Tone, stress, quantity, and quality: prosodic patterns and tonal wug-tests in Žiri Slovenian

Gašper Beguš[1] and Peter Jurgec[2]

[1] *Department of Linguistics, University of California, Berkeley*
[2] *Department of Linguistics, University of Toronto*

Abstract

The interactions between segmental and suprasegmental features are cross-linguistically rare. In this paper, we report on a prosodic system of Žiri Slovenian, which displays an intricate set of interactions between tone, stress, quantity, and vowel quality. Some of the patterns are well-motivated (e.g. the preference of High tone syllables to be stressed) while others lack phonetic or phonological motivation (e.g. the preference of long vowels to fall on the second syllable of a trochaic foot). Žiri also displays a rare case of interaction of prosody with vowel quality. To confirm productivity of the observed patterns, we conducted a wug experiment that tested the dependence of stress on vowel quality, word length, and tone. This paper brings forth a new instance of phonetically unmotivated phonological processes at the suprasegmental level, which appear less discussed than at the segmental level. We also discuss methodological issues arising from artificial experiments on tonal processes.

Keywords: pitch accent, Slovenian, Autosegmental Phonology, floating features, laboratory phonology

Word count: 11,222

1 Introduction

The interactions between segmental and suprasegmental features have generated a great deal of interest in phonological theory even though they are not all equally well-studied. The interaction between obstruent voicing and tone, for instance, is fairly well-understood: voiceless obstruents raise pitch and voiced obstruents lower pitch, and this phonetic effect can be phonologized (Hombert 1978; Bradshaw 1997, 1999; Kingston 2007; Donnelly 2007; Lee 2008; Pearce 2007, 2009; Tang 2008). For instance, in Siswati, a High tone becomes raising after a voiced obstruent (Odden 2011).

Vowel height can also affect tone: typically, vowel height correlates with pitch (Ladd & Silverman 1984; Ohala & Eukel 1987; Whalen & Levitt 1995; Fowler & Brown 1997; Connell 2002). This intrinsic fundamental frequency effect can be phonologized. In Awad Bing, for example, vowel-initial words have a Low tone, except for initial [i], which has a High tone (Cahill 2001). A extensive cross-linguistic survey conducted by Becker & Jurgec (2017) reveals that the negative correlation between vowel height and tone is also attested: Ngizim has a predictable High tone on the low vowel [a], but other vowels show no restriction (Schuh 1971). Other vowel quality interactions are also attested: tense vowels select lower tones than lax vowels in Rengao (Gregerson 1976). Beyond segmental features, sonority can also interact with tone (de Lacy 2002). In Uspanteko, tone realization in disyllables depends on the sonority difference between the two syllables (Bennett & Henderson 2013). Stress can also be involved. Interactions between vowel quality and stress have been reported for Standard Slovenian, where lax mid, but not other vowels avoid stress (Becker & Jurgec 2020). More broadly speaking stress has significant effect on vowel quality, both phonetically and phonologically, with unstressed syllables showing fewer vowel contrasts than stressed syllables (Fourakis 1991; Pitermann 2000; Crosswhite 2001). Sonority can also affect stress assignment, with stress generally preferring high sonority vowels (Kenstowicz 1997; de Lacy 2006), even though some of these cases have been recently put into question (Rasin 2017; Shih 2016, 2018; Shih & de Lacy 2020).

In this paper, we present data from Žiri Slovenian, which also displays interactions between prosodic and segmental features. As we will see, Žiri offers evidence that is not related to sonority: it is the markedness of [ɛ] that affects the position of stress and tone. This not only complements our understanding of possible interactions between segmental and suprasegmental properties, but also adds to the literature on the phonetically unmotivated and unnatural processes. These have been discussed substantially in the literature (Blevins 2004; Kiparsky 2006, 2008; Coetzee & Pretorius 2010; Beguš 2018, 2019, 2020, 2022), but most of the discussion focuses on segmental patterns. Less work exist on phonetically unmotivated suprasegmental phonology. In this paper, we present a phonetically unmotivated process that targets the distribution of stress.

Žiri Slovenian also displays interactions between stress and tone. Stress falls on the leftmost High tone (e.g. /pɒmɒ́ɾɑɑ́nʧɒ/ → [pɒˈmɒ́ɾɑɑ́nʧɒ] 'orange'). All words have at least on High tone, which can be seen in words without long vowels, which surface with a penultimate High tone (e.g. /plɛnitsɒ/ → [plɛˈnítsɒ]). What sets Žiri apart from other patterns reported in the literature, are the further interactions of tone and stress with vowel length and quality. Long vowels must have a High tone, and stress falls either on the long vowel (e.g. [kɒˈwɑ́ɑʧ] 'blacksmith') or on the preceding short vowel (e.g. [ˈbɒ́ɫɑ́ɑn] 'sick'). These two stress patterns are lexical and dependent on tone, with one exception: a long [ɛɛ] is always stressed. Other long vowels impose no restriction on stress.

Many prosodic systems incorporate both stress and tone. Ma'ya, for instance, has a tonal contrast on the final syllable as well as lexically contrastive stress (Remijsen 2002). What is more common, however, is that stress and tone interact with one another. In Ayutla Mixtec, the position of stress is predictable from the distribution of tone, generally targeting the highest tone (de Lacy 2002). In Choguita Rarámuri, stress is contrastive, and the stressed syllables contrast three tonal patterns; there are no tonal contrasts in unstressed syllables (Caballero & Carroll 2015). A more complex situation is found in Bosnian-Croatian-Montenegrin-Serbian (BCMS; previously known as Serbo-Croatian in the literature), where stress is assigned to the syllable preceding a High tone, which targets ends of morphological domains, or else the word-initial syllable (Zec 1999).

The complexity of the Žiri prosodic system, which requires reference to three suprasegmental properties, has been noted in the Slavic literature (Stanonik 1977; Greenberg 1987; Beguš 2011). In the context of the Western South Slavic pitch accent, Žiri is considered to have an exceptionally large number of prosodic contrasts. In disyllables, for instance, BCMS contrasts a falling and rising pitch accent, but stress is always initial. Standard Slovenian distinguishes falling and rising pitch accents, but stress can fall on either syllable, resulting in four different combinations. In Žiri, there are seven patterns in total, five of which have initial stress. The larger number is because Žiri allows two non-adjacent pitch peaks, while the other Western South Slavic varieties only allow one. As far as we know, the only other Slavic varieties that approach Žiri are a few BCMS dialects (Kapović 2008, 2015:685ff.). The large number of prosodic combinations also distinguishes Žiri from other Indo-European pitch accent systems, such as in West (Gussenhoven 2004; Köhnlein 2016) and North Germanic (Riad 2012; Myrberg & Riad 2015), where disyllabic words typically have two distinctive lexical pitch accents. Beyond pitch accent, most Slavic languages have secondary stress, which remains beyond the scope of this paper (Gouskova & Roon 2009; Gouskova 2010; Gouskova & Becker 2013; Jurgec 2010; Newlin-Łukowicz 2012; Łukaszewicz 2018; Łukaszewicz & Mołzcanow 2018; Ronelle 2019; see Jurgec 2023 for an overview across Slavic languages).

Our primary description of the Žiri pattern is based on the available literature (particularly Stanonik 1977), complemented by original fieldwork elicitation of the forms from native speakers. The transcriptions are corroborated by an acoustic analysis of pitch, instensity, and duration. We complement the fieldwork data experimentally with a perceptual wug-test on tone. Nonce word experiments involving tone are particularly rare. The present study contributes to the body of literature on tonal wug-tests in various Chinese languages (Zhang et al. 2006; Zhang & Lai 2010; Zhang & Liu 2016). To our knowledge, the experiment conducted in this study is the first tonal wug-test that looks at pitch accent in particular.

The paper consists of three parts. In Section 2, we describe the prosodic patterns in monosyllables and disyllables, which are based on extensive fieldwork. In Section 3, we examine stress and tone alternations which show asymmetries. In Section 4, we test these asymmetries in a perceptual wug-test. We find that the participants' judgments confirm the generalizations observed in the fieldwork data.

2 Prosodic patterns in Žiri

The variety of Slovenian described in this paper is that of Žiri [ʒiˈɾi], a town in Western Slovenia with a population 5,055 (Statistical Office of the Republic of Slovenia 2023). The number of speakers of the dialect can be approximated from the population size, but the precise number of native speakers is unknown.

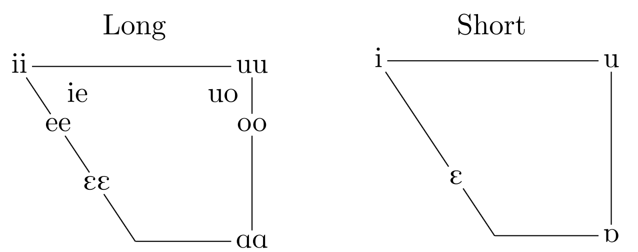
Žiri can be characterized as a pitch-accented variety of Slovenian. This means that tone interacts with other prosodic properties (Zec 1999; Hyman 2006; van der Hulst 2011). In the case of Žiri, tone is dependent on vowel length, vowel quality, and word size. Tone furthermore determines the position of stress. Žiri displays a unique combination of prosodic factors that are not found to the same extent in other varieties of Slovenian or the closely related BCMS. For instance, the Standard Slovenian pitch accent distinction is limited to two contrastive contours (Falling and Rising) limited to the stressed and posttonic syllable. Long vowels are possible only in stressed syllables (see Greenberg 2003 for a overview). In BCMS, the distribution of pitch is even more restricted (stressed syllables only, no word-initial contrast), while the quantity distinctions can appear in the stressed and all posttonic syllables (Ivić 1958; Lehiste 1961; Lehiste & Ivić 1963; Lehiste 1970; Lehiste & Ivić 1986). Like BCMS, Žiri allows unstressed Long vowels, but these can also further contrast tone, thus resulting in a greater number of attested prosodic combinations.

This paper is based on material and analysis in Stanonik (1977), Beguš (2011), and original fieldwork, conducted in the Žiri Valley in the summer of 2018. Participants consented to recording by signing informed consent forms approved by the Institutional Review Board (IRB) committee. Recordings were conducted in participants' homes using Sound Devices USB Pre 2 pre-amplifier (with 44.1 kHz sampling) and AKG C544L cardioid condenser head-mounted microphone. Participants were shown pictures of objects chosen for elicitation from an English picture dictionary (Adelson-Goldstein & Shapiro 2016) that contained no Slovenian words. They were asked to name objects and use them in sentences in order to elicit responses with a preposition. The interviewer (one of the authors) instructed the participants in the Žiri dialect in order to avoid influences of Standard Slovenian. A total of 12 participants (mean age = 68.7, median = 84, range from 23 to 92; the age of one participant is undisclosed) were recorded in elicitation sessions that lasted for approximately 2 hours each. A subset of the recordings were segmented in Praat (Boersma & Weenink 1992). Statistical analysis was performed in R (R Core Team 2013)

2.1 Vowel inventory and vowel length

Žiri distinguishes long and short vowels, as in (1). There are eight distinctive long vowels and four short vowels (Stanonik 1977). Notice also the rounding contrast in the low back vowels (long [ɑɑ] versus short [ɒ]) and the vowel height asymmetry between front and back vowels. The asymmetry plays a central role in the vowel quality restrictions, which apply only to the [ɛɛ].

(1) Žiri vowel inventory



Long and short vowels can appear in any position of the word (initial, medial, final), but there can only be one long vowel per word. Long vowels can be stressed or not, and the same is true for short vowels (Stanonik 1977). Vowel length is thus not predictable, so we posit that the distinction between long and short vowels is underlying. This makes Žiri similar to BCMS (Inkelas & Zec 1988; Zec 1999; Langston 1997) and some varieties of Slovenian (Lenček 1966; Bidwell 1969; Toporišič 1976/2000; Herrity 2000).

We will further see that long vowels impose additional restrictions on tone and stress: all long vowels carry a High tone, and must be either stressed or immediately posttonic. Short vowels must bear a High tone only when stressed and lack it in all other positions.

Phonetically, length is realized as increased duration. Figure 1 shows vowel duration by length. Here we include monosyllabic data across all participants; there were 38 tokens for Short-vowel monosyllables and 129 as many for Long-vowel monosyllables.

As we can see, Long vowels have a substantially higher duration than Short vowels. This differs from many other varieties of Slovenian where vowel length is no longer contrastive (see Jurgec 2011, 2019 for further discussion).

2.2 Tone in monosyllables

Next we look at the tone patterns in monosyllables. Among the words with long vowels, there are two distinct patterns. The first group of monosyllables have long vowels with a falling tone pattern. We transcribe these words with a High tone on the first mora of the long vowel, as in [ée]. The second pattern has a rising contour, which we transcribe with a High tone on the second mora of the long vowel. In the Slavic literature, the falling pattern is termed the circumflex, while the rising is termed the acute (Gvozdanovič 1980; Bethin 1998; Zec 1999; Toporišič 1976/2000; Greenberg 2000; Langston 2006). Finally, short vowels are pronounced with a High tone. The words illustrating the tonal contrasts on all vowels of the inventory are presented in (2).

(2) Distribution of tones in monosyllables (Stanonik 1977)

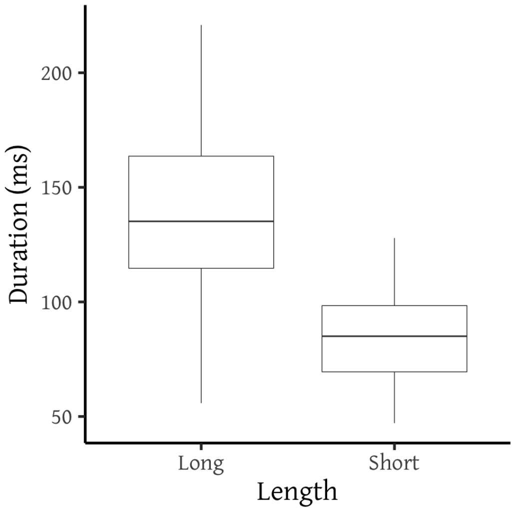


Figure 1: Duration of vowels by length in the elicited monosyllables. The box includes 50% of the data (interquartile range), with the middle line representing the median. The whiskers include the remaining values, as long as they are within 1.5 of the interquartile range. Outliers are represented as dots beyond that range; none are present in this dataset.

Long Falling		Long Rising		Short High	
ʒíiɾ	‘beechnut’	ʒiíɾ	‘Žiri’	zít	‘wall’
líet	‘ice’	spiét	‘bound’		
ɣɾéex	‘sin’	deéʦ	‘male’		
ʧɛ́ɛl	‘forehead’	ɛɛ́nː	‘one’	zɛ́t	‘son-in-law’
dɾúujx	‘others’	uús	‘cart’	łúʧ	‘light’
púot	‘path’	ɣuópʦ	‘muzzle’		
nóoʧ	‘night’	boóxk	‘God’		
ɣɾáɑt	‘castle’	mɑɑ́ʃk	‘male’	kɾɔ́x	‘bread’

Beyond the segmental inventory restrictions in (1), all combinations of vowel quality and tone are observed. It is worth pointing out, however, that Long Rising monosyllables are rarer than Long Falling (Stanonik 1977:298). This has to do with the historical developments in Žiri: Common Slovenian rising pitch developed into Long Falling in Žiri monosyllables (Beguš 2011; Stanonik 1977). The Long Rising pitch observed in Žiri is the result of segmental deletions, analogy, and borrowing. While these new Long Rising words are not rare by any measure, they do not quite reach the number of Long Falling words. For instance, Stanonik (1977) lists 94 Long Falling, but only 26 Long Rising monosyllables (or 22% of all long monosyllables).

The three-way contrast becomes clear when we examine the pitch tracks. Figure 2 presents the pitch tracks. Pitch tracks were extracted from annotated files using a Praat script that measured pitch in 10 equidistant intervals. The data was normalized by participant using R’s `normalize` function which gives the data in z-scores. In total, the data represents 167 tokens (71 are Long Falling, 58 are Long Rising, and 38 are Short). All acoustic data in this paper represents a similar number of tokens.[1]

[1]Rather than presenting pitch tracks of individual tokens, which is the practice in many phonological studies, we analyze multiple pitch tracks from several speakers together. This approach yields a more reliable analysis of tonal trajectories in a language. In the figures provided, both previous and subsequent, we have opted for a descriptive

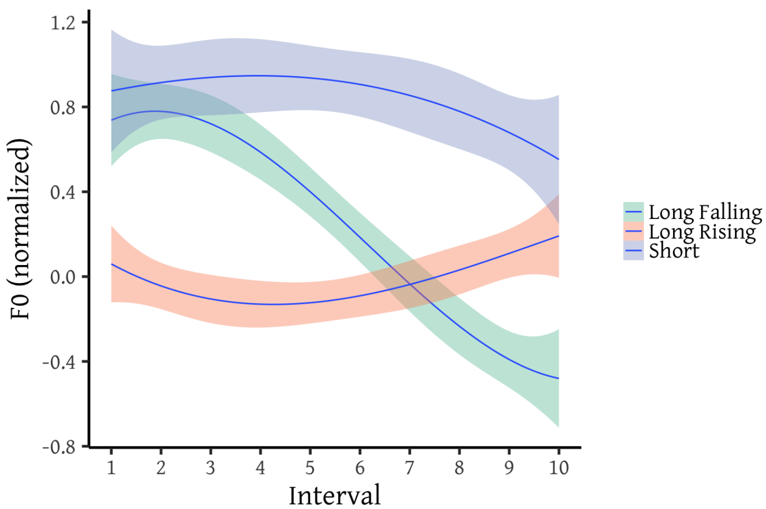


Figure 2: Normalized pitch tracks in the elicited monosyllables. The middle line for each group presents the smoothed trend line using the `lm` function, and the shaded areas present 95% confidence intervals.

The Long Falling pitch has a clear peak at the second interval, whereas the Long Rising pitch starts low and peaks at the end. Finally, the Short vowel has a relatively flat high pitch. The vowel is also significantly shorter, but this is not represented in Figure 2, as all vowels regardless of length have been split into ten intervals.

To analyze these contrasts in duration (Figure 1) and pitch (Figure 2) we make use of autosegmental representations (Goldsmith 1976 et seq.). We propose that only High tone is phonologically active (3), as in BCMS. For the falling contours, the High tone is associated with the first mora, whereas for the rising contours, the High tone is linked to the second mora. Short vowels are monomoraic and have a single High tone.

(3) Tonal contrasts in monosyllables

Long Falling	Long Rising	Short
H	H	H
lees	dees	zɛt

Monosyllables without a High tone are unattested. That is to say, each word must have at least one High tone. As we will see below, we will connect this gap with the interactions between stress and tone: stressed syllables must always have a High tone, and when the word has more than one, stress falls on the leftmost High tone.

2.3 Tone and stress in disyllables

In disyllables and longer words, stress also plays a role. As we well see, the position of stress is entirely predictable from vowel length, tone, and vowel quality. Stress can be readily identified by native speakers and can contrast lexical and grammatical meaning. In this section, we focus mainly on the phonological description of disyllabic prosodic patterns. Acoustically, stress is cued by higher

statistical analysis over an inferential one. This is because a detailed phonetic realization of the contrasts, necessitating a very large annotated data set, is not the focus of this paper and is left for future work.

pitch, increased duration, and higher intensity. We complement the description by acoustic analysis in Section 3.

Most Žiri words are rather short, we base this on the data reported by Stanonik (1977). Žiri does not have epenthesis observed in some other varieties of Slovenian, but exhibits a number of deletions, historically speaking. As such, data from other variaties of Slovenian can act as a conservative estimate of word in Žiri. Jurgec (2019) finds that 70% of stems in Šmartno Slovenian are monosyllabic. In a corpus study, Becker & Jurgec (2020) examine Standard Slovenian, which has 42% monosyllabic words, 51% disyllabic and only 7% trisyllabic or longer. There is only a handful of native stems that are longer than trisyllabic (Jurgec 2007), all others are loanwords. In this paper, we look at monosyllables and disyllables. The patterns described can be extended to longer words, but distributions in longer words are more limited (see also Stanonik 1977).

Initial long vowels. The disyllables can be divided into three groups by vowel length. While no word can have more than one long vowel, the long vowel can be initial or final, and there are also words without long vowels. Starting with disyllables with initial long vowels, we see the same tonal contrast as in monosyllables. These disyllables have both attested patterns, as expected (4). Notice that in these words all end in a consonant, but the same pattern is observed in words ending in a vowel (e.g. [ˈbɾɑ́ɑdɒ] ‘chin, beard’, [ˈzʋéezdɒ] ‘star’ versus [ˈwɑɑ́dɒ] ‘water’, [ˈseémɛ] ‘seed’). In Žiri, long vowels always bear a High tone, either on the first or second mora.

(4) Distribution of tone in disyllables with initial long vowels (Stanonik 1977)

Falling		Rising	
ˈskɑ́ɑkɒt	‘to jump’	ˈmɛɛ́dʋɛt	‘bear’
ˈstɑ́ɑɾɒst	‘age’	ˈeézɛɾ	‘lake’
ˈʒɑ́ɑɫɒst	‘sadness’	ˈjɛɛ́ʧmɛn	‘barley’
ˈɣɑ́ɑjtɾɒʃ	‘rose’	ˈsɾɛɛ́bɒɾ	‘silver’

Disyllables with initial stress were the most common type in our elicitations. Words with initial long vowels are the ones at the core impacted by prosodic alternations, as we will see in the following sections. Figure 3 presents pitch tracks in disyllables. Mirroring the data for monosyllables, we see a clear tonal contrast in the initial, stressed vowel: Long Falling pitch has a tonal peak at the third interval, whereas the Long Rising pitch has it at interval 9. Short vowels have considerably higher pitch overall. The three pitch tracks converge in the second, peninitial vowel. Note that duration is not represented here: initial short vowels are shorter than initial long vowels. The three pitch tracks converge in the second syllable, suggesting the lack of phonological High tone.

The higher pitch of short vowels is not shared among all participants. Figure 4 presents the pitch tracks for six individual participants. Only initial vowels are shown. As we can see higher pitch for short vowels is not shared across all participants. Participant 8, for instance, has a short vowel realization with pitch no higher than the other two pitch tracks. Participant 9 has the highest pitch for short vowels, but it is also subject to high variability, shown as a broad confidence interval. We interpret the overall higher pitch in short vowels when compared to long vowels as a phonetic rather than phonological effect. Additional acoustic parameters (duration, intensity) will be presented in Section 3.

Final long vowels. A more complex situation is found in disyllables with the final long vowel. Four distinct patterns are attested (5). The first two groups of words have final stress (a), and show the two-way tonal contrast seen in monosyllables and disyllables with initial stress. The second

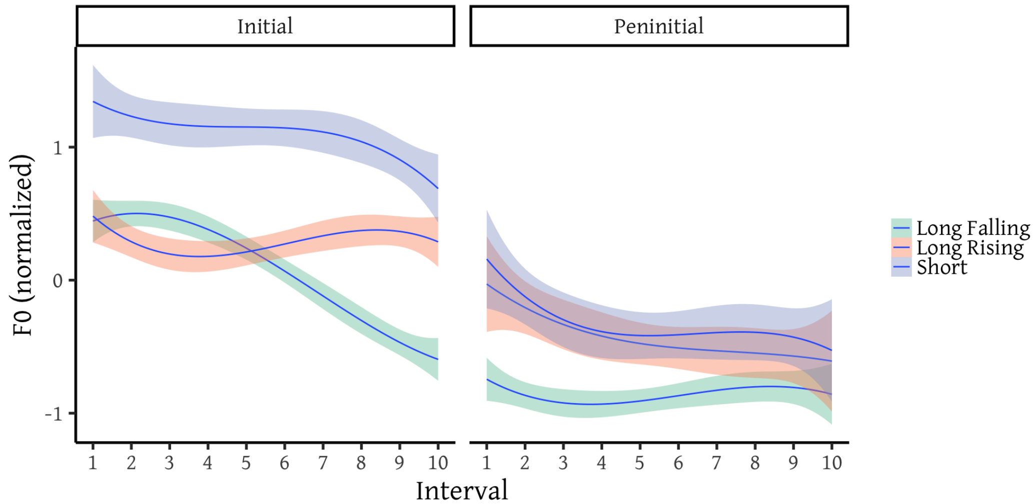


Figure 3: Normalized pitch tracks in the elicited disyllables, separated by vowel (Initial versus Peninitial).

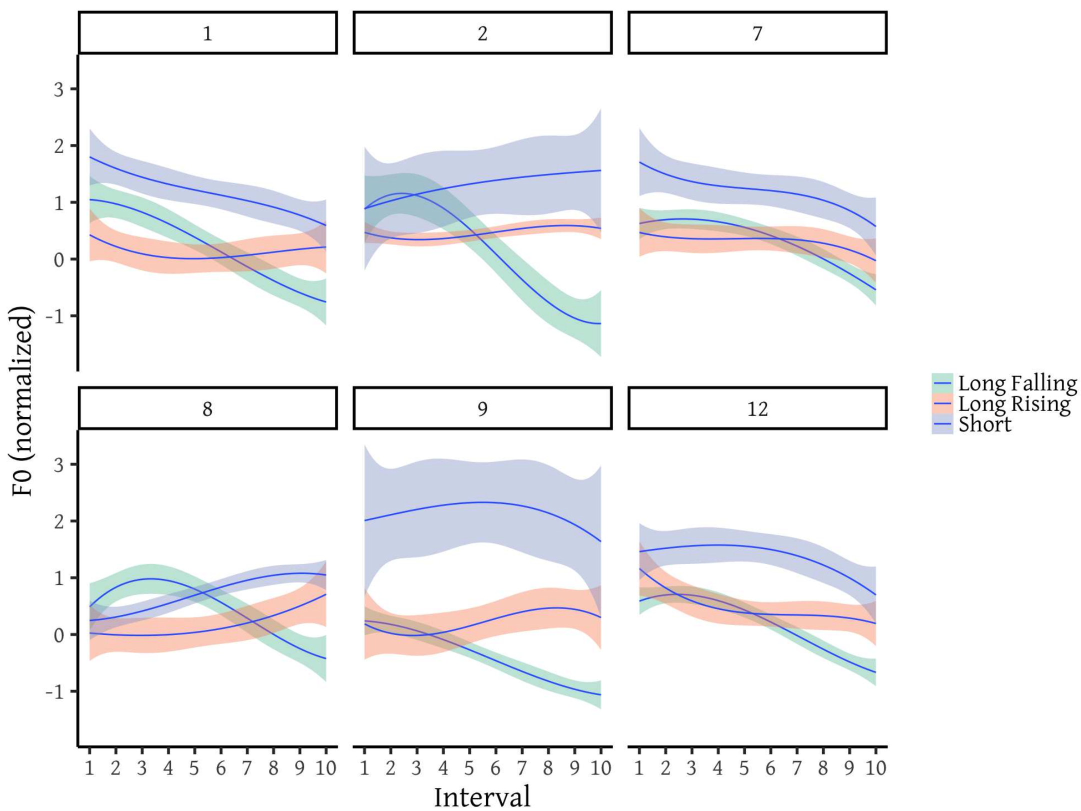


Figure 4: Normalized pitch tracks for initial vowels in the elicited disyllables for selected participants.

group of words, on the other hand, has initial stress (b). This situation is somewhat unusual as it involves a short stressed vowel followed by a long posttonic vowel. The stressed vowel bears a High tone, and long vowels also bear a High tone, as observed in words with final long vowels in (4).

(5) Distribution of tone in disyllables with final long vowels (Stanonik 1977)

a. Final stress

Falling		Rising	
ʒɛˈlíes	‘iron’	zɒˈklɛɛ́nt	‘to lock’
kɒˈléen	‘knee’	kɒˈzuóts	‘haystack’
pɒˈléen	‘log’	uˈɣɑɑ́nt	‘to guess’
kɒˈwɑ́ɑʧ	‘blacksmith’	ɒˈtɾɑɑ́ts	‘children’

b. Initial stress (unattested with [ɛɛ]

Falling		Rising	
ˈkɒ́kúoʃ	‘chicken’	ˈkɒ́ɾwɑɑ́w	‘bloody’
ˈʋɛ́ʧíeɾ	‘evening’	ˈpɒ́dɫoóʃk	‘bolt washer’
ˈbɒ́ɫɑ́ɑn	‘sick’	ˈlɛ́sién	‘wooden’
ˈɣɒ́ɫúop	‘dove’	ˈɒ́tɾuóp	‘bran’

Stanonik (1977) observes that prosodic patterns in Žiri are generally not affected by vowel quality: all long vowels can appear with either tone and can appear in the stresesd and posttonic position. The only exception is the long vowel [ɛɛ]. While [ɛɛ] can have a rising or falling tone it cannot appear in the posttonic position (Stanonik 1977:301). This absence is peculiar, since the interactions between vowel quality and prosody are very limited in the languages of the world. We return to this restriction in Section 3.

Recall that we model the difference between Long Falling and Long Rising monosyllables with two distinct autosegmental representations (3): a High tone can be linked to the first or second mora of a long vowel. The contrast between initial and final stress in disyllables with final long vowels (5) is crucial in determining the connection between tone and stress. This distinction suggests that words can have multiple underlying tones in Žiri. We represent the contrast between the two types of words with final long vowels by positing a different number of underlying High tones (6). In the words with final stress, there is only one underlying tone on the vowel. In the words with initial stress, however, there are two underlying tones, one on each syllable.

(6) Tone contrasts in disyllables with final long vowels

Falling	Rising
H (linked to the first e)	H (linked to o)
kɒleen	kɒzuots
H H (linked to ɒ and u)	H H (linked to ɒ and o)
kɒkuoʃ	ɒtɾuop

This means that disyllables can have one or two High tones. In words with two High tones, stress falls on the first syllable. Finally, in disyllables with only short vowels, stress is always initial, and realized with a High tone. All words thus must have a High tone on the stressed syllable, and vice versa. The vowel quality is not restricted; in particular, the short [ɛ] can appear in the stressed ([ˈmɛ́su] ‘meat’, [ˈʋɛʧíeɾ] ‘evening’, [ˈlɛ́sién] ‘wooden’) or posttonic position ([ˈplɑ́ɑʧɛt] ‘pay’, [ˈmɛɛ́dʋɛt] ‘bear’, [ˈkúʃɛɾ] ‘lizard’).

(7) Distribution of tone in disyllables with short vowels (Stanonik 1977)

ˈɒ́ku	‘eye’
ˈkúʃɛɾ	‘lizard’
ˈstɒ́bɒɾ	‘pillar’
ˈlípɒ	‘linden tree’

In summary, stress in disyllables can be initial or final, which depends on the distribution of tone and vowel length. Stress is initial if High tone is present underlyingly on the first vowel. Otherwise, stress is final if that vowel is long or initial in words without long vowels. These restrictions on tone and stress are not accidental but make sense once footing is considered. In Žiri, feet are trochaic, which Žiri shares with both tonal and non-tonal Standard Slovenian (Jurgec 2007, 2010, 2023). A shown in (8), disyllabic words with initial long vowels are entirely parsed into a disyllabic trochee. In words with initial short vowel, the footing depends on the distribution of tone: if the word only has a High on the long vowel, feet are monosyllabic. If the word has two High tones, the feet are trochaic. Finally, disyllables with only short vowels are footed in their entirety.

(8) Footing and prosodic contrasts in disyllables

	Falling	Rising	Short	
Initial Long	(ˈʒɑɑlɒst) [H on first ɑ]	(ˈeezeɾ) [H on second e]		Single High tone
Initial Short	kɒ(ˈleen) [H on second e]	kɒ(ˈzuots) [H on o]	(ˈɒku) [H on ɒ]	
	(ˈkɒkuoʃ) [H on ɒ, H on u]	(ˈɒtruop) [H on ɒ, H on o]		Two High tones

This analysis accounts for four things. First, High tone is limited to the foot with primary stress. Second, the foot head must have a High tone. Third, long vowels must be footed. Fourth, the default position of the foot is at the end of the word, as seen in words with only short vowels.

We do not make any assumptions about other feet in the word, which have no effect on our analysis. Words with more than two syllables are rare, but they generally pattern with disyllables. In words with a long vowel, stress falls either on the long vowel (e.g. [kɫɒˈbɑ́ɑsɒ] ‘sausage’, [ɣɫɒˈbɑɑ́kɒ] ‘deep-FEM’) or on the preceding short vowel (e.g. [pɒˈmɒ́ɾɑɑ́nʧɒ] ‘orange’, [tɛlɛˈʋíziíjɒ] ‘television’). In words with only short vowels, stress is always penultimate ([ɫɒˈpínɛ] ‘husk’, [bɒɾdɒˈʋítsɒ] ‘wart’), suggesting that feet are generally aligned with the right edge of the word, but this can be overruled by the requirement for long vowels to be footed. As with disyllables, no trisyllabic or longer words has [ɛɛ] in the posttonic syllable. We build upon these generalizations in the following section, which explores prosodic alternations.

3 Retraction

As we have seen so far, stress in Žiri is inherently linked to tone and vowel length. In words with a long vowel, for instance, stress can fall either on the long vowel or on the preceding short vowel, except when the long vowel is [ɛɛ] which is always stressed. We now move to alternations. These alternations constitute the core data that will be tested experimentally. In particular, we will see that while retraction is lexical, there are several asymmetries that at first appear accidental. Mirroring the distributional data, we found no instances of retraction from /ɛɛ/, and we will show that this generalization is productively extended to nonce words in Section 4.

The alternations involve words with initial stress, regardless of word length. We have seen the realization of tone in these words in isolation and connected speech. Slavic languages, however, are well-known for their ability to retract stress to the preceding clitic. Cross-linguistically, clitics can have a variety of shapes (see Anderson 2005, 2011 for a cross-linguistic overview and Zwicky & Pullum 1983 for English). In Žiri, however, clitics are monosyllabic, stressless, toneless, and contain only short vowels (as in Standard Slovenian, see Toporišič 1976/2000; Jurgec 2007). Put differently, proclitics form a Prosodic Word with the following content word (Nespor & Vogel 1986; Peperkamp 1997; Dixon & Aikhenvald 2002). In terms of word class, all clitics reported in this paper are prepositions or copulas.

3.1 Monosyllables

In Žiri, stress can retract from the word with initial stress to the preceding clitic. If the word is monosyllabic, the mechanism behind stress retraction is identical to the distribution of tone in disyllables. Recall that among disyllables with a final long vowel some have initial while others have final stress. We analyzed the distinction between the two types in terms of underlying High tone on the initial, short vowel. Monosyllables preceded by clitics show similar behaviour. With some monosyllables, clitics receive stress (and High tone), whereas with others, stress falls on the monosyllable (9). For example, the Long Falling monosyllable [núos] 'nose' is preceded by a High tone, stressed clitic [ˈnɒ́ núos] 'on (the) nose', thus displaying retraction. In contrast [púot] 'path' retains stress on the root, with the clitic surfacing without a High tone [nɒ ˈpúot] 'on (the) path'.

All clitics behave uniformly in that their prosody is fully predictable from the following word. For instance, the monosyllable [núos] 'nose' can be preceded by any clitic and it shows the same pattern regardless: [ˈpɒ́ núos] 'after, on top of', [ˈzɒ́ núos] 'for', [ˈʒɛ́ núos] 'already', [ˈjɛ́ núos] 'is' etc. Conversely, all clitics preceding [púot] 'path' will remain stressless: [pɒ ˈpúot] 'on, following', [zɒ ˈpúot] 'for, after', [ʒɛ ˈpúot] 'already'. [jɛ ˈpúot] 'is'. In fact, the same is true for all content words and all clitics.

Notice that short vowels display two distinct patterns, much like long vowels: the first group shows retraction, while the second retains stress on the stem. This differs from the situation in disyllables without clitics, where only one pattern is attested: all disyllabic and longer words without long vowels have predictable stress on the penultimate vowel (7). Retraction from short monosyllables is reported and tested for the first time in this paper.

When it comes to vowel quality, the only restriction is regarding the long [ɛɛ]: while Long Rising [ɛɛ́] is considerably more common than Long Falling [ɛ́ɛ], neither allow retraction (9-b). This does not extend to short vowels: [ˈpɒ mɛʃ] 'after (the) mouse' displays retraction, while [pɒ ˈsɛ́n] 'after (the) hay' does not.

(9) Monosyllables with proclitics

a. Retraction

Long Falling	núos	‘nose’	ˈnɒ́ núos	‘on (the) nose’
	nóoʧ	‘night’	ˈʒɛ́ nóoʧ	‘already night’
	wɾɑ́ɑt	‘neck’	ˈzɒ́ wɾɑ́ɑt	‘around (the) neck’
	méex	‘bellows’	ˈzɒ́ méex	‘for (the) bellows’
Long Rising	ɣuópts	‘muzzle’	ˈnɒ́ ɣuópts	‘on (the) muzzle’
	oóʧk	‘little eye’	ˈú oóʧk	‘into (the) little eye’
	jɑɑ́pk	‘apple’	ˈpɒ́ jɑɑ́pk	‘after (the) apple’
	xleépts	‘loaf’	ˈpɒ́ xleépts	‘after (the) loaf’
Short High	kɾɒ́x	‘bread’	ˈpɒ́ kɾɒx	‘to (the) bread’
	kɒ́p	‘pile’	ˈnɒ́ kɒp	‘on/onto (the) pile’
	ɫúʧ	‘light’	ˈpɒ ɫuʧ	‘to (the) light’
	mɛʃ	‘mouse’	ˈpɒ mɛʃ	‘after (the) mouse’

b. No retraction

Long Falling	ɣɾéex	‘sin’	ʒɛ ˈɣɾéex	‘already sin’
	míest	‘town’	u ˈmíest	‘in town’
	púot	‘path’	nɒ ˈpúot	‘on (the) path’
	ʧɛ́ɛl	‘forehead’	pɒ ʧɛ́ɛl	‘on (the) forehead’
Long Rising	wɾɑɑ́t	‘door-GEN.PL’	dɒ ˈwɾɑɑ́t	‘to (the) door’
	kɑɑ́sts	‘reaper’	pɒ ˈkɑɑ́sts	‘to (the) reaper’
	jɛɛ́sk	‘tongue’	zɒ ˈjɛɛ́sk	‘for (the) tongue’
Short High	xɒ́ɾpt	‘back’	zɒ ˈxɒ́ɾpt	‘behind (one’s) back’
	wɒ́s	‘village’	nɒ ˈwɒs	‘in (the) village’
	ɫúʧ	‘light’	u ˈɫúʧ	‘into (the) light’
	sɛ́n	‘hay’	pɒ ˈsɛ́n	‘after (the) hay’

All in all, the patterns in monosyllables with clitics are similar to non-alternating disyllables with a final long vowel. In these cases we see five prosodic combinations: retracted and non-retracted, with either a falling or rising pitch on the long vowel. Words with only short vowels will have penultimate stress, except in monosyllables with clitics, which may or may not retract.

To support these transcriptions, we present normalized pitch tracks in Figure 5. The panels on the left present pitch tracks on the clitic vowel, whereas the right presents the tracks on the stem vowel. The top two panels present non-retracted realizations, whereas the bottom two panels present retracted realization. The non-retracted realization have lower pitch on the clitic when compared to the stem vowel, corresponding with our interpretation of the lack of High tone on the clitic as well as the presence of High tone on the stem vowel. Long Falling pitch has a peak at the beginning of the stem vowel, whereas the Long Rising pitch has a much lower realization, with a rise towards the end. We interpret the distinction between Falling and Rising contours as having a High on the first or the second mora, respectively. Short vowels have high pitch throughout the stem vowel. These pitch tracks differ from the retracted versions. All three pitch accents have a higher realization on the clitic when compared to the stem vowel, which we interpret as having a High tone on the clitic. Moreover, the Long Falling pitch falls throughout the stem vowel, whereas Long Rising is U-shaped, with an increase towards the end of the stem vowel (as in the non-retracted version). Although these stem-vowel realizations are slightly different phonetically than in the non-retracted version, we interpret them as having the same phonological representations, with the High falling on the first mora of the Long Falling pitch and the second mora of the Long Rising pitch. The realization of retracted short vowels is also distinct from non-retracted, with the clitic having the highest pitch in the retracted condition. We represent the non-retracted realization as lacking a High tone on the clitic, while the retracted version has a High tone on the clitic. As for the stem vowel, the increased pitch in the non-retracted condition is consistent with a High tone. We interpret the non-retracted realization as lacking a High tone on the stem vowel, with the increased pitch on the stem vowel being a phonetic effect, but the evidence for this is inconclusive: the large confidence intervals suggest substantial variation across participants. Short vowels need to be investigated in subsequent research. We provide further acoustic data for disyllables below.

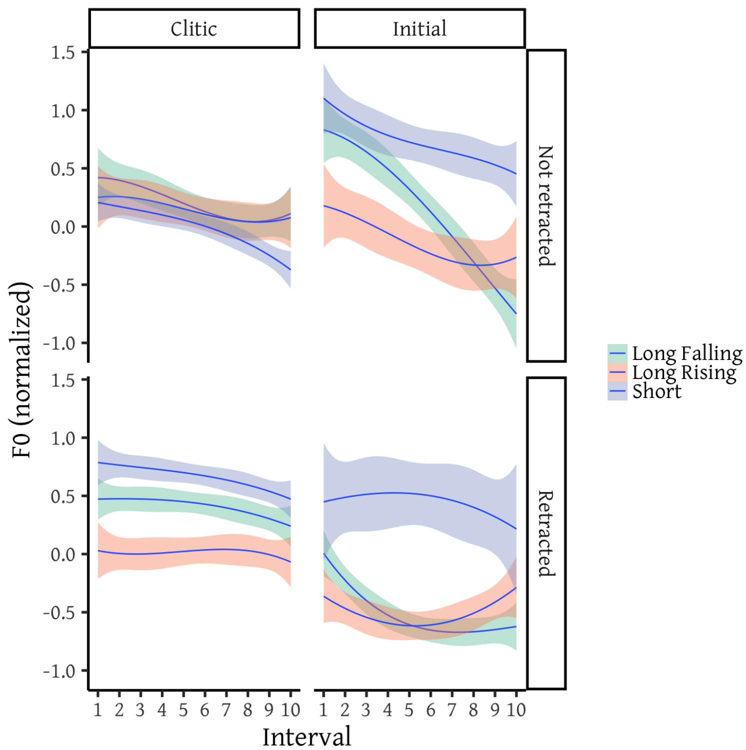


Figure 5: Normalized pitch tracks in the elicited monosyllables.

The distinction between retracting and non-retracting monosyllables is not predictable, and has to be specified lexically. We thus propose the distinction comes from the representation of these words. Recall that the disyllables could differ whether they have stress on the long vowel or the preceding vowel. The latter group had two underlying High tones. We suggest that the same mechanism is at play with clitics. The stems that show retraction have an additional High tone, which is not associated with a particular position in the monosyllable, but is instead floating (Odden 1988; Akinlabi 1996). The floating tone docks onto the clitic when possible, but it not realized otherwise. This allows us to distinguish the retracting and non-retracting monosyllables. The mappings are shown in (10).

(10) Retracting monosyllables have a floating High tone

	Input	Output
	H H	H H
Retraction	nɒ sook	('nɒ sook)
	H	H
No retraction	nɒ puot	nɒ ('puot)

Notice that monosyllables with short vowels also fall into two groups, with only some retracting. Unlike the long vowels, short vowel do not retain the High tone on the root. This suggests that the analysis of short vowels is more complex. One possible analysis is parallel to (10): the retracting short vowel roots have a floating High tone in addition to the linked one. The floating tone docks to the clitic, as with long vowels. Additionally, the High tone on the footed, posttonic short vowel delinks. This is because Žiri does not allow High tones on unstressed short vowels. An alternative analysis is also possible, with short vowel roots lacking an underlying linked tone, which is then assigned a High tone because all stressed syllables must have a High tone. Even if we adopt this analysis, floating tones can still be used to capture retraction.

We considered the entirety of Stanonik's data, which consists of 193 monosyllables. The vowels are not equally represented (e.g. among the long vowels, [ɑɑ] is the most frequent more frequent and [oo] is the least frequent), and CV(V)C monosyllables are more common than CV(V) and CV(V)CC monosyllables. Nevertheless, it seems that retraction is possible from all vowels and regardless of syllable structure.

The only exception is the long vowel [ɛɛ], which is also explicitly noted by Stanonik (1977:301). None of the words with [ɛɛ], regardless of tone, show retraction. This absence is peculiar, since the interactions between vowel quality and prosody are very limited in the languages of the world. While there is phonetic grounding for a connection between vowel quality and tone via intrinsic fundamental frequency or between stress and sonority, this is not a possible interpretation of the Žiri data: it is only [ɛɛ] that lack retraction, but not the remaining vowels. Some of these vowels are higher [ii, uu, ee, oo, ie, uo], whereas others are lower [ɑɑ] (the reverse is true for sonority). As such, it does not appear that the prosodic restriction on [ɛɛ] to be phonetically motivated. Moreover, the short [ɛ] has no restriction and can appear retracted or not. The key question of this paper is whether this absence is solely an artifact of the data sample. Furthermore, we ask whether this gap is systematic in the grammar of Žiri speakers or solely a lexical gap. This will be addressed experimentally in Section 4.

3.2 Disyllables

Stress can also retract from disyllables and longer words with an initial long vowel, which constitute the core of the data in this paper. As we will see, the disyllables display several restrictions, the productivity of which we will test experimentally.

This disyllabic data is shown in (11). The first departure from the non-alternating patterns and patterns observed in alternating monosyllables can be seen with initial Long Falling pitch. The disyllables attain a rising contour after retraction. For instance, 'head-ACC' is falling ['ɣlɑ́ɑwɒ], but attains a rising contour with retraction ['nɒ ɣlɑɑ́wɒ] 'on (top of the) head-ACC', which crucially differs from monosyllables ['nɒ́ núos] 'on (the) nose', as in (9). This is the only instance where we see a tonal alternation on the long vowel. The generalization is that when at least another syllable is available, two adjacent High tones are not allowed. Phonologically, this can be an OCP (Obligatory Contour Principle) effect. This is also consistent with the prosody of trisyllabic and longer words, which cannot have falling tone if the long vowel is not final. While there are examples like [tɛlɛˈʋíziíjɒ] ‘television’, the mirror pairs like the hypothetical *[tɛlɛˈʋízíijɒ] are unattested. We elaborate on this restriction on the distribution of tones in Section 4.3. In contrast to the Long Falling alternations, the Long Rising pitch is maintained in retracted forms. Finally, short vowels never show retraction in disyllables, which is expected given the preference for penultimate stress in these words.

(11) Disyllables with proclitics

a. Retraction

Long Falling	ˈɣláɑwɒ	‘head-ACC’	ˈnɒ́ ɣlaɑ́wɒ	‘on (top of the) head-ACC’
	ˈbrɑ́ɑdɒ	‘beard’	ˈzɒ́ brɑɑ́dɒ	‘for (the) beard’
Long Rising	ˈxɾuúʃkɒ	‘pear’	ˈpɒ́ xɾuúʃkɒ	‘after (the) pear’
	ˈjeézɛɾ	‘lake’	ˈnɒ́ jeézɛɾ	‘on (the) lake’

b. No retraction

Long Falling	ˈbɾéezɒ	‘birch tree’	pɒd ˈbɾéezɒ	‘under (the) birch tree’
	ˈkɾɑ́ɑwɒ	‘cow’	pɒ ˈkɾɑ́ɑwɒ	‘after (the) cow’
Long Rising	ˈkɑɑ́sɒ	‘scythe’	pɒ ˈkɑɑ́sɒ	‘after (the) scythe’
	ˈkɑɑ́zɒ	‘goat’	nɒ ˈkɑɑ́zɒ	‘on (the) goat’
Short High	ˈxíʃɛ	‘house’	u ˈxíʃɛ	‘in (the) house’
	ˈlípɒ	‘linden tree’	nɒ ˈlípɒ	‘on (the) linden tree’

To summarize, disyllables with clitics differ from monosyllables in two key respects: the Long Falling words merge with Long Rising when stress is retracted, and words with only short vowels never show retraction. In all other respects, the generalizations are identical: retraction is realized as High tone and stress on the clitic, the distinction between retracted and non-retracted words is lexical, and there are no retracted examples with [ɛɛ]. Stanonik (1977) does not elaborate on the distribution of retraction. In particular, monosyllables appear equally as likely to show retraction as disyllables, and Falling pitch retracts at rates similar to Rising pitch. When it comes to vowel quality, none of the known cases of disyllables with [ɛɛ] show retraction (e.g. [ˈzɛɛ́mlɒ] ‘soil, earth’ ∼ [u ˈzɛɛ́mlɒ] ‘in (the) soil, earth’; [ˈsɛɛ́dl̩] ‘saddle’ ∼ [nɒ ˈsɛɛ́dl̩] ‘in (the) saddle’), which is similar to monosyllables. All other vowels display at least some items with retraction. The vowel quality restriction, which lacks any clear phonetic grounding, will be explored in the following section.

Retraction in disyllables will form the core of our experiment, so we now turn to the acoustic analysis to support our transcriptions. In particular, we compare forms with and without retraction, while examining duration, intensity, and pitch tracks. The forms analyzed here all have initial stress when in isolation. Figure 6 shows normalized duration for each vowel (clitic, stem initial and peninitial) depending on vowel length and retraction. On the lefthand panel, we see that the duration of the clitic vowel is shorter than the initial, stressed long vowel. The peninitial vowel also has longer duration, but this has to do with phrase-final lengthening, a cross-linguistically common pattern (Oller 1973; Klatt 1975; Beckman & Edwards 1990). Nearly all our elicitations had the relevant word at the end of a phrase because this is the most neutral word order for clitic contexts. Initial short vowels have shorter duration than corresponding long vowels, but the duration is slightly longer than the clitic vowel, which we attribute to the phonetic effect of stress: stressed vowels are longer than unstressed vowels of the same length. Moving on to the righthand panel, the stressed, clitic vowel in the retracted forms has slightly longer duration when compared to matching non-retracted, unstressed clitic vowel (the leftmost boxplot among the retracted forms).

However, all clitic vowels are substantially shorter than the following long vowels, be they stressed (as in non-retractred words) or unstressed (as in retracted words). This suggests that stressed is phonetically realized as increased duration (e.g. short vowels are longer when stressed), but the phonological vowel length contrasts are maintained, with short vowels are shorter than long vowels, regardless of stress.

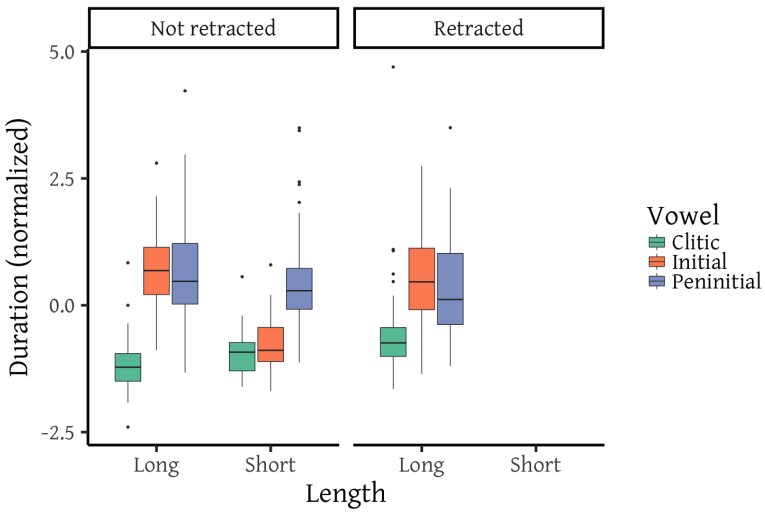


Figure 6: Normalized duration in the elicited disyllables by length.

We move on to intensity in Figure 7. We measured mean intensity for each vowel, which was normalized by participant (see Section 2.2 for the description of the normalization procedure). Here we see that peninitial vowels have the shortest mean intensity. This is because they are phrase-final and unstressed. Initial vowels in the non-retracted words have the highest intensity, since they are stressed. The clitic vowel has a slightly lower intensity in the non-retracted condition, but has the highest intensity in the retracted condition. While these differences are small, the consistency across different groups suggests that mean intensity is a correlate of stress. When the clitic vowel is stressed, as in the retracted condition, it will have higher mean intensity than the following long, unstressed vowel.

The duration and intensity data so far suggest that stress is indeed realized on the clitic with retraction. How about the pitch? Figure 8 presents normalized pitch tracks by vowel (clitic, initial, peninitial), depending on whether the forms show retraction or not. The initial vowel appears very similar to monosyllables (Figure 2) and disyllables (Figure 3), regardless of whether retracted or not. The pitch tracks converge on the peninitial vowel. As for the clitic vowel, the key distinction is the relative pitch height. In the non-retracted condition, the pitch on the clitic is crucially lower than the peak on the following vowel. While the three tones differ, they all contain a phonological High tone on the initial, stressed syllable. The relatively lower pitch on the clitic suggests no High tone on the clitic vowel. In contrast, the pitch in the retracted condition is higher (or equal) on the clitic in both conditions. This is consistent with a High tone on clitic. While there are no cases of short vowels (none of the short vowels show retraction), we can see that the Long Falling and Long Rising condions both converge, with a peak at the end ot the initial vowel, consistend with High tone on the second mora of that vowel. While there are small differences between the two, these can be attributed to phonetics and the fact that the segmental material has not been controlled for. What is clear is that the discition between the two pitch accents is much smaller on the retracted

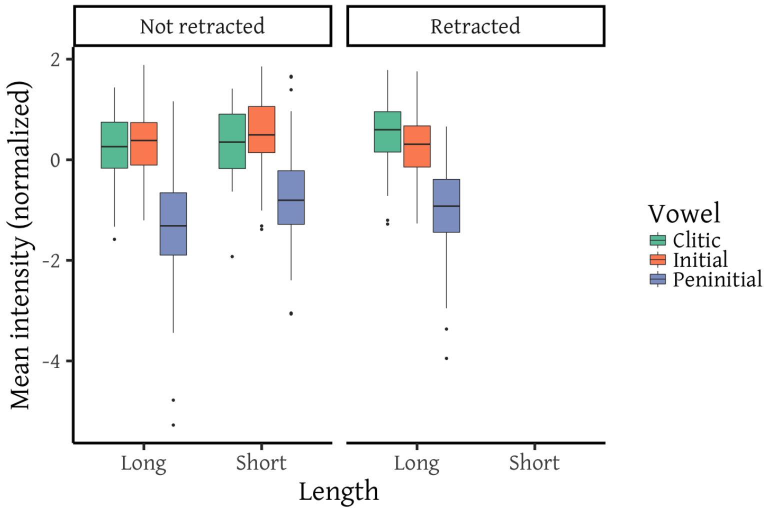


Figure 7: Normalized intensity in the elicited disyllables by length.

condition, supporting a neutralization analysis. We interpret these data as having a High tone on the clitic and on the second mora of the initial, long vowel.

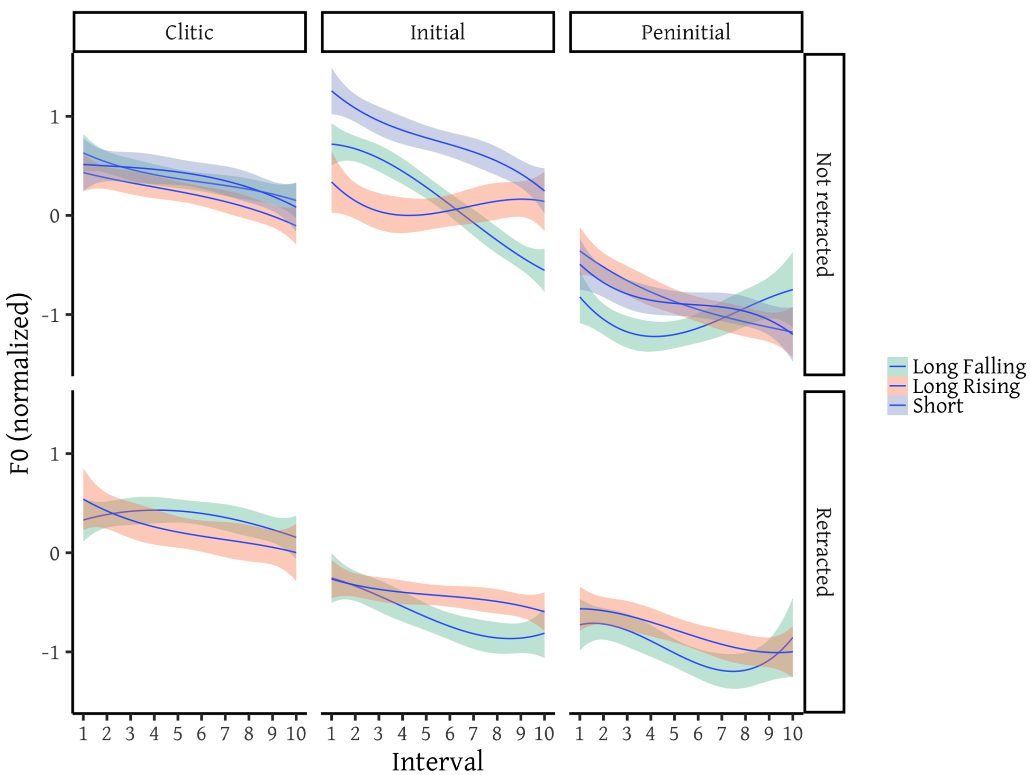


Figure 8: Normalized pitch tracks in the elicited disyllables.

We finally move to words with long [ɛɛ]. As we have seen in Section 3.2, these never show retraction. Figure 9 presents pitch tracks for words with [ɛɛ]. Long Rising pitch on [ɛɛ] is much more frequent than Long Falling (Stanonik 1977 presents about ten times as many Long Rising as Long Falling words with [ɛɛ]). In our elicitations, we only had Long Rising disyllables with [ɛɛ]. The data in Figure 9 closely match non-retracted Long Rising words containing other vowels, as in Figure 8. The acoustic analysis thus suggests that stress does not retract from [ɛɛ].

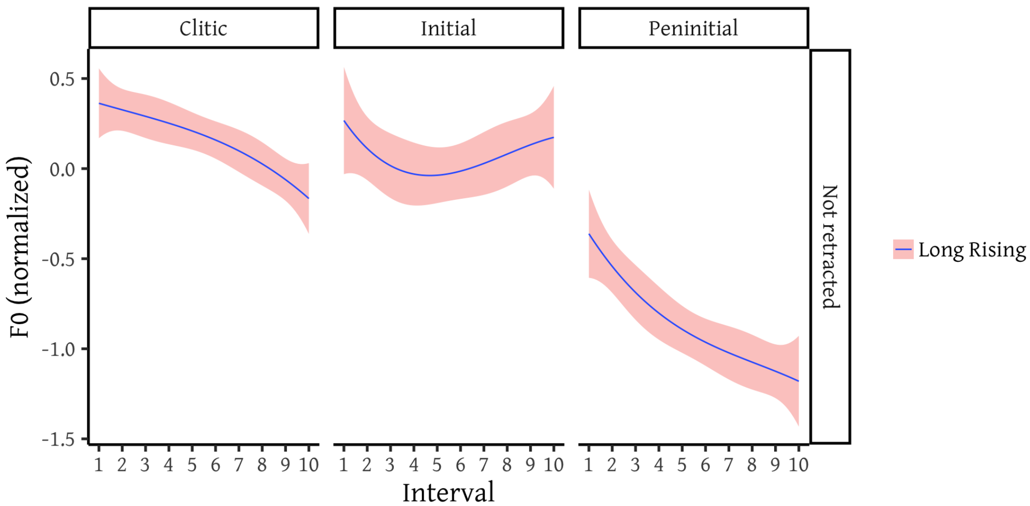


Figure 9: Normalized pitch tracks for disyllables with [ɛɛ].

Retraction presents the core data in this paper. We have seen that phonetically retraction is realized as a High tone and stress (longer duration, higher intensity) on the preceding clitic. Non-retracted forms, on the other hand, have stress on the the initial vowel of the noun. Phonologically, retraction is not predictable but must be lexically specified, which we analyzed as a floating tone. Considering only the combination of the clitic and the following stress vowel, the retracted forms appear to be directly parallel to disyllables in non-clitic contexts; the phonological difference between the two is whether the tones are underlyingly linked or floating. The alternations are thus representative of Žiri prosodic patterns more generally.

The data presented in this section allowed us to further explore the asymmetries first observed when looking at the distributions (Section 2). First, monosyllables display a greater range of patterns than disyllables. Monosyllabic content words with only short vowels can exhibit retraction, whereas disyllabic words never show retraction. While Long Falling and Long Rising monosyllables remain distict in monosyllables, Long Falling disyllables become Long Rising with retraction. Second, there is a key vowel quality difference. While most vowels can appear in retracted and non-retracted stems, long [ɛɛ] effectively blocks retraction, regardless of whether falling or rising, or whether appearing in monosyllables or disyllables, This restriction does not apply to short [ɛ]. It is unclear what the motivation for these patterns is. In the following section we thus explore the productivity of these asymmetries. In particular, we ask whether native speakers mirror the difference between monosyllables and disyllables, between Long Falling and Long Rising disyllables, and between [ɛɛ] and other vowels.

4 Tonal wug-test experiment

Section 2 established the main generalizations about the distribution of vowel length, tone, and stress in Žiri. In Section 3 we have seen that Žiri has a complex prosodic system that shows a key prosodic alternation—retraction. While retraction mirrors the distributional properties, it also allowed us to further probe the prosodic restrictions. In particular, we found that monosyllabic words are less restricted than disyllabic words, that falling pitch merges with the rising in disyllables, and that vowel quality is a key factor. However, our generalizations are based on a limited number of elicitations, which limits the reliability of our claims (although see Jurgec 2019 for a counter-example on another dialect of Slovenian). In this section, we tackle the question whether these asymmetries are productive using a nonce-word experiment.

We follow a growing body of literature that uses nonce-word experiments to corroborate speakers' grammatical knowledge (Berko 1958). For instance, Ernestus & Baayen (2003) show that Dutch speakers' productions of nonce words reflect distributional characteristics of the Dutch lexicon, with velars in root-final position eliciting relatively more voicing than labials and coronals. For Slovenian, Jurgec & Schertz (2020) show that velar palatalization at the root-suffix boundary is disfavoured when the stem contains another postalveolar due to a consonant co-occurrence restriction confirmed on corpus data (Jurgec 2016).

Even though the tonal generalizations are quite robust in the lexicon, research has shown that not all trends in the lexicon are productively extended to nonce words. In Becker et al. (2011), for instance, the lexicon displays different rates of laryngeal alternation in stops depending on vowel quality, but this was not mirrored in the nonce word task, although many other generalizations were. As for tone, Zhang et al. (2006) show that while several tone-sandhi alternations are completely regular in Taiwanese, they are not extended to nonce words. In Zhang & Lai (2010), participants extended a phonetically motivated Mandarin tone-sandhi to novel words; another type of sandhi, which lacks clear phonetic motivation, however, was applied at significantly lower rates. The productivity is a key issue for Žiri, where [ɛɛ] inhibits stress retraction. While there are some examples of interactions of prosody with vowel quality (see Becker & Jurgec 2017, 2020 for a review) or sonority (de Lacy 2006, 2007), the Žiri type of interactions do not have clear phonetic grounding. In particular, while the intrinsic pitch of vowels is dependent on vowel height, which could lead to tonogenesis, this analysis is not possible for Žiri. In order for this analysis to work, mid vowels would have to pattern with high or low vowels with respect to the distribution of tone. This is not what we find in Žiri: the mid vowel [ɛɛ] patterns differently than high and low vowels, as well as the two other mid vowels [ee] and [oo] and diphthongs. The same reasoning applies to sonority, and to the relationship between sonority and stress.

To assess the productivity of the interaction between vowel quality and prosody, we conduct a perceptual wug-test. Participants were asked to judge nonce-word paradigms. The results show that participants preferred less retraction with [ɛɛ] when compared to the other vowels. Moreover, the results further show that stress retraction is preferred in monosyllables more than compared to disyllables and in words with Rising tone more than with words with Falling tone. These experimental findings complement the elicitation-based study.

4.1 Methods

Materials. Our stimuli consisted of phonotactically valid words that were generated to vary on several parameters (summarized in Table 1). The monosyllables were of the shape CVC whereas the disyllables were ˈCVCɒ. The words could have either Long Falling, Long Rising, or Short pitch accent. However, not all combinations of tone and word length were included. For instance, there were no Long Rising monosyllables, as those are much less common in the lexicon than Long Falling monosyllables (see Section 2.2). We also did not include disyllables with only short vowels, as they never show retraction. In short, the gaps in the stimuli reflect the gaps in the lexicon, yet we will still be able to answer the key question about the interaction of stress, tone, quantity, and vowel quality. The final variable was vowel quality: among the Long Rising disyllables, some had the vowel [ɛɛ]. All other long stressed vowels were [ee, ɑɑ, oo], whereas the short vowels were [i, ɛ, ɒ]. About two thirds of the stimuli were minimal n-tuples, as the disyllabic pair in Table 1, while the remaining stimuli were not paired. We provide more detail when discussing individual comparisons in the section below. The stimuli were checked with the native speakers to make sure they are not real words.

Variables			Examples		
Words	Pitch accent	Vowel quality	Without clitic	Non-retracted	Retracted
Disyllables	Long Falling (27)	other	ˈɾéelɒ	nɒ ˈɾéelɒ	ˈnɒ́ ɾeélɒ
(63)	Long Rising (36)	[ɛ] (12)	ˈɾɛɛ́lɒ	nɒ ˈɾɛɛ́lɒ	ˈnɒ́ ɾɛɛ́lɒ
		other (24)	ˈbɑɑ́mɒ	nɒ ˈbɑɑ́mɒ	ˈnɒ́ bɑɑ́mɒ
Monosyllables	Long Falling (11)	other	móos	nɒ ˈmóos	ˈnɒ́ móos
(19)	Short (8)	other	ˈxɒ́t	nɒ ˈxɒ́t	ˈnɒ́ xɒt

Table 1: Summary of parameters for nonce word generation. The numbers represent the number of stimuli.

In total, there were 82 words, which are broken down by group in Table 1; see Appendix for a full list. For each stem, we recorded a triplet: a bare form and two forms with a preposition, one with retracted stress and the other without. Stimuli were recorded in an anechoic room with a Sound Devices USB Pre 2 pre-amplifier with 44.1 kHz sampling using AKG C544L cardioid condenser head-mounted microphone. We RMS-equalized stimuli in Praat (Boersma & Weenink 1992) using a Praat script by Beckers 2002) and converted .wav to .mp3 format with Audacity's LAME mp3 encoder for faster processing. The visual stimuli of unusual or non-objects were taken from Horst & Hout (2016) and Gonzales-Gomez et al. (2013).

Eliciting stimuli with tonal trajectories as complex as those in the Žiri dialect poses unique challenges. To achieve the desired tonal trajectories of nonce words, the researcher produced tonal trajectories and then asked a female speaker (age 26) to repeat them. This methodology was necessary due to the speaker's difficulty in producing tonal trajectories in nonce words, and the task was facilitated by the researchers's metalinguistic awareness and native competence in the relevant dialect. Each item was recorded several times in two separate sessions. The final triplets (stimulus and two options) were chosen after a careful acoustic analysis in Praat. Altogether 246 items were chosen (82 $\times$ 3 for each triplet).

Procedure. The experiment was conducted online using Experigen (Becker & Lavine 2012). IRB approval was obtained, and speakers were asked to complete an online consent form. Participants were recruited for the experiment with the help of a local radio station, personal connections, and a paid social media post that targeted inhabitants of the Žiri Valley. At the beginning of the experiment, the participants were asked to volunteer their demographic information, including age and place of residence. Participants were then told that they will hear three words. The first one will be a name of an imaginary object. The participants would then hear two versions of the same object in the clitic context. Each trial started with the picture on the left in Figure 10, under which the frame sentence "Sonya sees (button)" was written. When the participants clicked on the button, they heard the stimulus in the accusative and without the preposition. Then an additional picture appeared with an arrow above the object and the sentence "If you put it on something, would you say (button) or (button)?" When selected, the buttons played the stimulus with the preposition [nɒ] 'on'. One of the stimuli had retracted stress and the other had the stress on the stem. Individual stimuli had constant placement, but the order of trials was randomized for each participant. Retracted and unretracted words were approximately equally assigned to two positions across different groups of words. Adding a random intercept for the stimuli order does not change any significance levels of the estimates, which suggests order of the stimuli does not interfere with experimental results.

Once the stimuli were played, the sentence "What would you say? (You can play the words again.)" appeared as well as two buttons: "like above" or "like below". The participants were free to listen to the materials as many times as they wanted. Once they made a judgment, the next stimulus was played. All text was written using informal conventions (e.g. *vid'* instead of the standard *vidi* 'sees', *rekl* instead of the standard *rekli* 'said') to prime the participants for non-standard stimuli; see Jurgec (2019) for using similar methodology in a production experiment on another dialect of Slovenian. Stimuli in the current experiment were never presented orthographically.

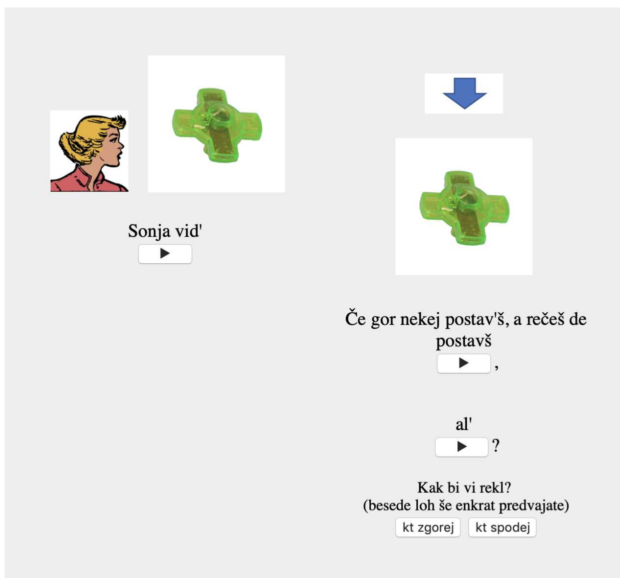


Figure 10: Web interface for the nonce word study using Experigen (Becker & Lavine 2012) and visual stimuli (non-objects) from Gonzales-Gomez et al. (2013) and Horst & Hout (2016).

Participants. We include in the analysis only those participants who indicated on the demographic survey that they were native speakers of the Žiri dialect without any linguistic training. 82 such participants responded to at least one judgment, but we include only participants who provided more than 10 judgments in the final analysis. Participants with fewer responses were excluded from the analysis in order to avoid participants who were just curious about the experiment and did not commit to listening to at least a few stimuli. We ran all our final models on data sets with all participants as well only those participants who made all 82 judgments; estimates of interests are significant in all three data sets with very similar estimates. Altogether 56 participants are included in the final analysis. Their self-reported mean age was 32 (the range was between 19 and 57 with a median of 29 years). 24 participants provided judgments to all 82 stimuli. The mean number of judgments for the remaining participants is 24 (ranging from 11 to 74, with a median of 18).

4.2 Results

The aim of the experiment was to explore whether word length, tone, and vowel quality have an effect on retraction. We find that the participants preferred retraction with monosyllables and with Rising pitch, but dispreferred retraction from [ɛɛ]. We review these results in turn.

Word length. To test if rates of retraction differ depending on word length, we analyze retraction rates from 11 pairs (22 items) of monosyllabic and disyllabic words with the Long Falling pattern. These minimal pairs differ only in the number of syllables, but are otherwise segmentally and suprasegmentally identical. For example, for the monosyllabic form [ˈxɑ́ɑt], participants chose between the non-retracted [nɒ ˈxɑ́ɑt] and retracted [ˈnɒ́ xɑ́ɑt]. For the non-clitic form [ˈxɑ́ɑtɒ], the participants chose between the non-retracted [nɒ ˈxɑ́ɑtɒ] and retracted [ˈnɒ́ xɑɑ́tɒ]. We also include 16 disyllabic words with the Long Falling tone without the monosyllabic pair. We include these additional items because the random slopes in our statistical analysis reveal that segmental material does not influence experimental outputs; we elaborate on these below.

We fit the data into a mixed-effects logistic regression model with Response as the dependent variable (retraction coded as success; N = 1259) and two predictors: Word Length and Vowel Quality ([ɑɑ, ee, oo]; sum-coded with [oo] as the reference level). The full model includes an interaction between the two predictors as well as random intercepts for participant and frame with by-participant and by-frame random slopes for Word Length.

To control for effects of segmental material and neighborhood density, we include random intercepts and slopes not by item, but by *frame*. For example, [ˈxɑ́ɑt] and [ˈxɑ́ɑtɒ] are coded as one frame, because they involve the same segmental material, except that [ˈxɑ́ɑtɒ] includes an additional syllable—but the number of syllables is a fixed effect and as such already controlled for in the model. Items that are not part of the mono- and disyllabic pairs are coded as unique frames. We model random intercepts for frames rather than items, because this allows random slopes for the predictor of interest (see also Beguš 2017 for a similar approach). Had we instead chosen items and random slopes for the predictors of interest, the models do not converge as each item has only one level of the predictor of interest.

The interaction between Word Length and Vowel Quality is not significant. In particular, the Akaike Information Criterion (AIC), a measure of the quality of statistical models, is 1385.6 in the model without the interaction and 1387.8 with it. Word Length is a significant predictor (AIC is 1385.6 in the model with the predictor and 1399.5 in the model without the predictor). The estimate of the difference between disyllables and monosyllables (β) is 1.24, while the z-score is 5.04, which is statistically significant ($p < 0.0001$). Figure 11 illustrates the effects with 95% confidence intervals.

By-participant and by-frame random slopes reveal relatively little variability across participants and frames. Random slope for the difference between disyllables and monosyllables is positive for all frames and for all participants. This also suggests that segmental material and neighborhood density do not crucially affect the results of the experiment.

Tone. To test if retraction preference differs between Long Falling and Long Rising tones, we analyze the data from 46 disyllables. The first vowel in the disyllables was either [ee] or [ɑɑ]. The data included 17 minimal pairs (34 items in total) in which the segmental material was constant, the only difference between them was the tonal trajectory of the stimulus (Long Falling versus Long Rising). For example, for the Long-Falling non-clitic form [ˈbɑ́ɑmɒ], speakers chose between

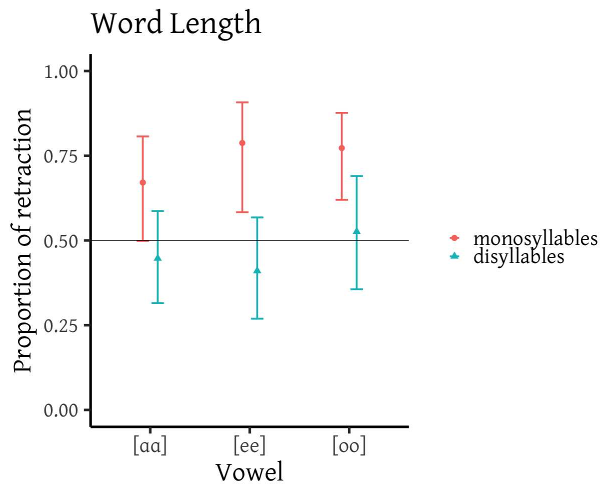


Figure 11: Estimates of a mixed-effects logistic regression model showing preference for retraction in disyllables with long vowels other than [ɛɛ] in the Falling tone condition. Error bars indicate 95% confidence intervals.

the non-retracted [nɒ ˈbɑ́ɑmɒ] and retracted [ˈnɒ́ bɑɑ́mɒ]. On the other hand, for the Long-Rising non-clitic form [ˈbɑɑ́mɒ], speakers chose between the non-retracted [nɒ ˈbɑɑ́mɒ] and retracted [ˈnɒ́ bɑɑ́mɒ]. In addition to 34 such minimal pairs, the data also includes 12 items in which the Long Falling and Long Rising patterns were not segmentally identical (5 are Long Falling, while 7 are Long Rising). Including these items is justified because the random slopes in our model reveal that segmental material does not influence experimental outputs (see below for details).

We fit the data into a mixed-effects logistic regression model with Response as the dependent variable (retraction coded as success; N = 1516) and two predictors: Tone (Long Falling and Long Rising; treatment-coded with Long Falling as the reference level) and Vowel Identity ([aa] vs. [ee], sum-coded with [ee] as reference). The full model includes an interaction between the two predictors as well as random intercepts for participant and frame with a by-participant and by-frame random slopes for tone. The interaction is not significant (AIC is 1701.5 in the model with the interaction and 1699.9 without it). The Tone is a significant predictor (AIC is 1699.9 in the model with the predictor Tone and 1710.9 in the model without it). The estimate is 0.90, with the z-score of 3.914, which is statistically significant $p < 0.0001$. Due to convergence, the model without predictor Tone had to be fit with the Nelder-Mead optimizer (all other models are estimated with the BOBYQA optimizer). Figure 12 illustrates the effects with 95% confidence intervals.

Estimates of the random slopes for the difference between High Rising and High Falling is positive for all frames. The same estimates are negative for only three out of 56 subjects. This again suggests that segmental material or neighborhood density do not crucially affect the results and that subjects are highly uniform in their responses.

Vowel quality. To test the effect of vowel quality on retraction, we analyze disyllables with the Long Rising pattern and vowels [ee, ɑɑ, ɛɛ] to maximally control for other influences. For example, for the non-clitic form [ˈbɛɛ́mɒ], participants chose between the non-retracted [nɒ ˈbɛɛ́mɒ] and retracted [ˈnɒ́ bɛɛ́mɒ]. For [ˈbeémɒ], the participants chose between the non-retracted [nɒ ˈbeémɒ] and retracted [ˈnɒ́ beémɒ].

The items include 7 minimal triplets (a total 21 items) that differ only in the first vowel [ˈbɛɛ́mɒ,

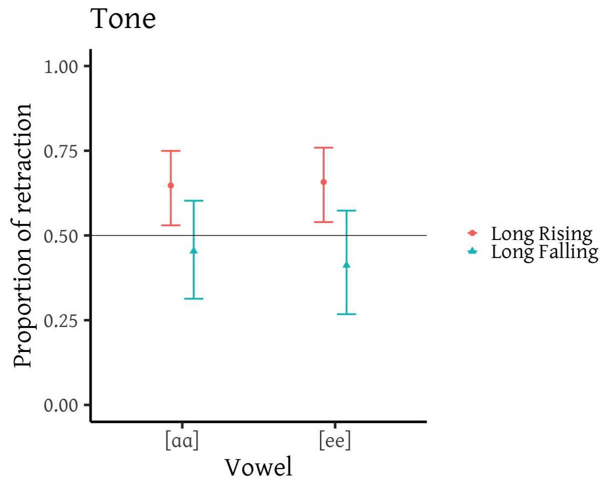


Figure 12: Estimates of a mixed-effects logistic regression model showing preference for retraction for Long Rising (compared to Long Falling) with long vowels other than [ɛɛ]. Error bars indicate 95% confidence intervals.

ˈbeémɒ, ˈbɑɑ́mɒ]. The two items with mid vowels are coded as one frame; the item with [ɑɑ] is coded as a separate frame. Additionally, we analyze five item-pairs (10 in total) that differ only in [ee] and [ɛɛ] as one frame each. Finally, we include five items without pairs that include Long Rising tone and vowel [ɑɑ] (separate frames) for a total of 36 items (with corresponding retracted and non-retracted options).

To test if rates of retraction differ between the three vowels, we fit the data to a mixed-effects logistic regression model with Response as the dependent variable (retraction coded as success, N = 1201) and the predictor Vowel Quality ([ee, ɑɑ, ɛɛ]; treatment-coded with [ɛɛ] as the reference level). The full model includes random intercepts for participant and frame with by-participant and by-frame random slopes for vowel quality. As Table 2 shows, retraction is significantly less frequent than chance for vowel [ɛɛ]. Retraction is also significantly more frequent for vowel [ee] when compared to [ɛɛ] and more frequent for vowel [aa] when compared to [ɛɛ]. Figure 13 illustrates the effects with 95% confidence intervals. Mild underdispersion was detected in all three models: 0.82, 0.83, and 0.77 (using the *overdisp_fun()* from Bolker 2022), but because underdispersion is mild and it can cause conservative estimates, we leave the models uncorrected for underdispersion.

	β	SE	z	p
(Intercept)	-1.006	0.265	-3.802	0.0001
Vowel [ee] (versus [ɛɛ])	1.740	0.305	5.698	0.0000
Vowel [ɑɑ] (versus [ɛɛ])	1.739	0.285	6.108	0.0000

Table 2: Estimates of a mixed-effects logistic regression model showing preference for retraction from [ee] and [ɑɑ] compared to [ɛɛ] (Intercept) in disyllabic words with the Long Rising pattern. SE stands for Standard Error.

Again, random intercepts and slopes suggest that participants are highly uniform in their responses. All estimates for by-frame random intercepts and slopes conform to the estimates of the main effects with no deviations. The difference between [ɛɛ] and [ee] is not positive for only three

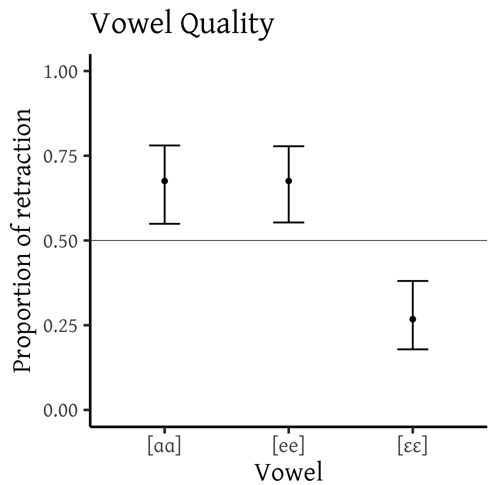


Figure 13: Estimates of a mixed-effects logistic regression model showing preference for retraction from [ee] and [ɑɑ] compared to [ɛɛ] in disyllabic words with the Long Rising pattern. Error bars indicate 95% confidence intervals.

participants (out of 56), and the difference between [ɛɛ] and [ɑɑ] for only one participant.

To summarize, the nonce-word experiment results suggest that retraction is preferred in monosyllables when compared to disyllables and in words with Falling pitch when compared to Rising pitch. Finally, [ɛɛ] inhibits retraction when compared to other vowels.

4.3 Discussion

The experiment allowed us to tackle the questions that go beyond the analysis of the data reported in Sections 2 and 3. In particular, we confirmed that retraction is preferred in monosyllables when compared to disyllables, and in words with Rising tone when compared to Falling tone. Participants also strongly dispreferred retraction from [ɛɛ]. In this section, we offer explanations for these patterns.

Word length. Participants preferred retraction in monosyllables at rates significantly higher than chance levels and in disyllables. This result is not surprising, since monosyllables often behave differently than disyllables. For instance, while BCMS contrasts rising and falling tones in disyllables and longer words, monosyllables allow only falling tone. Rising tone requires a posttonic syllable, which is only possible in disyllables (Inkelas & Zec 1988; Zec 1999; Langston 1997). When it comes to segmental patterns, monosyllables are entirely protected by initial syllable faithfulness, but disyllables or longer words are not (Beckman 1997). In Tamil, coda nasals of the stem assimilate to the onset of the suffix, except in monosyllabic stems (Christdas 1988).

In Žiri, however, it seems that stress retraction in monosyllables has a simpler explanation, which has to do with a preference for retaining the same tonal pattern. In the experiment, we were comparing monosyllabic and disyllabic Long Falling words. Recall that in disyllables the Falling tone there is an alternation in the long vowel: the non-clitic form ['bɑ́ɑmɒ] retains its falling contour when preceded by an unstressed clitic, but changes the contour to rising when preceded by a stressed clitic: ['nɒ́ bɑɑ́mɒ]. No such alternation is found in monosyllables: falling ['pɑ́ɑm] is maintained in ['nɒ́ pɑ́ɑm]. Hence the participants might prefer no tonal changes, and thus disfavour retraction in disyllables which necessarily leads to a tonal alternation on the long vowel. This reveals that an output-to-output faithfulness constraint on tonal identity inhibits stress retraction in disyllables, but have no effect on monosyllables. Under this view, retraction is a function of word length only indirectly: participants prefer to retain the contour on the long vowel, which applies equally to all words. Disyllables with stress retraction neutralize tone on the posttonic vowel while monosyllables do not. These results are consistent with other experimental findings. All other things being equal, participants will prefer uniform paradigms. There is a variety of theoretical approaches that capture this concept, such as Output-to-Output Correspondence (Benua 1997), Paradigm Uniformity (Kenstowicz 2004; Burzio 2005), and Lexical Conservatism (Steriade 1997).

A reviewer asks whether the productive generalizations are made at the level of the underlying representations or surface forms. While most phonological research has focused on output-based generalizations (Ernestus & Baayen 2003; Hayes et al. 2009; Jurgec & Schertz 2020), there is also evidence about input-based generalizations. For instance, Becker & Gouskova (2016) show that Russian speakers make generalizations about mid vowel deletion both based on the input as well as output. While consistent with the Russian analysis, the Žiri data are perhaps better interpreted through paradigmatic relationships: the participants evaluated paradigms, generally preferring uniformity, except when this is not possible, as in Long Falling disyllables.

Tone. We also saw that rising tone prefers more retraction than falling tone. In non-retracted configurations both types of tones are distinctive. In retracted configurations, however, the contrast is neutralized: only rising tone is possible on the surface. For instance, [ˈnɒ́ bɑɑ́mɒ] can be the clitic form of [ˈbɑɑ́mɒ] or [ˈbɑ́ɑmɒ]. The tonal change in the words with falling tone can be explained as an Obligatory Contour Principle (OCP) effect: two adjacent tones are a marked situation, which is resolved by shifting the High tone from the first mora to the second one when preceded by a High tone on the clitic. Cross-linguistically, the prohibition on adjacent identical tones may be resolved by deleting one of the tones or shifting one of the tones so that they are no longer adjacent (Myers 1997). The latter situation is what happens in Žiri disyllables.

Returning to the asymmetry between the Rising and Falling tones, Output-to-Output Correspondence becomes relevant yet again. Participants preferred more retraction with Rising tones, which retain the same contour regardless of whether they are retracted or not. Long Falling disyllables prefer less retraction than Long Rising disyllables. This is because a retracted form would lead to tonal change, violating the pressure for the uniformity of tone across all instances of the same word. This complements the results seen in monosyllables, where we also saw a significant prefernce for uniform paradigms.

Vowel quality. We finally move to vowel quality which also interacts with retraction. This interaction is tied to a specific vowel quality: retraction from [ɛɛ] is dispreferred compared to the other vowels. This type of interaction between segmental and prosodic properties is very unusual. Most other types involve sonority, but in Žiri this is clearly not the case. High sonority vowels may prefer stress (Kenstowicz 1997), but [ɛɛ] is intermediate in sonority between [ee] and [ɑɑ] which we had in our nonce words. De Lacy (2006) and Blumenfeld (2006) make an explicit claim that sonority, but not segmental features, can interact with stress assignment and tone, and Rasin (2017), Shih (2016, 2018), Shih & de Lacy (2020) argue that even sonority cannot affect stress placement. Our results offer clear evidence that vowel quality interacts with prosody, and that this is unrelated to sonority. Retraction from [ɛɛ] is dispreferred in production as well. The speaker who recorded the stimuli had difficulties producing the retracted pattern with this vowel.

A similar pattern is found in Standard Slovenian. There are both tonal and stress restrictions.

Lax mid vowels cannot have a falling tone in Standard Slovenian (Becker & Jurgec 2017): in native words, this means that the tone will change to accommodate the vowel quality, whereas in loanwords, which generally only have falling tone, the vowel tenses. There is a second interaction between vowel quality and stress: lax vowels are marked and avoid stress. Becker & Jurgec (2020) analyze this situation in terms of positional faithfulness, which is satisfied by shifting stress to the following vowel in disyllables. When stress is stem-final, the vowel quality changes instead, and monosyllables are faithful.

Žiri offers another piece of evidence that interactions between vowel quality and prosody are attested. When compared to Standard Slovenian, however, there are a few key differences. First, it is only [ɛɛ] that is affected, since there is no corresponding back mid lax vowel. Second, [ɛɛ] in Žiri cannot be posttonic, regardless of its tone. When stressed, [ɛɛ] can have a Rising or Falling tone. When stress retracts from the Falling tone, the resulting tone is Rising in non-final syllables, and Falling in the word-final syllable. Because retraction is strongly disfavored, both tonal patterns are ruled out on unstressed [ɛɛ] and both are possible on stressed [ɛɛ], so the restriction in Žiri cannot be related to tone, but has to do with footing. One way to capture that is to say that [ɛɛ] has to be aligned with the left edge of the foot. This type of constraint complements the two other patterns in Standard Slovenian: a markedness constraint on a combination of tone and vowel quality (Becker & Jurgec 2017) or a positional faithfulness constraint on a specific prosodic position and vowel quality (Becker & Jurgec 2020). In Žiri the positional faithfulness analysis is not available, because stress can shift (from all vowels but [ɛɛ]) to another instance of [ɛ]. Moreover, the short [ɛ] does show the same restrictions than long [ɛɛ]. In the elicitation data, we have both retracted and non-retracted monosyllables with [ɛ], as in (9). In the experiment, the short [ɛ] nonce words showed similar, above chance-levels rates of retraction than other short vowels (see Appendix).

The Žiri pattern singles out the long mid lax vowel [ɛɛ] while other long and short vowels behave identically. There is no obvious grounding for the pattern, regardless if the interaction is about stress in combination with quantity, as argued above, or tone. Phonetically unmotivated processes are fairly well understood at the segmental level (Blevins 2004; Kiparsky 2006, 2008; Coetzee & Pretorius 2010; Beguš 2018, 2019, 2020). For instance, in Ojibwe [n] alternates with [ʃ]: [ki-naːn̲-aː] 'you fetch him' versus [ki-naːʃ̲-im-i] 'you fetch us' (Buckley 2000). There is no apparent phonetic motivation for this process, but is not obviously antagonistic to some universal phonetic tendency (Beguš 2019). Žiri provides an example of a phonetically unmotivated process that involves prosody and a segmental feature. The results of the wug-test clearly document such an interaction in Žiri, complementing the data in other varieties of Slovenian.

5 Conclusions

This paper provides a description of complex prosodic interactions in Žiri Slovenian. We have seen that Žiri displays an interaction of tone, stress and quantity, which further interact with vowel quality. Stress in Žiri docks to the leftmost syllable with a High tone. Stress falls on the long vowel or the syllable immediately preceding it. In words with only short vowels, stress is penultimate. High tone can only surface within the foot.

The complexity of the system defines a new frontier of what a pitch accent language might look like. Although pitch accent as a term is controversial (see Hyman 2006, 2009; Hyman & Leben 2020), it has been used to characterize prosodic patterns in languages ranging from Swedish, Latvian, Japanese to Basque, Luganda, and Yaqui. Compared to these languages, Žiri displays a greater number of prosodic contrasts. Disyllables, for instance, fully contrast seven different prosodic shapes based on the combination of stress, tone, and quantity. All prosodic contrasts fall within a single disyllabic foot, even in trisyllabic or longer words, contrasting Žiri from tonal languages like Mandarin, Vietnamese or Mazatec.

Žiri displays active alternations in which stress retracts to the preceding clitic. These alternations display several preferences, the productivity of which we corroborate in a perception experiment. We find that the participants generally prefer uniform paradigms. This means that there is more retraction in monosyllables when compared to disyllables because only the latter involve a tone alternation. Moreover, participants prefer more retraction from rising tone than from falling tone. This again has to do with the fact that retraction from a falling tone requires a tonal change, but this is not the case for rising tone paradigms in Žiri.

The key finding of this paper concerns interactions of prosody and vowel quality. The particular restriction in Žiri involves the long mid lax vowel [ɛɛ], which displays lower rates of retraction when compared to tense mid vowels and low vowels. This interaction is thus not related to vowel height or sonority. It is also not related to tone, because the retracted forms can bear either tone, albeit this is dependent on the position of the vowel within a word. This interaction is phonetically unmotivated, and adds to the growing body of work on possible interactions between segmental and suprasegmental properties.

Our final contribution is methodological. Tonal wug-tests are rare and our work shows how they can be used to corroborate the data based on elicitation. In the paper, we outline a variety of challenges in recording the stimuli and interpreting the results.

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Appendix: Mean ratings by item

Item	Word Length	Tone/ Length	V	Mean Retr.	N	Item	Word Length	Tone/ Length	V	Mean Retr.	N
ˈzɑɑ́mɒ	disyllable	Rising	ɑɑ	.750	36	ˈpɑ́ɑmɒ	disyllable	Falling	ɑɑ	.485	33
ˈtɑɑ́nɒ	disyllable	Rising	ɑɑ	.719	32	ˈzɑ́ɑnɒ	disyllable	Falling	ɑɑ	.484	31
ˈwɑɑ́pɒ	disyllable	Rising	ɑɑ	.677	31	ˈwɑ́ɑnɒ	disyllable	Falling	ɑɑ	.467	30
ˈbɑɑ́mɒ	disyllable	Rising	ɑɑ	.657	35	ˈɾɑ́ɑxɒ	disyllable	Falling	ɑɑ	.455	33
ˈɾɑɑ́xɒ	disyllable	Rising	ɑɑ	.647	34	ˈtɑ́ɑɫɒ	disyllable	Falling	ɑɑ	.452	31
ˈtɑɑ́bɒ	disyllable	Rising	ɑɑ	.629	35	ˈtɑ́ɑbɒ	disyllable	Falling	ɑɑ	.429	35
ˈɾɑɑ́ɾɒ	disyllable	Rising	ɑɑ	.588	34	ˈɾɑ́ɑpɒ	disyllable	Falling	ɑɑ	.389	36
ˈpɑɑ́mɒ	disyllable	Rising	ɑɑ	.576	33	ˈwɑ́ɑpɒ	disyllable	Falling	ɑɑ	.364	33
ˈtɑɑ́ɫɒ	disyllable	Rising	ɑɑ	.500	36	ˈzɑ́ɑmɒ	disyllable	Falling	ɑɑ	.346	26
ˈɾɑɑ́pɒ	disyllable	Rising	ɑɑ	.486	37	ˈbɑ́ɑmɒ	disyllable	Falling	ɑɑ	.258	31
ˈɾɑɑ́ɣɒ	disyllable	Rising	ɑɑ	.485	33	ˈkéetɒ	disyllable	Falling	ee	.526	38
ˈtɑɑ́xɒ	disyllable	Rising	ɑɑ	.469	32	ˈméepɒ	disyllable	Falling	ee	.500	34
ˈteénɒ	disyllable	Rising	ee	.758	33	ˈɾéebɒ	disyllable	Falling	ee	.500	34
ˈɾeébɒ	disyllable	Rising	ee	.710	31	ˈɾéeɫɒ	disyllable	Falling	ee	.500	32
ˈpeémɒ	disyllable	Rising	ee	.677	31	ˈɾéexɒ	disyllable	Falling	ee	.429	35
ˈleébɒ	disyllable	Rising	ee	.667	33	ˈméesɒ	disyllable	Falling	ee	.400	30
ˈzeémɒ	disyllable	Rising	ee	.657	35	ˈtéebɒ	disyllable	Falling	ee	.257	35
ˈɾeéɫɒ	disyllable	Rising	ee	.636	33	ˈɫóoɾɒ	disyllable	Falling	oo	.639	36
ˈteéxɒ	disyllable	Rising	ee	.613	31	ˈɫóomɒ	disyllable	Falling	oo	.581	31
ˈkeétɒ	disyllable	Rising	ee	.567	30	ˈmóopɒ	disyllable	Falling	oo	.563	32
ˈɾeéxɒ	disyllable	Rising	ee	.531	32	ˈmóosɒ	disyllable	Falling	oo	.429	35
ˈteébɒ	disyllable	Rising	ee	.514	35	ˈmóoɾɒ	disyllable	Falling	oo	.400	40
ˈʋeéɫɒ	disyllable	Rising	ee	.455	33	ˈwɑ́ɑn	monosyllable	Falling	ɑɑ	.765	34
ˈbeémɒ	disyllable	Rising	ee	.394	33	ˈzɑ́ɑn	monosyllable	Falling	ɑɑ	.607	28
ˈpɛɛ́mɒ	disyllable	Rising	ɛɛ	.472	36	ˈpɑ́ɑm	monosyllable	Falling	ɑɑ	.600	35
ˈɾɛɛ́ɫɒ	disyllable	Rising	ɛɛ	.433	30	ˈxɑ́ɑt	monosyllable	Falling	ɑɑ	.588	34
ˈɾɛɛ́xɒ	disyllable	Rising	ɛɛ	.364	33	ˈméep	monosyllable	Falling	ee	.806	36
ˈtɛɛ́xɒ	disyllable	Rising	ɛɛ	.344	32	ˈmées	monosyllable	Falling	ee	.667	36
ˈɾɛɛ́bɒ	disyllable	Rising	ɛɛ	.323	31	ˈɫóoɾ	monosyllable	Falling	oo	.879	33
ˈlɛɛ́bɒ	disyllable	Rising	ɛɛ	.294	34	ˈɫóom	monosyllable	Falling	oo	.833	36
ˈtɛɛ́bɒ	disyllable	Rising	ɛɛ	.273	33	ˈmóop	monosyllable	Falling	oo	.647	34
ˈʋɛɛ́ɫɒ	disyllable	Rising	ɛɛ	.257	35	ˈmóos	monosyllable	Falling	oo	.600	35
ˈtɛɛ́nɒ	disyllable	Rising	ɛɛ	.250	36	ˈmóoɾ	monosyllable	Falling	oo	.528	36
ˈbɛɛ́mɒ	disyllable	Rising	ɛɛ	.235	34	ˈʃɒ́n	monosyllable	Short	ɒ	.676	34
ˈkɛɛ́tɒ	disyllable	Rising	ɛɛ	.235	34	ˈpɒ́x	monosyllable	Short	ɒ	.571	36
ˈzɛɛ́mɒ	disyllable	Rising	ɛɛ	.171	35	ˈɫɒ́p	monosyllable	Short	ɒ	.545	35
ˈɾɑ́ɑɣɒ	disyllable	Falling	ɑɑ	.576	33	ˈsɒ́k	monosyllable	Short	ɒ	.429	35
ˈtɑ́ɑxɒ	disyllable	Falling	ɑɑ	.571	35	ˈtɛ́s	monosyllable	Short	ɛ	.563	32
ˈɾɑ́ɑɾɒ	disyllable	Falling	ɑɑ	.556	27	ˈɾɛ́l	monosyllable	Short	ɛ	.556	36
ˈxɑ́ɑtɒ	disyllable	Falling	ɑɑ	.517	29	ˈʋíx	monosyllable	Short	i	.611	33
ˈtɑ́ɑnɒ	disyllable	Falling	ɑɑ	.514	37	ˈɾík	monosyllable	Short	i	.600	35

Table 3: Mean proportions of retraction ("Mean retr.") by word in the experiment. "N" stands for the number of judgments across all participants. The items are ordered by word length, then tone/length, then V(owel), and finally, mean retraction.