94

c. *mila majka* [ˈmi.la ˈmaːj.ka] ‘beloved mother’

	*L/FinS	AdjFirst	p
Adj N ˈmi.la ˈmaːj.ka			0.98
N Adj ˈmaːj.ka ˈmi.la	−1	−1	0.02

3.1.3 Alignment

The patterning of trisyllables is somewhat exceptional, calling for two additional metrical constraints: ALIGN(ω_{max}, R, Ft, R) and TRISYLLABLEINERTIA. I start by introducing the former.

Recall from Figure 3 that modifier size and inversion likelihood are positively correlated: Controlling for the size of the head noun, the longer the modifier, the higher the probability of modifier-finality. As a result, we expect a consistent gradient along the left vertical: Modifier-finality rate should increase steadily going from the origin ($2\sigma \times 2\sigma$) to the upper-left region ($2\sigma \times 4\sigma$).

However, the top two panels in Figure 3 depart from the expected gradient. In these weight profiles, the $3\sigma \times 2\sigma$ conditions show lower modifier-finality rates than the corresponding $2\sigma \times 2\sigma$ conditions. This is completely unexpected from END-WEIGHT’s perspective, given that inversion is slightly more frequent in $2\sigma \times 2\sigma$, where END-WEIGHT is moot, than in $3\sigma \times 2\sigma$, where END-WEIGHT directly benefits from it. I illustrate this puzzling pattern in (15–16).

(15) *ljuta guja* [ʎuː.ta guː.ja] ‘angry snake’ ($2\sigma \times 2\sigma$)

a. Adj N:	ˈʎuː.ta ˈguː.ja	0.80
b. N Adj:	ˈguː.ja ˈʎuː.ta	0.20

(16) *jarkoga sunca* [ˈjaːr.kɔː.ga ˈsuːn.tsa] ‘bright sun.GEN’ ($3\sigma \times 2\sigma$)

a. Adj N: ˈjaːr.kɔː.ga ˈsuːn.ʦa 0.85
b. N Adj: ˈsuːn.ʦa ˈjaːr.kɔː.ga 0.15

Similarly, recall that, holding modifier size constant, the size of the head noun and inversion likelihood are inversely correlated: The longer the head noun, the less likely the noncanonical, modifier-final order. This correlation manifests itself in the bottom horizontal. Moving from the origin ($2\sigma \times 2\sigma$) to the bottom-right region ($2\sigma \times 4\sigma$), one expects the rate of modifier-finality to decline monotonically, as the size of the head noun increases.

The gradient holds in three out of four weight profiles, the sole exception being the top-left panel in Figure 3. In this exceptional case, the $2\sigma \times 3\sigma$ condition undergoes inversion more frequently than the corresponding $2\sigma \times 2\sigma$ condition (Fisher's exact test OR = 2.11, $p < 0.0001$). This pattern contradicts END-WEIGHT, since the likelihood of moving a disyllable over a trisyllable (in $2\sigma \times 3\sigma$) is higher than the likelihood of moving a disyllable over a disyllable (in $2\sigma \times 2\sigma$), as the data in (17–18) indicate.

(17) *ljuta guja* [ˈʎuː.ta ˈguː.ja] 'angry snake' ($2\sigma \times 2\sigma$)
a. Adj N: ˈʎuː.ta ˈguː.ja 0.80
b. N Adj: ˈguː.ja ˈʎuː.ta 0.20

(18) *mlada slavuja* [ˈmlaː.da sla.ˈʋuː.ja] 'young nightingale.GEN' ($2\sigma \times 3\sigma$)
a. Adj N: ˈmlaː.da sla.ˈʋuː.ja 0.65
b. N Adj: sla.ˈʋuː.ja ˈmlaː.da 0.35

The unified explanation for both exceptions is that the orders which place a trisyllable in final position are less frequent than END-WEIGHT predicts. Examining the word-size distribution in a sample of poems from Vuk's collection, Ružić (1975, 143–146) reports that lines with a trisyllable in final position are underrepresented in meter, being less frequent than lines ending in a disyllable, and especially than lines ending in a quadrisyllable. This dispreference for final trisyllables explains both departures from the general END-WEIGHT-driven gradient in Figure 3.

What, then, drives this trisyllable-final markedness? I analyze final trisyllable avoidance as an alignment effect (McCarthy and Prince, 1993). The alignment constraint in question, defined in (19), dictates that the right edge of a prosodic word must coincide with the right edge of a foot, penalizing strong positions which contain a word-final syllable. Line-final trisyllables are unproblematic themselves, because their right edge mechanically coincides with the end of the line. However, when a trisyllable is line-final, the preceding prosodic word ends in position 7, the strong position of the fourth foot, which results in an edge misalignment.

(19) ALIGN(ω_{max}, R, Ft, R)
In a foot $Ft(S, W)$, S and W must belong to the same maximal prosodic word, ω_{max}.

Somewhat paradoxically, binomials show a marked tendency to place trisyllables in line-final position (Maretić, 1907; Ružić, 1975), as (20) shows.

(20) *zlata i bisera* [ˈzlaː.ta i=ˈbi.sɛ.ra] 'gold.GEN and pearl.GEN'
a. $2\sigma - 3\sigma$: ˈzlaː.ta i=ˈbi.sɛ.ra 0.97
b. $3\sigma - 2\sigma$: ˈbi.sɛ.ra i=ˈzlaː.ta 0.03

Unlike NPs, final trisyllables in binomials are not preceded by the right edge of another prosodic word, but by the proclitic conjunction *i* 'and,' which forms a recursive prosodic word (Selkirk, 1996) with the following trisyllable. As a result, the line-final maximal prosodic word is quadrisyllabic. If the disyllabic conjunct is final, as in (20b), it hosts the proclitic and forms with it a trisyllabic prosodic word, the very configuration penalized by Align.[6]

Thus, the two seemingly contradictory patterns, namely the strong preference for final trisyllables in binomials and their avoidance in NPs, fall out from the same alignment constraint. The effect of edge alignment is illustrated in Figure 5. In each of the four diagrams, the structure above the melodic tier is the prosodic structure of the linguistic material. The structure below the melodic tier represents the metrical template. Metrical constraints govern the mapping of prosodic structure onto the metrical template. Align governs one aspect of this mapping: the correspondence between the edges of ω_{max} and metrical feet (see Hayes et al., 2012 on the role of edge alignment in meter).

The tableaux in (21) show the full violation profiles of the structures in Figure 5.

(21) Dispreference for prosodic word-foot misalignment

a. *zlata i bisera* [ˈzlaː.ta i=ˈbi.sɛ.ra] ‘gold and pearl’

	End-W	Align	*L/FinS	AdjFirst	p
$2\sigma + 3\sigma$ ˈzlaː.ta i=ˈbi.sɛ.ra			-1		0.97
$3\sigma + 2\sigma$ ˈbi.sɛ.ra i=ˈzlaː.ta	-1	-1			0.03

b. *od jarkoga sunca* [ɔd=ˈjaːr.kɔː.ga ˈsuːn.t͡sa] ‘of bright sun’

	End-W	Align	*L/FinS	AdjFirst	p
Adj N ɔd=ˈjaːr.kɔː.ga ˈsuːn.t͡sa	-1				0.85
N Adj ɔd=ˈsuːn.t͡sa ˈjaːr.kɔː.ga		-1		-1	0.15

In (21a), the preferred binomial order is $2\sigma + 3\sigma$. This candidate violates *L/FinS but is nonetheless chosen near-categorically because the alternative order violates both End-Weight and Align. In (21b), Align and AdjFirst gang up (in the sense of Jäger and Rosenbach, 2006) against End-Weight: The violator of End-Weight (adjective–noun) is strongly preferred to the doubly violating adjective-final alternative.

3.1.4 Trisyllable inertia

Consider the difference between (22) and (23). In (22), the modifier and the head are both disyllabic, whereas in (23), both NP members are trisyllabic. End-Weight, which is sensitive to the relative, not absolute word size, fails to discriminate between the two environments. Nevertheless, these environments show different inversion propensities: Trisyllables (23) resist inversion more than disyllables (22). In other words, while the relative size effect is moot, *absolute* word size appears to play a role.

(22) *ljuta guja* [ˈʎuː.ta ˈguː.ja] ‘angry snake’ ($2\sigma \times 2\sigma$)

a. Adj N: ˈʎuː.ta ˈguː.ja 0.80

b. N Adj: ˈguː.ja ˈʎuː.ta 0.20

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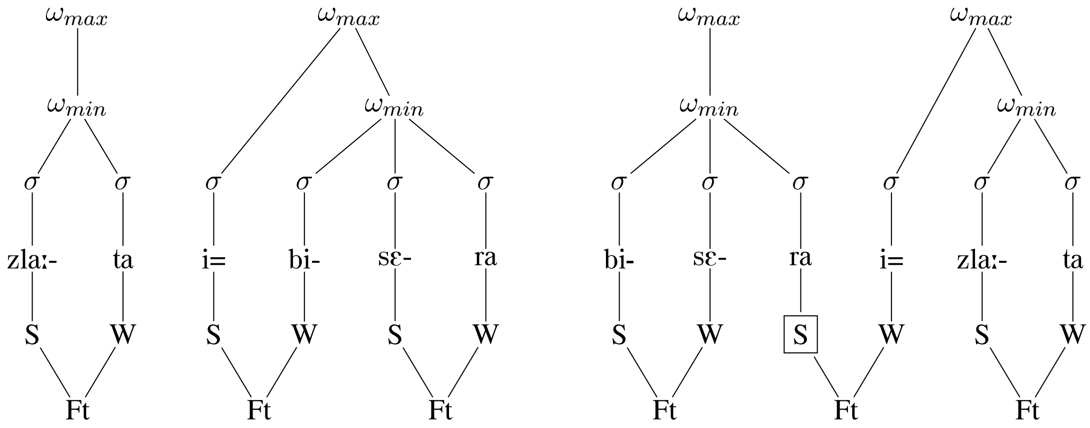
[6] Align has the added benefit of potentially explaining why monosyllables are avoided in weak positions (Zec, 2008): If a monosyllable occupies a weak position, the preceding prosodic word’s right edge occurs foot-internally.

(a) Unmarked (binomials)

(b) Marked (binomials)

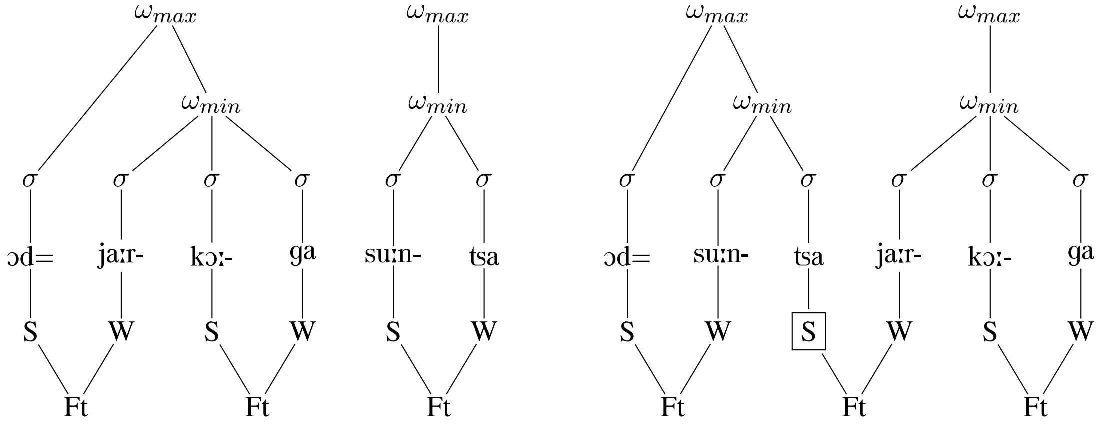


zlata i bisera ‘gold and pearl’

bisera i zlata ‘pearl and gold’

(c) Unmarked (NP)

(d) Marked (NP)



od jarkoga sunca ‘from bright sun’

od sunca jarkoga ‘from sun bright’

Figure 5: Edge alignment markedness in binomials (**a**–**b**) and NPs (**c**–**d**). Strong positions filled by ω_{max}-final syllables incur ALIGN penalties (marked with boxes). Structures **(b)** and **(d)** are more marked than their counterparts in **(a)** and **(c)**, respectively.

(23) *hrišćanska zlamenja* [ˈxri.ʃʨaːn.skaː ˈzla.mɛː.ɲa] ‘Christian insignia’ ($3\sigma \times 3\sigma$)

a. Adj N: ˈxri.ʃʨaːn.skaː ˈzla.mɛː.ɲa 1.00

b. N Adj: ˈzla.mɛː.ɲa ˈxri.ʃʨaːn.skaː 0.00

No constraint introduced thus far accounts for the different inversion propensities in $2\sigma \times 2\sigma$ (22) vs. $3\sigma \times 3\sigma$ (23). Within each environment, the modifier and the head noun are identical along all relevant prosodic dimensions: syllable count, weight, and stress (all items in 22 and 23 have initial stress). Similarly, ALIGN fails to discriminate between canonical and noncanonical orders, since in $2\sigma \times 2\sigma$, both disyllable orders are ALIGN-compliant, and in $3\sigma \times 3\sigma$, the word boundary falls within a foot irrespective of how the two trisyllables are arranged. The asymmetry appears to be based solely on the absolute word size.

The contrast between (22) and (23) is not an isolated pattern. As Figure 6 shows, across all weight profiles and construction types (including now VPs and possessives), the $3\sigma \times 3\sigma$ environments consistently exhibit lower proportions of noncanonical order than the corresponding $2\sigma \times 2\sigma$ environments (modulo the attenuation effect in the bottom-left panel, where inversion rates are pushed to the floor by the weight mapping constraints).

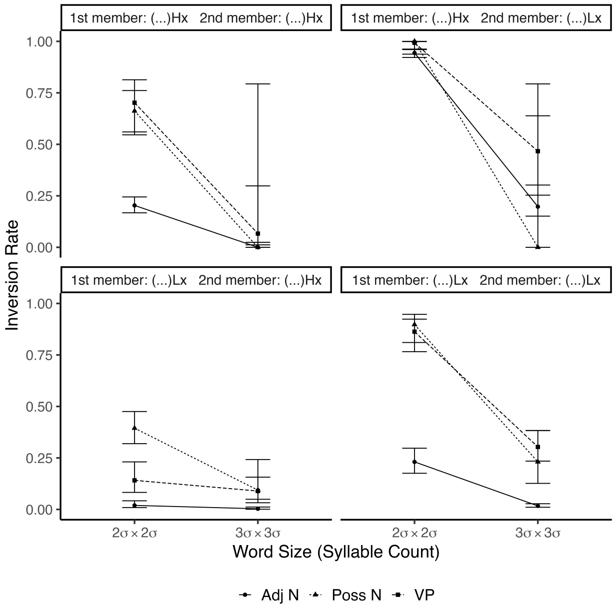


Figure 6: Trisyllable inertia: In each weight profile (panels) and construction type (line patterns), XPs consisting of two trisyllables are less likely to deviate from canonical order than their disyllabic counterparts. The vertical axis shows rates of noncanonical order.

The constraint responsible for this effect, dubbed TRISYLLABLEINERTIA (3σINERT), is perplexing: Its sole purpose is to prevent trisyllables from inverting in the presence of another trisyllable. Trisyllables may invert when the head is disyllabic (subject to an ALIGN penalty), showing that the constraint is not *MOVETRISYLLABLE. Likewise, disyllables frequently invert over trisyllables (§3.1.3), which indicates that the constraint is also not *MOVEOVERTRISYLLABLE. Puzzling as it is, the effect is statistically robust, as Figure 6 indicates and the logistic and MaxEnt models further confirm. The fact that all weight profiles and construction types show the same downward slope is particularly telling, as it suggests the effect is not an artifact of any single prosodic environment. An explanatory account of trisyllable inertia must await future research.[7]

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[7] I suspect that NPs with longer words (e.g. quadrisyllabic adjective and quadrisyllabic noun) may well exhibit inertia, but this

3.1.5 Stress-weight interaction

Avoidance of stressed light syllables in the ninth position is another phonological factor modulating word order. If a stressed syllable is assigned to the final strong position, it is preferably heavy (Jakobson, 1966). The effect is robust: In the random sample of 3,771 lines introduced in §3.1.2, 84% of stressed syllables occupying position 9 are heavy (the grand mean is 29%). The effect is driven by the constraint in (24).

(24) *StressedLight/FinalStrong (*ˈL/FinS)
Assess a violation for every stressed light syllable assigned to the final strong position.

Note that *ˈL/FinS and *L/FinS are in a stringency relation: Every violation of the former is a violation of the latter but not vice versa. Stressed lights are therefore more marked than their unstressed counterparts in the final strong position, as they violate both weight-mapping constraints. Unstressed lights in position 9 are penalized only by *L/FinS. By contrast, heavy syllables do not incur any penalties in the ninth position, regardless of whether they are stressed or not.

*ˈL/FinS's effect on adjective order is isolated in (25–26). The two environments differ only in the position of stress in the trisyllabic modifier: antepenultimate in (25) and penultimate in (26).

(25) *u careve dvore* [u=ˈʦa.rɛ.ʋɛ ˈdʋɔː.rɛ] 'in tsar's castle'
a. Adj N: u=ˈʦa.rɛ.ʋɛ ˈdʋɔː.rɛ 0.93
b. N Adj: u=ˈdʋɔː.rɛ ˈʦa.rɛ.ʋɛ 0.07

(26) *i bijela dana* [i=bi.ˈjɛ.la ˈdaː.na] 'and white day.GEN'
a. Adj N: i=bi.ˈjɛ.la ˈdaː.na 1.00
b. N Adj: i=ˈdaː.na bi.ˈjɛ.la 0.00

In both environments, the canonical order is strongly preferred to the modifier-final alternative. The syntactic constraint AdjFirst and several phonological constraints gang up against End-Weight. Inversion satisfies End-Weight, but violates AdjFirst along with at least two phonological constraints: Align and *L/FinS.

Inversion is more likely to take place in (25) than in (26); Fisher's exact test OR = 10.50, $p = 0.001$. This is because in (26), inversion results in a *stressed* light in the ninth position, incurring a *ˈL/FinS violation on top of all other penalties shared with (25). The tableaux in (27) illustrate this additive effect of *ˈL/FinS.

(27) Stress effect in light penults

a. *u careve dvore* [u=ˈʦa.rɛ.ʋɛ ˈdʋɔː.rɛ] 'in tsar's castle'

	End-W	Align	*L/FinS	*ˈL/FinS	AdjFirst	p
Adj N u=ˈʦa.rɛ.ʋɛ ˈdʋɔː.rɛ	−1					0.93
N Adj u=ˈdʋɔː.rɛ ˈʦa.rɛ.ʋɛ		−1	−1		−1	0.07

b. *i bijela dana* [i=bi.ˈjɛ.la ˈdaː.na] 'and white day.GEN'

	End-W	Align	*L/FinS	*ˈL/FinS	AdjFirst	p
Adj N i=bi.ˈjɛ.la ˈdaː.na	−1					1.00
N Adj i=ˈdaː.na bi.ˈjɛ.la		−1	−1	−1	−1	0.00

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effect cannot be probed in the second hemistich given its limited size.

The minimally distinct environments which isolate the effect of *ˈL/FinS (like 27) are rare because polysyllabic forms with stressed light penults are uncommon in BCMS. In our random sample, only 17% of trisyllables have penultimate stress, approximately half of which are light. Besides lexical statistics, Simonović and Kager (2020) document an ongoing process which shifts prominence to stem-initial syllables in some BCMS verbal paradigms.[8] This shift further depletes the already sparse pool of polysyllables with penultimate stress. Despite the sparsity of the relevant items, the logistic and MaxEnt models support *ˈL/FinS's inclusion in the grammar.

3.2 Other construction types

In this section, I analyze the phonological effects on word order in possessive–noun pairs, VPs, and coordinate constructions (or binomials). The crucial takeaway is that no additional phonological constraints are needed to variable word order in these construction types.

Inversion rates are higher across the board in possessives and VPs than in the corresponding adjective–noun conditions, as I show in §3.2.1. I capture the construction-specific skews by introducing two additional linearization constraints, defined in (28).

(28) a. VerbFirst
VPs are head-initial (see 5). Assign a violation for every head-final VP.
b. PossessiveFirst (PossFirst)
Possessives are prenominal (see 7). Assign a violation for every postnominal possessive.

Further, binomial order is shown in §3.2.2 to be more strictly regulated in meter than in ordinary language. I attribute their patterning to the meter's amplified sensitivity to phonological factors, which completely override competing semantic predictors of binomial order.

3.2.1 Possessives and VPs

Figure 7 shows inversion rates for the possessive–noun construction and VPs. In possessives, non-canonical order is noun–possessive, and in VPs, object–verb. The data are sparser than in the adjective–noun construction, as indicated by missing cells in the heatmaps, especially in possessives. The sparsity stems from the fact that possessives are a closed class comprising exclusively monosyllabic (e.g., *moj*- [mɔj-] 'mine') and disyllabic stems (like *njihov*- [ɲi.xɔʋ-] 'theirs'). The VP data are skewed because verb forms tend to be syllabically longer than their complements,[9] though most prosodic environments are populated reasonably well.

The main findings are the following. Comparing inversion rates in the adjective–noun construction with the possessive–noun construction and VPs (Figure 7), the latter show higher rates of deviation from canonical order. This is true across the board: Any cell in the possessive or VP plots with ample data shows a higher inversion rate than the corresponding adjective–noun condition in Figure 3. The construction types' divergent inversion propensities indicate that each construction has its own syntactic baseline. Further, as mixed effects logistic regression in §3.3 will confirm, the default order that meter employs in possessives (when phonological factors are moot) does not match their canonical order from ordinary language.[10]

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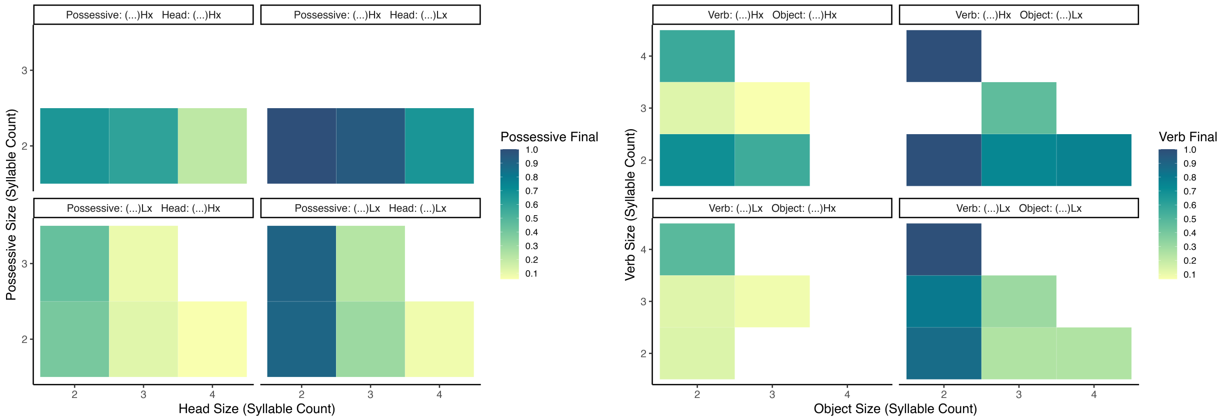
[8] E.g. *stojimo* 'stand.PRS.1PL;' older [stɔ.ˈjiː.mɔ] → [ˈstɔ.jiː.mɔ].

[9] Due primarily to the rich verbal morphology in BCMS (including theme vowels, tense and agreement suffixes, and prefixal aspect markers).

[10] A clarification is in order, to ward off any potential confusion. I draw a distinction between canonical order that each construction exhibits in ordinary language (adjective–noun, possessive–noun, verb–object) and their default order in meter, i.e. the order poets preferably choose when phonological factors are not at play (see further §3.3).



(a) Possessive–Noun

(b) verb–object

Figure 7: Rates of deviation from BCMS canonical order in **(a)** possessive–noun pairs and **(b)** VPs.

Beyond the shifted baselines in possessives and VPs, the phonological effects that modulate constituent order in these construction types are consistent with the adjective–noun data. In each weight profile, inversion propensity is positively correlated with the size of the first member (vertical axis) and inversely correlated with the size of the second member (horizontal axis), indicative of prosodic end-weight (see §3.1). Deviations from the gradient along the leftmost vertical and bottom horizontal (especially in VPs) are attributable edge alignment (§3.1.3). The weight effect (§3.1.2) also follows the same general pattern as in NPs: Inversion propensity is highest when the first member has a heavy penult and the second has a light penult (top-right panel), and lowest when the opposite is true (bottom-left panel). Along the diagonal, $2\sigma \times 2\sigma$ conditions consistently display higher inversion rates than the corresponding $3\sigma \times 3\sigma$, indicative of trisyllable inertia (§3.1.4). The assessment of the stress effect (§3.1.5) in possessives and VPs is hampered by sparse data, but logistic and MaxEnt models provide supporting evidence.

3.2.2 Binomials

Binomial order in meter is less variable than in other construction types (Maretić, 1907). Consider the data in (29–30).

(29) *smilje i bosilje* [ˈsmiː.ʎɛ i ˈbɔ.siː.ʎɛ] ‘immortelle and basil’
a. $2\sigma - 3\sigma$: ˈsmiː.ʎɛ i ˈbɔ.siː.ʎɛ 1.00
b. $3\sigma - 2\sigma$: ˈbɔ.siː.ʎɛ i ˈsmiː.ʎɛ 0.00

(30) *zlata i bisera* [ˈzlaː.ta i ˈbi.sɛ.ra] ‘gold and pearl’
a. $2\sigma - 3\sigma$: ˈzlaː.ta i ˈbi.sɛ.ra 0.97
b. $3\sigma - 2\sigma$: ˈbi.sɛ.ra i ˈzlaː.ta 0.03

In both examples, the preferred binomial order places the longer, trisyllabic conjunct in final position. As already shown in (21a), this strong preference is driven by two constraints: Align and End-Weight. In (29), no constraint favors (29b) over (29a). Consequently, the marked binomial order (29b) is unattested. The tableau for (30) has already been provided in (21a): The disyllable-final order (30b) is penalized by End-Weight and Align, but favored by *L/FinS, which explains its marginal attestation in the corpus.

Binomial order is strikingly fixed in folk meter, as folk poets almost invariably choose the phonologically unmarked options. Meter thus departs from ordinary language, where binomial order is more flexible. To illustrate, Table 1 compares the frequencies of binomial order in four frequently conjoined noun pairs in meter versus ordinary language (srWaC 1.2 corpus; Ljubešić and Klubička, 2014).

A		B		meter % AB	total	ord. lang. % AB	total
[ˈɔ.tat͡s]	‘father’	[ˈmaːj.ka]	‘mother’	100%	17	71%	1,410
[ˈsrɛ.brɔ]	‘silver’	[ˈzlaː.to]	‘gold’	100%	12	31%	996
[ˈnɔ.ga]	‘leg’	[ˈruː.ka]	‘arm’	100%	11	19%	1,757
[ˈʋiː.nɔ]	‘wine’	[ˈra.ki.ja]	‘rakija’	100%	37	71%	658

Table 1: Binomial order in folk epic vs. ordinary language. AB order is less phonologically marked than BA.

Binomial order varies considerably in ordinary language and tends to be fixed in meter. This marks a departure from NPs and VPs, whose order is largely fixed in ordinary language, but may vary more freely in meter. The apparent discrepancy lends itself to a straightforward explanation. In ordinary language, binomial order is affected by a series of factors, both phonological and, importantly, non-phonological. The latter include semantic factors such as animacy, gender, specificity and many others (Cooper and Ross, 1975; Benor and Levy, 2006; Lohmann and Takada, 2014; Morgan and Levy, 2016, a.o.). Phonological predictors thus interact with, and compete against, non-phonological factors. These conflicting pressures lead to more variable binomial order.

Meter heightens sensitivity to phonological factors, effectively suppressing semantic ones. A good example is *ruke i noge* ‘arms and legs’ versus *noge i ruke* ‘legs and arms’ from Table 1. In ordinary language, ‘arms and legs’ is strongly preferred to its transposition (81% vs. 19%), likely due to semantic factors (arms are closer to the perceptual source than legs). In meter, however, ‘legs and arms’ is the only attested order because *ruke* [ruː.kɛ] ‘arms’ has a heavy penult, being attracted to final position by the weight-mapping constraints. With competing syntactic and semantic pressures virtually out of the way, phonological markedness alone governs binomial order in meter.

Further evidence that phonological markedness is the sole determinant of binomial order in meter comes from the fact that the only binomials that show word-order alternation are those whose conjuncts have identical prosodic properties, such that phonology is indifferent, as in (31).

(31) *i viša i lipša* [i=ˈʋi.ʃaː i=ˈlip.ʃaː] ‘taller and prettier’

a. ɔd= mɛ.nɛ =jɛ || i= ˈʋi.ʃaː i= ˈlip.ʃaː
from 1SG.GEN be.PRS.3SG and taller and prettier
‘She is taller and prettier than me.’ (I, 342:27)

b. nɛk =jɛ maːn.da || i= ˈlip.ʃaː i= ˈʋi.ʃaː
though be.PRS.3SG Manda.NOM and prettier and taller
‘though Manda is prettier and taller’ (I, 342:31)

3.3 Regression analysis

The results of the corpus survey are statistically assessed with a mixed effects logistic regression model, using the `lme4` R package (Bates et al., 2015). The regression dataset uses the violation vector format (Smith and Pater, 2020), shown in Table 2. For each tableau, constraint scores are computed as the violation differences between the canonical and noncanonical orders. A positive score indicates that canonical order incurs a violation not shared by noncanonical order, that is, the constraint favors inversion. A negative score indicates that the constraint favors canonical order. Zero indicates that the constraint is indifferent between the two orders.

Example		Can. order	Inversion	END-W	ALIGN	3σINERT	*L/FINS	*ˈL/FINS
[ˈʎuː.ta ˈguː.ja]	‘angry snake’ (12a)	333	85	0	0	0	0	0
[ˈbi.jɛ.lɔː.ga ˈgraː.da]	‘white city’ (12b)	83	341	+1	0	0	0	0
[draː.giː ˈgɔ.spɔ.daː.ru]	‘dear master’ (12c)	216	3	−1	0	0	0	0
[ˈʦa.rɛ.ʋɛ ˈdʋɔː.rɛ]	‘tsar’s castle’ (27a)	853	69	+1	−1	0	−1	0
[bi.ˈjɛ.la ˈdaː.na]	‘white day’ (27b)	130	1	+1	−1	0	−1	−1

Table 2: Word order tallies and violation vectors for tableaux (12) and (27).

The dependent variable in the model is a matrix of counts for noncanonical vs. canonical order: `cbind (inversion,canonical)`. The model includes the five phonological constraints introduced in §§3.1.1–3.1.5 as fixed predictors, and random intercepts for construction types. Effectively, the model estimates the log-odds of inversion, that is, deviation from canonical order, as a function of the phonological properties of the head and the dependent. Table 3 summarizes the results.[11]

Random effects	variance	st. dev.		
Construction type (N= 4)	1.75	1.32		
Fixed effects	β	SE	z	p
(Intercept)	−0.35	0.67	−0.52	0.60
END-WEIGHT	1.94	0.07	28.40	0.000
ALIGN	1.77	0.07	26.84	0.000
3σINERT	2.45	0.10	24.65	0.000
*L/FINS	1.84	0.07	27.38	0.000
*ˈL/FINS	1.62	0.08	20.14	0.000

Table 3: Mixed-effects logistic regression output (fixed effects).

Turning to the fixed effects first, all five phonological constraints are positively correlated with the likelihood of inversion. Given the violation coding employed (Table 2), a significant positive effect means that inversion is more likely when the phonological constraint penalizes canonical order more than its noncanonical counterpart.

The global intercept in Table 3 represents the grand mean inversion likelihood across constructions. The random intercepts capture construction-specific baseline inversion propensity when phonological factors are held constant. Construction-specific intercepts, shown in Table 4, are obtained by adding to the grand mean each construction's deviation from it (extracted using the `ranef()` function). Negative construction-specific intercepts indicate that inversion is less likely than canonical order at baseline; positive construction-level intercepts indicate that inversion is more likely than canonical order even at baseline.[12]

The possessive–noun construction has a strong positive intercept, which indicates that meter's default

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[11] A model with random slopes by construction type failed to produce reliable estimates, possibly due to the small number of grouping levels in construction type.

[12] The intercept for binomials is not interpretable, since binomials do not have a canonical order. I arbitrarily coded one binomial order as "canonical" for modeling purposes.

Construction	Constraint	Intercept
binomial	N/A	−1.97
adjective–noun	ADJFIRST	−0.91
possessive–noun	POSSFIRST	1.45
verb–object	VERBFIRST	0.08

Table 4: Random intercepts for construction types.

order differs from ordinary language's canonical order, that is, possessives are postnominal by default in poetry. The VP intercept is also positive but near zero, suggesting that meter may not have a default order for VPs at all (corroborated in §4 by model selection). The meter therefore differs from ordinary language not only phonologically (in that it allows phonology to override syntax), but also *syntactically*, employing for some constructions different default orders from modern standard BCMS. Table 5 summarizes these syntactic differences between ordinary language and meter.

Construction type	Canonical order (BCMS)	Default order (folk meter)
binomials	none	none
NP (adjectival modifier)	adjective–noun	adjective–noun
NP (possessive)	possessive–noun	noun–possessive
VP	verb–object	none (?)

Table 5: Differences in syntactic defaults between modern standard BCMS and folk meter.

The fact that the possessive–noun intercept is positive has ramifications for MaxEnt modeling. If the relevant syntactic constraint simply demanded the ordinary-language default, it would receive a negative weight. An omnibus MaxEnt model that allows negative weights bears this out. POSSFIRST, requiring that possessives be prenominal, receives a strong negative weight (−1.50), consistent with the positive intercept in the regression model. VERBFIRST, requiring head-initiality in VPs, receives a positive weight, albeit minuscule (0.02). On the premise that it is desirable to exclude negative weights in HG (see e.g. Keller, 2000), I reformulate the constraint on possessive–noun order to reflect meter's default preference for postnominal possessives identified by the regression analysis.

(32) POSSESSIVEFINAL
Possessives are postnominal. Assign a violation for every prenominal possessive.

4 A MaxEnt model of poetic word order

In this section, I present a model of BCMS oral folk meter which derives word-order variation from the interaction between phonological and syntactic constraints. The analysis is couched in MaxEnt (Goldwater and Johnson, 2003; Hayes and Wilson, 2008), a probabilistic variant of HG. Much like the logistic model from §3.3, the MaxEnt models discussed here predict word order from the phrase members' prosodic properties. The dependent variable, word-order choice, is binary, since poets choose between adherence to the canonical order and deviation from it.

In §4.1, I introduce MaxEnt as a framework. In §4.2, I conduct model selection to determine which of the proposed constraints are useful. In §4.3, I present the performance metrics for the final model.

4.1 MaxEnt

The phonological effects that condition word-order alternations in meter are subtle and gradient, but statistically robust. The grammar of meter is thus stochastic rather than deterministic. The general framework this study adopts to accommodate the gradience and variation in poetic grammar is MaxEnt (Goldwater and Johnson, 2003; Hayes and Wilson, 2008). The rationale for choosing MaxEnt over alternatives is provided in §5.2.

MaxEnt is a probabilistic variant of HG. In HG, candidates are assigned Harmony scores based on their performance on *all* constraints in the grammar (33). Every constraint k in the constraint set C has a weight w_k, and for each candidate i, c_{ik} denotes the number of violations i incurs to k. The Harmony score H_i is the negative sum of constraint-specific violation counts scaled by the corresponding constraint weights.

(33) $$H_i = -\sum_{k \in C} w_k c_{ik}$$

The MaxEnt grammar is intrinsically probabilistic, directly generating probability distributions over candidates from their Harmonies. Probabilities are computed via the softmax function (34): Harmony scores are exponentiated and normalized by the sum of exponentiated Harmonies over all candidates j in the candidate pool.

(34) Candidate probability in MaxEnt

$$p_i = \frac{e^{H_i}}{\sum_j e^{H_j}}$$

For binary output, (34) reduces to the logistic cumulative distribution function of the Harmony difference between the two candidates (35) (Zuraw and Hayes, 2017; Flemming, 2021). Since our data involve binary output (inversion vs. no inversion), the probability of inversion can be computed as in (35).

(35) Inversion probability as a function of Harmony difference

$$p(\text{inversion}) = \frac{1}{1 + e^{-(H_{\text{inversion}} - H_{\text{canonical order}})}}$$

$$e \approx 2.72$$

All MaxEnt simulations were conducted in R using the `maxent.ot` package (Mayer et al., 2024). The package's `optimize_weights()` function uses limited-memory BFGS (L-BFGS) optimization to find constraint weights that maximize the likelihood of the data given the model. To prevent overfitting (Goldwater and Johnson, 2003), all models use Gaussian priors on constraint weights (μ = 0, σ = 100).

4.2 Model selection

In §3, I introduced eight constraints. These constitute our baseline model of poetic grammar. Ideally, a grammar model should include all and only the constraints that actively contribute to meter, which raises two questions: Can we explain the patterns of syntactic variation in BCMS folk meter with fewer constraints than currently assumed without significant information loss? And does the baseline set contain all constraints needed to capture these patterns, or is recourse needed to additional constraints?

The model selection procedure implemented here is rooted in the MINIMUM DESCRIPTION LENGTH principle (Rissanen, 1978; Grünwald, 2007), which dictates that added model complexity is justified if and only if the addition of a constraint sufficiently improves model fit. The goal is to find the most parsimonious model (in terms of the number of constraints) that minimizes information loss. As an approximation to the minimum description length principle, I use the Bayesian Information Criterion (BIC; Schwarz, 1978), which trades off model fit against complexity (36).

(36) $\text{BIC} = k\,\ln(n) - 2\,\ln(\hat{L})$
where:
k = N constraints
$\ln(n)$ = log-transformed total N observations
$\ln(\hat{L})$ = model's log-likelihood

BIC is a more conservative inclusion criterion for constraints than other criteria used in the MaxEnt literature: likelihood ratio test (Hayes et al., 2012; Breiss and Hayes, 2020) and second-order Akaike Information Criterion (AIC_c; Shih, 2017a; Henriksson, 2022), given that BIC imposes a stronger penalty for model complexity (Burnham and Anderson, 2004). Lower BIC indicates better fit. The rule of thumb is that the BIC change from subset to baseline model, ΔBIC, must exceed 2 to justify retaining a constraint; ΔBIC > 10 constitutes strong evidence for retention (Raftery, 1995).

4.2.1 Are all baseline constraints justified?

I compare the baseline, superset model (k = 8) against subset models that each omit a single constraint (k = 7). These are nested models in that each subset model is a proper subset of the baseline, differing only in the absence of one constraint. This procedure isolates each constraint's individual contribution, testing whether dropping a given constraint worsens model fit. A constraint is retained when dropping it results in a sufficiently higher BIC: $\Delta\text{BIC}_{\text{subset}-\text{baseline}} > 2$. The results are shown in Figure 8.

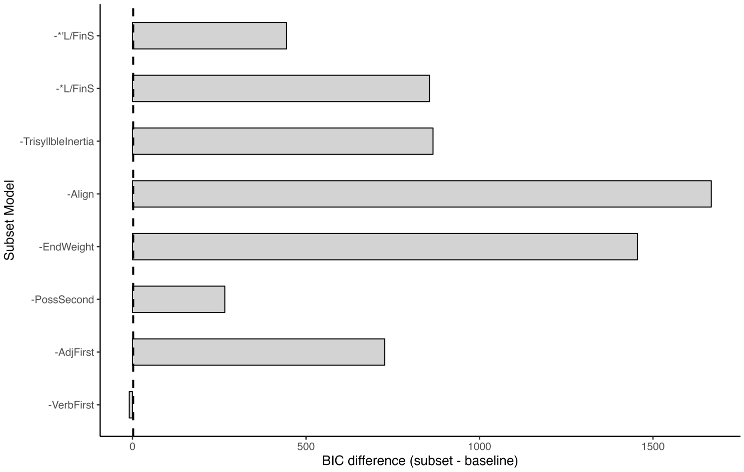

Figure 8: Model comparison (BIC change; baseline model BIC = 9,686). The dashed vertical line represents the inclusion threshold. A constraint is supported when BIC change > threshold.

The BIC comparison finds strong evidence (in the sense of Raftery, 1995) for seven out of eight baseline constraints: Dropping any of these leads to a substantial BIC increase (indicative of poorer fit). The only exception is VERBFIRST, whose omission yields the lowest BIC of all models compared (ΔBIC = -9.55). Although the superset model has a slightly higher log-likelihood than the more parsimonious model without VERBFIRST (Δlog-likelihood = 0.04), this gain is too small to justify the added complexity.

The implication is that the metrical data provide no evidence for a default constituent order in VPs, in line with the logistic model in §3.3. Verb–object order in meter appears to be modulated primarily by phonological factors, much like binomials (§3.2.2), whereas adjective–noun and possessive–noun constructions exhibit clear syntactic defaults.

I therefore retain all baseline constraints except VERBFIRST. I refer to the resulting model as the *updated baseline model*. This outcome accords with the inferential statistical analysis in §3.3: All phonological constraints, along with the syntactic constraints on adjective–noun and noun–possessive order, are robustly supported.

4.2.2 Local conjunction and ban-only-the-worst-of-the-worst

Having excluded VERBFIRST as unnecessary, I now turn to the question of whether additional constraints may be needed in the grammar. Since constraints interact cumulatively, a reasonable starting point is to test the utility of interaction terms, known in constraint-based phonology as LOCAL CONJUNCTIONS (LC; Smolensky, 2006).[13] For a constraint pair A, B, their LC A & B assigns a violation whenever A and B are simultaneously violated in a designated local domain (here, verse line). MaxEnt grammars produce a wide range of cumulativity effects (linear and non-linear) with no recourse to LC (Breiss and Albright, 2022). The role of LC in MaxEnt is therefore different from strict-ranking OT, where LCs are used to accommodate all instances of ganging-up cumulativity (Smolensky, 2006; Pater, 2009). In MaxEnt, LCs amplify the severity of coincident constraint violation, being particularly helpful in cases of extreme superlinearity, where the effect of simultaneously violating multiple constraints is much more severe than a combination of their independent effects (Green and Davis, 2014; Shih, 2017a; Milenković, 2026).

Hayes (2021, 38) notes that liberal use of LC in MaxEnt undermines the "possibility of making strict predictions about quantitative signatures." I adopt a strict inclusion criterion for interaction terms: Much like the simplex constraints used here are statistically corroborated and have a precedent in the literature, the same must be true of their LCs. One conjunction this meets these criteria is END-WEIGHT & *L/FINS, defined in (37).

(37) END-WEIGHT & *L/FINS
Assign a violation for every verse line that violates both END-WEIGHT and *L/FINS.

Verse lines may violate either END-WEIGHT or *L/FINS, but the coincident violation of these independent constraints are vehemently avoided. That these two independent metrical factors are somehow interrelated has been known for more than a century. For example, Maretić (1907, 59) reports that folk poets strongly disprefer placing light-initial disyllables (like *polje* [ˈpɔ.ʎɛ] 'field') in line-final position. Light-initial final disyllables violate *L/FINS and, when preceded by a longer word, END-WEIGHT as well. This is a typical BAN-ONLY-THE-WORST-OF-THE-WORST pattern (BOWOW; Smolensky, 2006; Legendre et al., 2006). The key finding is that the effect of simultaneously violating END-WEIGHT and *L/FINS is so strong that base MaxEnt cannot capture it adequately by means of its built-in additive cumulativity.

Given the independent violation rates of END-WEIGHT or *L/FINS in meter, their coincident violations are severely underrepresented, as diagrammed in Figure 9.[14] About 20% of lines violate END-WEIGHT but not *L/FINS, and 44% of lines satisfy the former and violate the latter constraint. Only 1% of lines violate both constraints simultaneously. Assuming independence, the chance rate of coincident violation is 0.20 × 0.44 = 9% (observed/expected ratio 0.15). The interaction is therefore SUPERLINEAR (Legendre et al., 2006; Smith and Pater, 2020; Breiss and Albright, 2022), and rather extremely so: Violating END-WEIGHT and *L/FINS has a much more detrimental effect on line frequency than the combination of their independent contributions.

I test the utility of the proposed interaction term using the selection procedure outlined in §4.2.1, comparing the updated baseline model with the superset model enriched with END-WEIGHT & *L/FINS. I use

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[13] Interaction term is a term used in the context of regression analysis, whereas LC is used in HG and OT. Given the conceptual equivalence of the two terms, I use them interchangeably throughout.

[14] The violation-count method is not completely nuanced, as it fails to distinguish between cases where constraint violations are incurred but avoidable, and those where violations are unavoidable (MaxEnt/logistic models do). However, it can serve as a convenient illustration of the extreme underrepresentation of doubly violating verse lines.

	End-W satisfied	End-W violated
*L/FinS satisfied	5,290 (34.4%)	3,112 (20.2%)
*L/FinS violated	6,792 (44.1%)	**203 (1.3%)**

Figure 9: BOWOW diagram: Independent violations of End-Wight and *L/FinS are tolerable and common, but their coincident violations are extremely rare.

BIC as the selection criterion, applying standard inclusion threshold ($\Delta\text{BIC}_{\text{superset}\,-\,\text{baseline}} < -2$). The superset model has a substantially lower BIC ($\Delta\text{BIC} = -171$), which strongly supports the inclusion of the conjoined constraint. Inclusion is further supported by the high weight assigned to the conjunction in the MaxEnt model (see §4.3).

In sum, BCMS folk meter displays a BOWOW pattern which the grammar with simplex constraints only cannot fully accommodate. The interaction necessitates a conjoined constraint even in HG. This finding adds to the growing evidence for LCs in MaxEnt and HG (Hayes et al., 2012; Green and Davis, 2014; Shih, 2017a; Milenković, 2026).

4.3 Final model

In this section, I report the final model's performance. Constraint weights are reported in Table 6. The scatterplot in Figure 10 shows the observed vs. predicted probabilities. Overall, the final model provides a strong fit to the data (weighted $r^2 = 0.97$).

Constraint	Weight
AdjFirst	0.97
PossSecond	1.52
3σInert	2.29
Align	2.24
End-Weight	2.04
*L/FinS	1.81
*ˈL/FinS	0.99
End-Weight & *L/FinS	1.53

Table 6: Constraint weights in the final model.

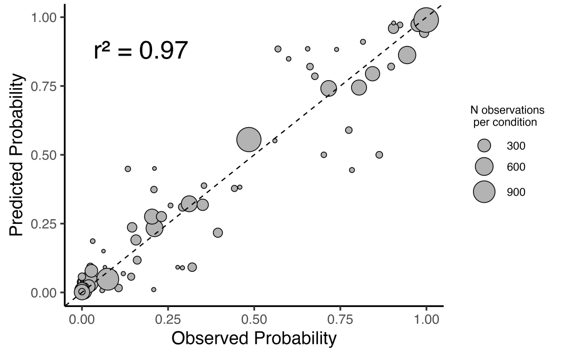

Figure 10: Observed vs. predicted probabilities (final model).

5 Discussion

This section develops the probabilistic interleaving model of the syntax–phonology interface in meter and offers evidence for it. §5.1 outlines the main tenets of the proposed theoretical approach. §5.2 provides evidence for MaxEnt as a model of gradience and variation. §5.3 defines parameters along which possible theories of the syntax–phonology interface differ and locates the proposed model in the space of existing proposals in the literature. §§5.4–5.5 motivate the remaining two ingredients of the probabilistic interleaving model: bidirectional flow of information between syntax and phonology, and parallelism. §5.6 summarizes the section.

5.1 Proposal: probabilistic interleaving model

It is widely assumed that in natural language, all syntactic constraints invariably dominate all phonological constraints (S≫P; Golston, 1995; Tranel, 1998; Anttila, 2016).[15] Proposals have been made that S≫P is suspended in poetic meter, such that phonological constraints may override syntactic ones (Rice, 1997; Golston and Riad, 2000; Fitzgerald, 2003, 2007; Kentner and Franz, 2019). Poets thus avail themselves of syntactic inversions that make verse lines more metrically well-formed (Youmans, 1983, 1989; Fitzgerald, 2007; Hayes et al., 2012). As Fitzgerald (2007) demonstrates, suspending S≫P does not entail that phonology invariably outranks syntax in meter. Were this the case, any deviation from ordinary-language syntax would be permissible in metered verse. Nevertheless, there are inversions that meter does not admit, suggesting that some syntactic constraints dominate their phonological counterparts. Fitzgerald therefore concludes that the most adequate model of the syntax–phonology interface in meter is one in which syntactic and phonological constraints are interleaved (e.g., S≫P≫S).

The present analysis adopts the gist of Fitzgerald's interleaving approach, with one important modification. I propose a PROBABILISTIC INTERLEAVING MODEL of the syntax–phonology interface in meter, in which syntactic and phonological constraints are part of a single parallel probabilistic weighted-constraint grammar. The probabilistic interleaving model, I show, accounts for the gradient nature of phonological effects on poetic word order, along with the ubiquitous interactions between independent factors in the grammar.

In BCMS folk meter, it happens to be true that most phonological constraints outweigh syntactic ones (as Table 6 shows). However, despite being individually weaker than most phonological constraints, syntactic constraints do not invariably give way to phonology. An example is provided in (38), repeated here from (12b). Inversion is strongly preferred to the canonical order because the modifier is syllabically longer than the head noun. However, ADJFIRST figures as a counterweight to END-WEIGHT, resulting in a tangible probability for the canonical order.

(38) Phonology outranks syntax, but syntax pushes back: *bijeloga grada* [ˈbi.jɛ.lɔː.ga ˈgraː.da] 'white city.GEN'

			ADJFIRST 0.97	END-W 2.04	*H*	Pred	Obs
a.	Adj N	ˈbi.jɛ.lɔː.ga ˈgraː.da		-1	-2.04	0.26	0.20
b.	N Adj	ˈgraː.da ˈbi.jɛ.lɔː.ga	-1		-0.97	0.74	0.80

In addition, though relatively weak individually, syntactic constraints have robust effects on word-order choice through interactions with phonological constraints. This is illustrated in (39) below.

Taking stock, the grammar of poetic word order is gradient rather than deterministic. Phonological and syntactic factors interact cumulatively, showing joint effects of constraint violations on the frequency of word-order alternatives. These observations motivate a shift from Fitzgerald (2007)'s approach, couched in strict-ranking Classical OT, to a weighted-constraint account situated in MaxEnt HG. The proposed model thus retains Fitzgerald's parallel interactionist grammar architecture, but situates it in a probabilistic MaxEnt system.

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[15] Although counterexamples have been documented (Harford and Demuth, 1999; Teeple, 2008; Shih and Zuraw, 2017).

5.2 MaxEnt as a model of gradience and free variation

The first ingredient of the proposal is MaxEnt as a model of gradience and variation. MaxEnt has precedent in generative metrics (Hayes and Moore-Cantwell, 2011; Hayes et al., 2012; Hayes and Schuh, 2019; McPherson and Ryan, 2018; Henriksson, 2022), though viable alternatives exist, including StOT (Boersma and Hayes, 2001) and NHG (Boersma and Pater, 2016). Here I demonstrate that MaxEnt is best suited to modeling patterned variation of the kind encountered in BCMS folk meter (see McPherson and Hayes, 2016; Zuraw and Hayes, 2017; Smith and Pater, 2020; Flemming, 2021 for a comprehensive framework comparison).

First, I compare the final StOT, NHG, and MaxEnt models (with the eight constraints from Table 6) using mean absolute error, root mean squared error, and r^2, all weighted by sample size.[16] The results are given in Table 7. MaxEnt provides a superior fit to the data compared to the rival frameworks, showing smaller error and higher correlation between observed and fitted probabilities.

Metric	StOT	NHG	MaxEnt
mean absolute error	0.11	0.08	0.04
root mean square error	0.19	0.14	0.07
r^2	0.83	0.90	0.97

Table 7: Error metrics and r^2 for final models in StOT, NHG, and MaxEnt.

Beyond overall goodness-of-fit, there are two substantive reasons why MaxEnt outperforms the alternatives. First, violations of multiple independent constraints interact cumulatively in meter: Coincident violations add up, jointly reducing candidate probability (Jäger and Rosenbach, 2006). StOT predicts only a limited range of such ganging-up interactions, suppressing the joint contribution of interacting constraints (Hayes and Londe, 2006; Maslova, 2007; Smith and Pater, 2020; Flemming and Magri, 2026), which drives much of its poor fit relative to stochastic HGs. To illustrate, in (39), AdjFirst and *L/FinS gang up against End-Weight. StOT erroneously assigns a greater probability to the doubly violating inversion candidate, which satisfies End-Weight. (The numbers below the constraint labels indicate their ranking values/weights.)

(39) Ganging-up cumulativity: *bijelijem gradom* [ˈbi.jɛ.li.jɛm ˈgraː.dɔm] 'white city.INS'

		AdjFirst	End-W	*L/FinS				
	StOT	85.10	86.60	85.20				
	NHG	1.95	3.34	2.39				
	MaxEnt	0.97	2.04	1.81	StOT	NHG	MaxEnt	Observed
a.	ˈbi.jɛ.li.jɛm ˈgraː.dɔm		−1		0.45	0.72	0.68	0.69
b.	ˈgraː.dɔm ˈbi.jɛ.li.jɛm	−1		−1	0.55	0.28	0.32	0.31

Further, the metrical data are rife with instances of simply harmonically bounded word orders. In simple harmonic bounding (Prince and Smolensky, 1993/2004), the violations of one candidate are a proper subset of its rival's violations. Deterministic OT and HG, as well as StOT, categorically exclude simply harmonically bounded candidates, but in MaxEnt, they are never assigned zero probability. This permissiveness is often viewed as problematic, but a strain of work (primarily on meter) reports cases of harmonically bounded candidates with nonzero probabilities that only MaxEnt readily captures (Hayes and Moore-Cantwell, 2011;

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[16] StOT and NHG simulations were conducted in OTSoft (Hayes et al., 2013) using default learner parameters (see Zuraw and Hayes, 2017, 511).

Hayes and Schuh, 2019). Given the preponderance of such cases in BCMS folk meter, MaxEnt's ability to accommodate them emerges as the framework's virtue.

NHG, as implemented here,[17] can likewise assign nonzero probabilities to simply harmonically bounded candidates, but under conditions that differ from MaxEnt, which is beyond the scope of this article. What matters is that in the present setting, NHG assigns a near-floor probability to simply harmonically bounded word orders whose observed probabilities are relatively high. Example (40) puts this remark on a more concrete footing.

(40) Simple harmonic bounding: *ljuta guja* [ˈʎuː.ta ˈɡuː.ja] 'angry snake'

	AdjFirst				
StOt	85.10				
NHG	1.95				
MaxEnt	0.97	StOT	NHG	MaxEnt	Observed
a. ˈʎuː.ta ˈɡuː.ja		1.00	0.99	0.72	0.80
b. ˈɡuː.ja ˈʎuː.ta	−1	0.00	0.01	0.28	0.20

Syntactic inversion is harmonically bounded whenever no phonological constraint justifies deviation from canonical order. In (40), I contend, no phonological constraint compels the adjective in [ɡuː.ja ʎuː.ta] 'snake angry' to occur postnominally, since weight, stress, syllable count, and boundary alignment are all moot. This is a textbook case of simple harmonic bounding: The non-canonical order violates AdjFirst for no apparent reason, while the canonical order is violation-free. Nevertheless, inversion takes place in about one-fifth of lines in (40). In MaxEnt, this unmotivated inversion is explained by the inertia of AdjFirst. This constraint ensures the harmonically bounded word order is dispreferred to the canonical order, but its weight is not high enough to push the bounder close to the ceiling. The quantitative fit is not perfect, but the MaxEnt model does considerably better than its NHG counterpart, which predicts the bounder to be much closer to the ceiling.

Discussion of simple harmonic bounding is inherently confounded by the possibility that the apparently harmonically bounded candidate is favored by a constraint not included in the current set. This, I argue, is not the case here. The adjective and noun in (40) are identical along all prosodic parameters known to affect word order. Moreover, since all examples come from non-rhymed verse, rhyme cannot be responsible for inversion. Other stylistic factors are also controlled for.

Summing up, MaxEnt captures the variable patterns in BCMS folk meter with greater success than the alternative stochastic frameworks considered here. MaxEnt's superior performance comes from its solid handling of ganging-up cumulativity (39) and its permissiveness regarding simple harmonic bounding (40).

5.3 Syntax–phonology interface

The purpose of this section is twofold. The first goal is to situate the proposed probabilistic interleaving model in the spectrum of approaches to the syntax–phonology interface. The second is to identify viable alternatives and compare them with the proposed model. Before evaluating competing theories against the data, I outline three major parameters along which they may differ (41).

(41) Parameters

a. Locus of movement: Do movement operations take place in syntax alone, or can some instances of movement take place in phonology?

b. Directionality: Can syntax directly access phonological information?

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[17] Censored NHG in which winners are picked at random when candidates are tied after noise perturbation (Hayes, 2017; Hayes and Kaplan, 2025).

c. SEQUENTIALITY: Do syntax and phonology apply sequentially or in parallel?

Some approaches maintain that only syntax can perform movement operations (Bošković, 2001), that is, as Shih and Zuraw (2018) put it, "word order and linearization are the purview of (morpho)syntax." By contrast, Agbayani and Golston (2010, 2016); Agbayani et al. (2015) argue that some movement operations take place post-syntactically, in the phonological component, targeting *prosodic* constituents (such as prosodic words and phrases). Evidence for this mechanism comes from apparent movement phenomena that violate syntactic locality constraints, such as Ancient Greek hyperbaton (Agbayani and Golston, 2010).

Arguably the most extensively debated issue at the syntax–phonology interface is whether information between the two modules flows unidirectionally, from syntax to phonology, or bidirectionally. The widely accepted, FEED-FORWARD APPROACH maintains that there is no direct communication between syntax and phonology, and that syntax is PHONOLOGY-FREE (Zwicky and Pullum, 1986a,b; Miller et al., 1997; Anttila, 2016). This accords with the classical Y-model of grammar (Chomsky, 1995), in which syntax is the generative core and phonology is an interpretive branch with no direct impact on the generative component. The feed-forward approach does not exclude phonological effects on word order. Phonologically conditioned word-order variation is either considered external to grammar, i.e. usage-related, [18] or attributed to post-syntactic filtering by phonology (Bošković, 2001; Anttila, 2016). The INTERACTIONIST APPROACH holds that phonological factors can directly influence syntactic processes, that is, syntax has access to phonological information and its output can be directly shaped by it (Shih and Zuraw, 2018; Bruening, 2019; Breiss and Hayes, 2020; see also Richards, 2016, arguing that syntactic operations can be sensitive to prosodic information). Architectures involving bidirectional flow of information between syntax and phonology are commonly assumed for poetic meter (e.g., Fitzgerald, 2007).

Finally, existing models of the syntax–phonology interface differ as to whether the two modules are sequentially ordered or apply in parallel. The standard Y-model and related models instantiate a DERIVATIONAL APPROACH, in which the syntactic component first generates structures that are then fed into the interpretive branches: phonology (PF) and semantics (LF). Models assuming PARALLEL ARCHITECTURES maintain that distinct modules, i.e. dimensions of linguistic structure (syntax, semantics, and phonology), are processed simultaneously rather than in a fixed sequence (Bresnan, 2000; Breiss and Hayes, 2020).

At first glance, it is tempting to conflate directionality with sequentiality, equating non-interactionist with derivational models, and interactionist with parallel models. However, the two parameters are orthogonal: Not all non-interactionist models are inherently derivational, and not all interactionist models are inherently parallelist.

Both non-interactionist and interactionist models of the syntax–phonology interface have derivational and parallel implementations. Figure 11 sketches the derivational variants of (a) the non-interactionist filtering approach of Anttila (2016) and (b) Shih and Zuraw (2018)'s interactionist model.

Non-interactionist and interactionist models can also be implemented in a parallelist system such as classical OT. The directionality of the syntax–phonology interface (i.e. whether phonology can directly influence stntactic operations) is determined by constraint ranking. To ensure that phonological information is invisible to the syntactic component, all syntactic constraints must outrank their phonological counterparts (Golston, 1995; Rice and Svenonius, 1998; Anttila, 2016), as in (42a).[19] By contrast, interactionist parallel models presuppose the interleaving of phonological and syntactic constraints, such that the two constraint types are freely rankable, as in (42b).

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[18] For instance, Miller et al. (1997, 74) maintain that phonological effects on variable adjective–noun order in French represent "a usage tendency that the grammar does not mandate." The authors seem to imply that such gradient effects are extraneous to grammar because they involve statistical tendencies rather than categorical rules, and "grammatical theory does not aim to predict statistical facts about usage" (*op. cit.*, 69). I follow Anttila (2016, 319f.) in rejecting this view.

[19] One caveat is that unidirectionality via $S \gg P$ can only be strictly enforced in deterministic OT. In a system like HG, even if all S outweigh all P, P could still potentially overcome S by means of ganging-up and counting cumulativity (Jäger and Rosenbach, 2006).

(a) Phonology as a post-syntactic filter (adapted from Anttila, 2016, 118).

(b) Interactionist model (derivational variant; reproduced from Shih and Zuraw, 2018, 3, ex. 1).

Figure 11: Derivational implementations of the phonology-as-filter model **(a)** and the interactionist model **(b)**.

(42) a. Unidirectional parallel model as syntax over phonology: $\{S_1, \ldots, S_n\} \gg \{P_1, \ldots, P_n\}$

			S_1	S_n	P_1	P_n
a.		Candidate 1	$*!$			
b.		Candidate 2		$*!$		
c.	☞	Candidate 3			$***$	$**$

b. Interactionist parallel model as interleaved ranking: $P_1 \gg S_1, S_n \gg P_n$

			P_1	S_1	S_n	P_n
a.	☞	Candidate 1				$***$
b.		Candidate 2	$*!$			
c.		Candidate 3		$*!$		

The probabilistic interleaving model proposed in this article falls in the category of parallel interactionist models of the kind presented in (42b). The poetic grammar is assumed to handle phonological and syntactic information simultaneously in a parallelist MaxEnt system, capturing the tension between competing phonological and syntactic pressures with considerable quantitative precision, as shown in §§4.3–5.2.

Having situated the proposed model in the space of possible models of the syntax–phonology inetrface, I now turn to the question of whether a parallel interactionist model is the necessary consequence of the data, that is, whether such a model provides the only viable explanation of phonologically conditioned syntactic variation in BCMS folk meter. §5.4 provides evidence for the interactionist approach. §5.5 justifies the parallelist implementation.

5.4 Interactionist versus non-interactionist models

This section addresses the question of non-interactionist vs. interactionist architectures for poetic grammar. I consider two accounts that uphold the principle of phonology-free syntax: the filtering theory (§5.4.1) and post-syntactic PF movement (§5.4.2). Since non-interactionist models involve more restrictive grammar architectures than their interactionist counterparts (Zwicky and Pullum, 1986a; Golston, 1995; Anttila, 2016), they are to be preferred on grounds of restrictiveness provided they handle the data with equal success. I show, however, that both non-interactionist alternatives fail on this count, and conclude that the interactionist model provides the only viable account of the data.

5.4.1 Alternative #1: Phonology as filter

The FILTERING THEORY, also known as the VARIATION + FILTERING THEORY, holds that phonology cannot feed information into the syntactic component (Bošković, 2001; Anttila, 2016). Syntax generates structures fully oblivious to phonological well-formedness requirements, and phonology functions as a post-syntactic filter over the structures admitted by the syntactic component. The appeal of the filtering theory is that it allows phonology to modulate word order under certain conditions, while preserving the restrictiveness of the feed-forward architecture.

In an OT setting, the filtering effect of phonology on syntax is viewed as the emergence of the unmarked (TETU; McCarthy and Prince, 1994). Phonology is generally overridden by syntax and can affect word order only when syntax itself does not discriminate between the structural variants. Unidirectionality falls out from the uniform ranking of all syntactic constraints over all phonological constraints (Golston, 1995; Rice and Svenonius, 1998; Anttila, 2016). Example (43a) illustrates the suppression of phonology by syntax under the syntax-over-phonology proviso (though note again that a system allowing cumulativity effects could not invariably enforce unidirectionality even if all S $\gg$ all P). Structure 1 in (43a) is phonologically unmarked, but it loses out to its highly phonologically marked competitor, Structure 2, which is preferred by syntax. In (43b), both candidates are syntactically well-formed, so that the winner is determined by the phonological constraint.

(43) Phonological effects on word order as TETU

a.

	S	P
a. Structure 1	*!	
b. ☞ Structure 2		***

b.

	S	P
a. ☞ Structure 3		
b. Structure 4		*!

The filtering theory makes a testable prediction: Phonology can only modulate word order in the absence of a syntactic default (Golston, 1995), as in the toy example in (43). Construction (43a) has a syntactically defined default order, Structure 2, and no degree of phonological ill-formedness can knock it out.

This prediction finds support in pervasive phonological effects on binomial order (Benor and Levy, 2006; Ryan, 2019a) and choice of syntactic construction (Anttila et al., 2010; Shih et al., 2015) across languages. In coordinate structures, there is no syntactically basic order, which is the exact kind of environment where the filtering theory predicts robust phonological effects on word order.[20]

However, phonological effects on word order are not limited to syntactic constructions with no default order, and thus do not invariably instantiate TETU. Cases have been reported in which phonology modulates word order even in the presence of a syntactic default, that is, where one order is preferred by syntax and phonology may trigger deviation from it, effectively overriding syntax (Thuilier, 2012; Shih and Zuraw, 2017, 2018; Ryan, 2019b). Strong evidence to this effect is furnished by the variable order of adjectival modifiers in Tagalog (Shih and Zuraw, 2017). Tagalog adjectives are prenominal by default, but the default order may shift in response to non-syntactic constraints, including phonological ones. This is precisely what we observe in BCMS folk meter: Adjective order can defy the syntactic preference to satisfy phonological constraints (recall e.g. 8–9; 12b–14b).

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[20] In syntactic theory, there is an orthogonal question of whether coordinate structures have flat or hierarchical structures (see e.g. Munn, 1993). This question in no way affects the present discussion; what matters is that per syntax, *X and Y* is not inherently better than *Y and X*.

Proponents of the filtering theory argue that interactionist models are overly permissive (see Golston, 1995), potentially generating ubiquitous effects of phonological well-formedness constraints on word order even in syntactically headed XPs, which are less sensitive to phonology in natural language than e.g. binomials (though see Harford and Demuth, 1999; Kentner, 2018; Shih and Zuraw, 2018; Ryan, 2019b; Breiss and Hayes, 2020, among others). In meter, however, this kind of permissiveness is generally considered unproblematic, even desirable: Meter is assumed to relax the syntax-over-phonology proviso (Golston and Riad, 2000; Fitzgerald, 2003, 2007), allowing the kinds of deviations from syntactic defaults that are rarely, if ever, tolerated in natural language. I return to the restrictiveness issue in §5.6.

BCMS folk meter offers empirical evidence against the filtering theory as a model of phonologically conditioned word-order alternations in poetic meter. Phonological effects on word order are not invariably TETU patterns. Phonology affects poetic word order even when syntax is not indifferent. Whether similar interactionist models can be plausibly extended to ordinary language is a matter of an ongoing debate (Anttila, 2016; Shih and Zuraw, 2018).

5.4.2 Alternative #2: Post-syntactic PF movement and indirect reference

The PF movement approach allows phonology to move prosodic constituents post-syntactically (Agbayani and Golston, 2010, 2016; Agbayani et al., 2015). Here I examine whether PF movement can be implemented as a general theory of phonologically conditioned word-order variation in meter, not the adequacy of the mechanism itself (see e.g. Bošković, 2001 for criticism of PF movement).

As shown in Figure 12, the PF movement approach holds that the syntactic component determines the hierarchical dominance relations between constituents, but not their linear precedence relations. Linear precedence is determined at the interface between syntax and phonology, where the output of syntax is prosodified. The prosodified structures are fed into phonology proper, where phonological well-formedness requirements may shift the existing order of prosodic constituents via PF movement. The model therefore predicts that phonology never refers to syntactic labeling (Agbayani and Golston, 2010, 158) and that domain reference is mediated strictly by prosodic structure, in line with the indirect reference hypothesis (Selkirk, 1986; Nespor and Vogel, 2007; Bennett and Elfner, 2019).

PF movement is not cost-free, being penalized by the anti-movement STAY constraints, such as the one defined in (44).

(44) STAY-φ (Agbayani and Golston, 2010)
No daughter of φ may move.

Given that the PF movement approach assumes indirect reference, it makes a falsifiable prediction about construction-specific inversion rates: Construction types can display different inversion propensities only if they are prosodified differently. This is because phonological constraints may drive movement of *prosodic* constituents, not syntactic movement, which takes place in the syntactic component under purely syntactic conditions. If, for instance, NPs and VPs are both prosodified as prosodic phrases, PF movement of prosodic words within a phrase should be penalized equally by STAY-φ in both construction types.

With that in mind, consider the difference between adjectives and possessives in (45). Recall first that in meter, adjectives are prenominal by default, while possessives are postnominal. The default orders for (45a) and (45b) are therefore *rođena brata* ‘blood broher’ and *družina moja* ‘crew my,’ respectively. Under meter’s default order, the final member in both cases is a disyllable with an initial stressed light, while the preceding element is a trisyllable whose penult is light and unstressed. In both cases, the phonological markedness profiles of the default and non-default orders are identical. Multiple markedness constraints gang up to move the trisyllable over the disyllable (with the exception of ALIGN, which prefers the disyllable to remain line-final). With STAY-φ as the sole anti-movement constraint, the two construction types should display

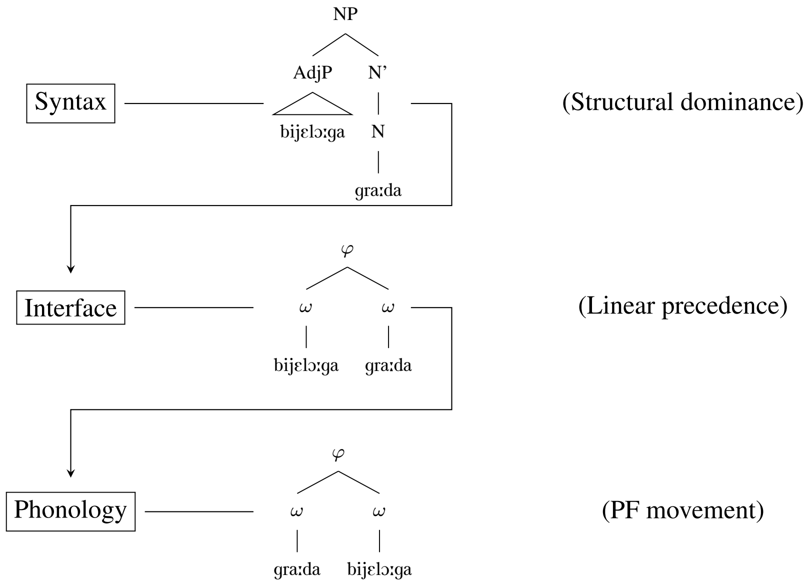

Figure 12: The grammar architecture under the post-syntactic PF movement model (adapted from Agbayani and Golston, 2010, 155; ex. 94).

the same rates of movement because they both consititute prosodic phrase domains. Identical probability distributions across the two tableaux are produced regardless of the weight assigned to Stay-φ.

(45) Stay-φ predicts identical inversion rates for adjective–noun and noun–possessive

a. *rođena brata* [ˈrɔ.ʥɛ.na ˈbra.ta] ‘blood brother’

	Stay-φ	Align	End-W	*L/FinS	End-W & *L/FinS	*ˈL/FinS	H	Pred	Obs
	1.00	2.24	2.04	1.81	1.53	0.99			
a. ˈrɔ.ʥɛ.na ˈbra.ta			−1	−1	−1	−1	−6.37	0.20	0.16
b. ˈbra.ta ˈrɔ.ʥɛ.na	−1	−1		−1			−5.05	0.80	0.84

b. *družina moja* [ˈdru.ʒi.na ˈmɔ.ja] ‘crew my’

	Stay-φ	Align	End-W	*L/FinS	End-W & *L/FinS	*ˈL/FinS	H	Pred	Obs
	1.00	2.24	2.04	1.81	1.53	0.99			
a. ˈdru.ʒi.na ˈmɔ.ja			−1	−1	−1	−1	−6.37	0.20	0.29
b. ˈmɔ.ja ˈdru.ʒi.na	−1	−1		−1			−5.05	0.80	0.71

Contrary to this prediction, the two constructions behave differently: The noun–possessive construction resists inversion more strongly than the adjective–noun construction (Fisher’s exact test OR = 0.45, p =

0.002). If PF movement were responsible for word-order variation, the difference between adjectives and possessives in (45) could only be explained by assuming that they map to different prosodic structures in meter. However, the two constructions both map to prosodic phrases. The anti-movement constraint(s) must therefore directly reference syntactic structure, as is the case in the model proposed in §§3–4. This is shown in (46).

(46) a.

		ADJFIRST	ALIGN	END-W	*L/FINS	END-W & *L/FINS	*ˈL/FINS	*H*	Pred	Obs
		0.97	2.24	2.04	1.81	1.53	0.99			
a.	ˈrɔ.ʥɛ.na ˈbra.ta			−1	−1	−1	−1	−6.37	0.21	0.16
b.	ˈbra.ta ˈrɔ.ʥɛ.na	−1	−1		−1			−5.02	0.79	0.84

b.

		POSSSECOND	ALIGN	END-W	*L/FINS	END-W & *L/FINS	*ˈL/FINS	*H*	Pred	Obs
		1.52	2.24	2.04	1.81	1.53	0.99			
a.	ˈdru.ʒi.na ˈmɔ.ja			−1	−1	−1	−1	−6.37	0.31	0.29
b.	ˈmɔ.ja ˈdru.ʒi.na	−1	−1		−1			−5.49	0.69	0.71

Given that each *syntactic* construction has its own linearization constraint, the grammar in (46) captures the observed construction-specific inversion rates despite their identical prosodification, unlike its STAY-φ counterpart in (45). The results suggest that phonology directly refers to syntactic structure in meter, that is, domain reference is not strictly mediated by prosodic structure. I conclude that the PF movement approach, as implemented in Agbayani and Golston (2010, *et seq.*), does not provide an adequate model of phonologically conditioned syntactic variation in meter.

5.5 Parallelism versus derivationalism

The final ingredient of the proposed theory is parallelism: In meter, syntactic and phonological information is processed simultaneously rather than in an ordered sequence. Derivational alternatives exist, however, such as the one outlined in Figure 11b. I argue that the parallelist implementation adopted here is superior to a derivational model outlined in Shih and Zuraw (2018), because it provides a simple, quantitatively grounded account of the gradient nature of phonological effects on word order and eschews some of the vagueness inherent to the existing derivational implementation.

The upshot of the derivational model considered by Shih and Zuraw is that the syntactic component initially generates the preferred, default order and sends it to phonology, where its well-formedness is evaluated. If ill-formed, the structure is sent back to syntax, which then generates an alternative, nondefault order, whose phonological well-formedness is in turn evaluated by the phonological component.

This looping architecture leaves much room for interpretation, especially in a stochastic system where phonological effects on word order are gradient and subtle. For one, it is unclear under which conditions phonology gets to send the initial output of syntax back to the generative component. Unless properly restricted, the architecture may allow phonology to reject syntactic output until a perfectly phonologically unmarked structure is arrived at. The grammar must then define some well-formedness threshold below which the phonological component may reject the output of syntax. But how exactly should such a threshold be defined? How phonologically marked does a structure need to be for phonology to send it back to the generative component? Should this threshold be defined in terms of relative rather than absolute markedness, that is, how marked a structure is relative to its alternatives? But if the modules apply in an ordered sequence, how does phonology assess the default order's well-formedness relative to non-default orders that have yet to be generated by syntax?

More importantly, in a derivational system, I do not see a straightforward way of generating probability distributions over word-order alternatives as rigorously as in a parallel MaxEnt grammar.

Neither of these concerns constitutes a prohibitive objection against derivational interactionist models. However, future implementations must address the issues of well-formedness thresholds and probability mapping raised here. The parallelist alternative proposed here readily avoids both, obviating the need for additional mechanisms.

5.6 Section conclusion

I propose that in meter, syntax and phonology interact directly, in a parallel MaxEnt grammar. Evidence for MaxEnt over other models of free variation comes from the models' handling of ganging-up cumulativity and harmonic bounding (§5.2). In §5.4, I provide two pieces of evidence against feed-forward models: (i) phonological constraints may affect poetic word order even when the syntactic component defines a default order (contra the variation + filter theory), and (ii) phonology directly references syntactic categories, given that different construction types which map to the same prosodic structures pattern differently in meter. In §5.5, I argue for parallelism over derivationalism, based primarily on the indeterminacy and underspecification of the existing derivational interactionist model (Shih and Zuraw, 2018).

One final remark deserves attention. The proposed model is certainly more permissive than its non-interactionist alternatives, predicting that word order (at least in poetry) can be affected by diverse phonological phenomena. It does not, however, fall into the category of "anything goes" models. The crucial point is that pathological patterns like those that motivated the feed-forward architecture (Zwicky and Pullum, 1986a), e.g., "head-move if labial-initial," arise not from the interleaving of independent phonological and syntactic constraints, but from the random intersection of unrelated phonological and syntactic dimensions (e.g., place of articulation and head movement). As long as such mixed phonology–syntax constraints are excluded from CON, interactionist models are less likely to produce pathological patterns of the kind described by Zwicky and Pullum (1986a); see also Breiss and Hayes (2020, 363). On this proposal, syntactic and phonological constraints remain independent. The modules are distinct, albeit interleaved, and this independence is what makes the model more restrictive than "anything goes." That said, the model does predict that poetic word order can be sensitive to a wide range of phonological factors, potentially still predicting some problematic patterns of phonological influence on syntax. Future work should determine the limits of how far poets will go to enforce phonological well-formedness.

6 Conclusion

This article provides an account of phonologically conditioned syntactic variation in South Slavic folk meter. The results bear on two independent lines of inquiry in linguistic theory: the debate between competing stochastic constraint-based frameworks and the syntax–phonology interface in poetic meter. On the former front, the study supports MaxEnt HG (over StOT and NHG) as a theory of free variation and adds to the existing evidence for conjoined constraints in HG. On the latter, the results support a parallel interactionist model of the syntax–phonology interface in meter, whereby grammatical information flows bidirectionally between the syntactic and phonological components. Whether such a model is viable for natural language is a question for future work. The data analyzed here do not speak directly to the nature of the syntax–phonology interface in natural language, but point to what kinds of empirical phenomena might probe this issue.

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