The production of lexical tone in Croatian

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Jevgenij Zintchenko Jurlina

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1. Gutacher: Prof. Dr. Henning Reetz
2. Gutachter: Prof. Dr. Sven Grawunder

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ABSTRACT

Jevgenij Zintchenko Jurlina: The production of lexical tone in Croatian
(Under the direction of Prof. Dr. Henning Reetz and Prof. Dr. Sven Grawunder)

This dissertation is an investigation of pitch accent, or lexical tone, in standard Croatian. The first chapter presents an in-depth overview of the history of the Croatian language, its relationship to Serbo-Croatian, its dialect groups and pronunciation variants, and general phonology. The second chapter explains the difference between various types of prosodic prominence and describes systems of pitch accent in various languages from different parts of the world: Yucatec Maya, Lithuanian and Limburgian. Following is a detailed account of the history of tone in Serbo-Croatian and Croatian, the specifics of its tonal system, intonational phonology and finally, a review of the most prominent phonetic investigations of tone in that language.

The focal point of this dissertation is a production experiment, in which ten native speakers of Croatian from the region of Slavonia were recorded. The material recorded included a diverse selection of monosyllabic, bisyllabic, trisyllabic and quadrisyllabic words, containing all four accents of standard Croatian: short falling, long falling, short rising and long rising. Each target word was spoken in initial, medial and final positions of natural Croatian sentences. This research fills several gaps in the existing literature. Namely, the production of tone was investigated in words with a syllabic /r̩/, in pretonal syllables and in non-initial context. Acoustic parameters measured included duration, F_0 in every 10% of the nucleus duration, overall pitch, pitch range and pitch peak alignment.

Results showed that differences between falling and rising accents in Croatian are produced mainly with tonal parameters and that the most salient features were pitch peak alignment and overall pitch. The difference between long and short accents was primarily durational and optionally tonal. Words produced in initial and medial sentence positions had a rising contour in their accented syllable, while in the final, segments were usually falling.

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acc.	accusative
adj.	Adjective
CSS	Croatian Supradialectal Speech
CZS	Common Zagreb Speech
ča.	Čakavian
dat.	dative
EH	Eastern Herzegovinian dialect
f.	feminine
gen.	genitive
inf.	Infinitive
inst.	Instrumental
IP	Intonational phrase
kaj.	Kajkavian
LF	long falling accent
loc.	locative
LR	long rising accent
m.	masculine
n.	neuter
nom.	nominative
PAS	proclitical accent shift
pl.	plural
PPA	Pitch Peak Alignment
ppt.	past participle
PS	Proto-Slavic
PTL	posttonal length
SD	Standard Deviation
SF	short falling accent
sg.	singular

SFRY	Socialist Federal Republic of Yugoslavia
SR	short rising accent
što.	Štokavian
TBU	Tone Bearing Unit
TTL	true tonal language
voc.	vocative
YM	Yucatec Maya

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INTRODUCTION

This dissertation is a study in the production of pitch accent in standard Croatian. Croatian is a South Slavic language spoken mainly in Croatia, and is very closely related to its other standardized regional varieties: Serbian, Bosnian and Montenegrin, forming a dialect continuum with them. The different aspects of Serbo-Croatian which relate to this study will be discussed in more detail in §1.1.

Croatian, along with the other Serbo-Croatian standard varieties, is most often characterized as a pitch accent language (Pletikos & Vlašić, 2007; Lehiste & Ivić, 1996). Traditionally, four types of accents are distinguished: short falling, short rising, long falling and long rising. These accents will henceforth be referred to as, respectively: SF, SR, LF and LR. According to most prescriptive handbooks of Serbo-Croatian, Croatian, Serbian, Bosnian and Montenegrin (Stevanović, 1986; Babić, Brozović, Moguš, Pavešić, Škarić & Težak, 1991; Stanojčić & Popović, 1992; Jahić, Halilović & Palić, 2000; Čirgić, Pranjković & Silić, 2010), the prosodic system of these languages is basically the same, each having the four above-mentioned tones. There are, of course, differences in the realization of these accents in the various languages, but for the purpose of this investigation, they will all be considered elements of a single system.

The traditional method of transcribing tone, which is prevalent in all works concerning Serbo-Croatian accentuation, will be used throughout this dissertation. The corresponding diacritics and several examples of the four different accents of Croatian are demonstrated below in (1.1).

(1.1) The four accents of Croatian

Short falling: *kȉša* ‘rain’, *stȁrac* ‘old man’

Short rising: *sèstra* ‘sister’, *kùpus* ‘cabbage’

Long falling: *pîvo* ‘beer’, *dôći* ‘to come, inf.’

Long rising: *ráditi* ‘to do, inf.’, *prózor* ‘window’

Distinctive opposion of tone occurs only in words with an initial accented syllable, since that is the domain (with a very few exceptions) to which the falling accents are restricted. The rising accents, on the other hand, can appear on any syllable but the final one. There are also exceptions to this last rule, but they are mainly found in loanwords.

Additionaly, Croatian contrasts between long and short posttonal syllables (i.e., those that appear after the accented syllable). Phonologically long syllables (PTL - posttonal length) are marked with a macron, as in *plȁmēn* ‘flame’, opposed to *plȁmen* ‘fiery, m. sg. nom.’. Unaccented short syllables are sometimes marked with a breve, like in *kȕćă* ‘house’. Since there is no vowel length distinction in pretonic position, all pre-accented vowels are phonologically short, and long vowels (or a syllabic /r̩/) are restricted to the accented and posttonal syllables. The distribution and typology of the accentual system of Croatian will be discussed in §2.4.

The acoustic properties in the production of tone in Croatian have been investigated with somewhat greater detail since the 1960s, starting with Ilse Lehiste’s and Pavle Ivić’s article *Accent in Serbo-Croatian: An Experimental Study* in 1963[1]. There are two acoustic measurements which are common to most of these investigations: fundamental frequency and the contour thereof as well as the duration of the segments analyzed. The main differences between these works regarding F_0 lie in where and how it was measured. Older investigations usually have a positional approach: F_0 is measured at the onset and offset of the syllable as well as at the pitch peak. Newer papers are characterized by a percental method, where the fundamental frequency is measured at set steps in the duration of the syllable nucleus, for example every 10% or 25%. Some authors have measured the intensity of accented and post-accentual syllables (Purcell, 1973; Lehiste & Ivić, 1996; Pletikos & Vlašić, 2007; Pletikos, 2008). As with fundamental frequency, there were two prevalent methods of measuring intensity: positional (syllable nucleus onset, offset and intensity peak) and percental. Several works focused on the position of the accentual peak and its alignment relative to the different syllables in the word, additionally comparing the Belgrade and Zagreb dialects (Smiljanić & Hualde, 2000; Smiljanić, 2003, 2006). An interesting variation to this approach can be found in Zsiga & Zec (2012), where F_0 was additionally measured at the end of a pitch fall and at the beginning of a pitch rise. Zintchenko Jurlina (2013) measured not only the frequencies of pitch peaks and valleys, but also their position inside every syllable nucleus. To show the relation between the various syllables, two delta values were calculated between the end points and starting points of the various nuclei.

As varied as are the measurements used in each paper, the materials and speakers recorded are even more diverse. The number of informants in the phonetic investigations (which will

[1] The work used in this dissertation, *Prozodija reči i rečenice u srpskohrvatskom jeziku* (1996), which is a translation of *Word and Sentence Prosody* from 1986, is a compilation of various publications by Lehiste and Ivić from 1962 to 1986.

be reviewed in more detail in §2.4.3) ranged from 3 (Zsiga & Zec, 2012) to as much as 89 (Pletikos, 2008). However, in most cases, there were between four and six speakers. Another important aspect is the informants' gender. Several authors recorded both males and females (Lehiste & Ivić, 1996; Smiljanić, 2006; Pletikos & Vlašić, 2007; Pletikos, 2008), while recording members of only one gender was done equally often (Purcell, 1973; Smiljanić & Hualde, 2000; Zsiga & Zec, 2012; Zintchenko Jurlina, 2013). In some works, the speakers' background was not very consistent. For instance, Lehiste & Ivić (1996) had professional radio speakers among their informants. Pletikos & Vlašić (2007) recorded informants from all over Croatia, some of which came from very distinct dialect zones. Several authors even recorded themselves as informants in their investigations (Lehiste & Ivić, 1996; Zsiga & Zec, 2012). Zintchenko Jurlina (2013) recorded only speakers from the same dialectal background. Distinct differences in the material recorded and analyzed can also be observed. Almost all investigations had target words in either short carrier phrases or short natural sentences designed to elicit a specific pragmatic or prosodic environment. Pletikos & Vlašić (2007) were the only ones to record isolated words. To elicit declarative and interrogative intonation (and a more natural pronunciation) and place target words in different positions in a sentence, Purcell (1973) designed a small text composed of short sentences, which was read like a short story. Lehiste & Ivić (1996) conducted a similar experiment using sentences unrelated to each other. They were also among the only ones to combine their investigation of tone with vowel quality (including syllabic /r̩/), even though it was but a minor theme in their work. Zintchenko Jurlina (2013) also incorporated vowel quality in his recorded material, but instead of syllabic /r̩/, the diphthong /i͜e/ was analyzed. With respect to the target words themselves, there seems to be a greater conformity between the different authors, with di- and trisyllabic words appearing in all the recordings. Since there is no tonal opposition outside the first syllable and monosyllabic words can only have falling accents, most authors focused only on multisyllabic words with initial accentuation. A very noticeable gap is the phonetic realization of accent in pretonal syllables. So far, not even one study has broached this subject specifically.

It is the intent of this dissertation to bridge these numerous methodological irregularities and gaps. The general idea is to cover various aspects of tone production in Croatian using a broad combination of acoustic measurements, while recording a relatively large and diverse set of target words (with respect to their syllable structure and accentuation) with the help of a homogeneous group of informants. The terms "homogeneity" and "heterogeneity" will be used in this dissertation when referring to similarities or differences within a certain group.

For instance, a group of speakers with the same dialectal background is more homogeneous than one where several different dialects are spoken. Similarly, a group consisting of both males and females is deemed more heterogeneous than one with members of only one gender. The acoustic parameters analyzed in this work include duration, fundamental frequency and its contours (measured at every 10% of the segment duration), pitch range, pitch peaks and their alignment. Intensity was not included in the acoustic analysis since its role in contrasting the different accents has shown to be mostly insignificant (see §2.4.3.1 and §2.4.3.3 fore more information). The dialectal and gendered homogeneity of the informants is a major concern. For this reason, all 10 speakers were males of approximately the same age and were carefully selected according to their and their parents' dialectal background, which was the Eastern Herzegovinian dialect. Although vowel quality in general is of no significant interest to this dissertation, the syllabic /r̥/ and the production of tone therein will be specifically discussed in a separate subsection (see §2.4.3.5). A subject which has been very much neglected in all previous investigations is the prosodic properties of pretonal syllables. To analyze said properties, tri- and quadrisyllabic words with different accentuation patterns (with an accented first, second or third syllable) were recorded not only to measure the phonetic realization of pretonality in particular segments, but also to determine if there were any differences between them, or "degrees". Also, the only study to include words with more than three syllables was conducted by Lehiste & Ivić (1996). Even though such words were recorded, their data was not presented. Another important aspect of this dissertation is the relationship between short and long posttonal syllables and the realization of tone therein, which is why all multisyllabic target words (except for the ones with a syllabic /r̥/, which had no posttonal length) were selected to represent the different possible combinations. For instance, there were four types, or patterns, of trisyllabic words with a short falling accent, which can be seen in (1.2).

(1.2) Examples of trisyllabic target words with a short falling accent (V stands for vowel)

V̏ V̆ V̆ *pȍbjĕdă* 'victory'

V̏ V̄ V̆ *pjȅvānjĕ* 'singing'

V̏ V̆ V̄ *kȉšŏbrān* 'umbrella'

V̏ V̄ V̄ *hȕmānōst* 'humanitarianism'

As in Purcell (1973) and Lehiste & Ivić (1996), the interaction between tone and intonation (see §2.4.2.4) was also investigated. This was done by placing each target word in three simple and equally long declarative Croatian sentences. The first sentence of each triplet had the target word at the beginning, the second in the middle and the third at the end. For this purpose, 360 distinct sentences were created. Interrogative intonation was not examined due to the corpus already being large enough. For a more detailed account of the materials and measurements used, see Chapter 3.

The following subsection presents a general description of the Croatian language and its relationship to Serbo-Croatian (§1.1), and the rest of the dissertation is outlined in §1.1.6.

1.1 General Description of Croatian

This section deals with the history of the modern Croatian language and its relationship to Serbo-Croatian (§1.1.1), the phonemic inventory (§1.1.2), the classification of the language within the system of dialect groups and pronunciation variants (§1.1.3 – 1.1.4), and the Eastern Herzegovinian dialect, which is the one most relevant to this dissertation (§1.1.5).

1.1.1 Modern Croatian and Serbo-Croatian

Croatian is a part of the western branch of the South Slavic languages, which in turn belong to the Slavic languages, forming the Balto-Slavic subgroup (together with Latvian and Lithuanian) of the Indo-European language family. Together with Bosnian, Serbian and Montenegrin, Croatian forms a dialect continuum which is known as Serbo-Croatian. Mutual intelligibility is very high, except between extreme opposites (north-west vs. south-east), where some speakers might have difficulties understanding each other (Sussex & Cubberley, 2006). Croatian is spoken by approximately 6 million people worldwide, and together with Bosnian, Montenegrin and Serbian, the speakers of these languages number around 20 million (Slavic Languages & Cultures Department – UCLA, 2017). Serbo-Croatian was not only a linguistic reality (what is called a pluricentric language, like English or German), but also the official language of the Socialist Federal Republic of Yugoslavia (henceforth SFRY). In 1954, the Novi Sad Agreement was signed, which declared that the national language of Serbs, Croats and Montenegrins is one language and that the literary standard was developed in two centers, Belgrade and Zagreb, with two pronunciations. Six years later, *Pravopis hrvatskosrpskoga književnog jezika* ('Standardized orthography of the literary Croato-Serbian language') was published in Zagreb in the Latin script and using the ijekavian pronunciation variant. At the same time, the „Belgrade version" of the orthography was published in Cyrillic with an ekavian pronunciation („ijekavian" and „ekavian" will be explained in §1.1.4). Another major difference between the two versions was the title: *hrvatskosrpski* in Zagreb and *srpskohrvatski* ('Serbo-Croatian') in Belgrade. However, the *Deklaracija o nazivu i položaju hrvatskog književnog jezika* ('Declaration about the name and status of the

Croatian literary language'), which appeared in 1967, called for the use of the term „Croatian" for the language spoken by Croats, thus going against the ruling principle of the Novi Sad Agreement. As a result, several Croatian cultural figures came under political repression. Moreover, the planned paralell publication (much like the *Standardized orthographies* above) of standardized dictionaries was completed only in Belgrade (Stevanović, Marković, Matić & Pešikan, 1990[2]). Nevertheless, 1971 saw the appearance of the *Hrvatski pravopis* ('Croatian standardized orthography'), which paved the way for many more standard Croatian presprictive works. This pattern continued until the breakup of Yugoslavia, which de facto ended the existence of Serbo-Croatian as an official language, replacing it with the standard varieties mentioned above (Moguš, 2009, pp. 198-206). The subsequent differences (as opposed to the ones before the Breakup) which emerged between the newly official regional standards were mostly motivated by political reasons. For more information about current sociolinguistic aspects of Serbo-Croatian in general and Croatian specifically, I refer the interested reader to Snježana Kordić's *Jezik i nacionalizam* ('Language and nationalism'), which appeared in 2010.

All of the above, of course, does not mean that Croatian did not exist as a seperate language before 1954. On the contrary, Croatian is a language with a very rich literary tradition. One of the oldest and most famous monuments of Croatian can be found on the Baška Tablet, dating to ca. 1100 and written in the Glagolithic script (Moguš, 2009). The standard varieties mentioned above started to gain official status in their respective countries during and after the Yugoslav Wars. The history of the Croatian language is a fascinating but extensive subject, outside the scope of this dissertation. The purpose of this subsection is merely to introduce and explain the relationship between Serbo-Croatian and Croatian. The next two subsections should not only shed some light on several dialectological and phonological aspects of Croatian, but also highlight the differences between the standard varieties.

Several other terms exist for the language, such as Serbo-Croat or Yugoslavian. A widely-used term in the past twenty-odd years is BCS, or Bosnian/Croatian/Serbian (Werle, 2009). To make the name sound more neutral, „standardized Neo-Štokavian" was also proposed, but was virtually unknown outside of the scientific community (Brozović & Ivić, 1988). Some speakers, especially in the diaspora and regardless of nationality and spoken standard variety, simply refer to their speech as *naš jezik* ('our language'), thus trying to avoid confusion.

[2] The first edition of the dictionary was published in 1967.

Throughout this dissertation, I will use only the most common designation, which is Serbo-Croatian.

1.1.2 The Phonemic Inventory

This subsection presents the various sounds of Croatian while pointing out important allophones and differences between the varieties of Serbo-Croatian. The consonants will be discussed first, followed by the vowels. Table 1.1 below contains all the consonant phonemes of standard Croatian.

Table 1.1. Consonant phonemes of standard Croatian. The orthographic representation is on the left and the phonemic on the right (Landau, Lončarić, Horga & Škarić, 1995)

		Bilabial	Labio-dental	Dental	Alveolar	Post-alveolar	Palatal	Velar
Plosive	voiceless	p /p/		t /t/				k /k/
	voiced	b /b/		d /d/				g /g/
Affricate	voiceless			c /t͜s/		č /t͜ʃ/	ć /t͜ɕ/	
	voiced					dž /d͜ʒ/	đ /d͜ʑ/	
Nasals		m /m/			n /n/		nj /ɲ/	
Fricative	voiceless		f /f/	s /s/		š /ʃ/		h /x/
	voiced			z /z/		ž /ʒ/		
Trill					r /r/			
Approximant			v /ʋ/				j /j/	
Lateral Approximant					l /l/		lj /ʎ/	

As can be seen from the table, Croatian has many obstruents, especially in the alveolar-palatal region. Much like Polish, Croatian contrasts between affricates at the dental, post-alveolar and alveolo-palatal[3] places of articulation (Jassem, 2003). Even though the voiced dental affricate is lacking on a phonemic level, it does appear in the language allophonically as a result of a regressive voicing assimilation (which can cross word boundaries, especially with clitics). For example, the combination *lovac bi* 'the hunter would' is pronounced [loʋad͜z‿bi] (Babić et al., 1991). In the same manner, /x/ can turn into [ɣ]. Many speakers in Croatia and Bosnia and Herzegovina, however, do not fully realize this contrast. In such cases, the post-alveolar affricates merge with the palato-alveolar, thus resulting in forms like [t͜ɕekati] instead of [t͜ʃekati] (*čekati* 'to wait, inf.') or [d͜ʑamija] instead of [d͜ʒamija] (*džamija* 'mosque'). Kapović (2006) and Halilović, Tanović & Šehović (2009) attest to this

[3] In Table 1.1 „palatal“ refers to two places of articulation: <j>, <nj> and <lj> are „purely“ palatal, whereas <ć> and <đ> are alveolo-palatal.

phenomenon in Zagreb and Sarajevo. It is difficult to say how many speakers do this and where, but from my personal experience, most speakers from Zagreb, Rijeka, Istria and the Dalmatian coast pronounce both rows as alveolo-palatal. Slavonians (northeastern Croatia) tend to pronounce all affricates correctly. This neutralization is even more pronounced in Bosnia and Herzegovina where one rarely hears post-alveolar affricates. Speakers of standard Serbian and ethnic Serbs from Croatia and Bosnia and Herzegovina, however, are rarely affected by this merge.

Although there are no alveolo-palatal fricative phonemes in Croatian, they still appear as allophones before alveolo-palatal affricates. For instance, /liːʃt͜ɕe/ is most often pronounced [liːɕt͜ɕe] (*lišće* 'leaves') and /groːʒd͜ʑe/ as [groːʑd͜ʑe] (*grožđe* 'grapes') (Babić et al., 1991).

The Montenegrin language, which was officially standardized in 2009 with the publication of a prescriptive orthography (both the Latin and Cyrillic scripts are used) and an orthographical dictionary (Perović, Silić & Vasiljeva, 2009), has added the alveolo-palatal fricatives as phonemes. The Latin graphemes used are <ś> and <ź>, and Cyrillic <с́> and <з́> for the voiceless and voiced sounds, respectively. However, the use of these graphemes is still facultative and the orthographical dictionary allows for two forms: <sjekira> or <śekira> ('axe'), or <zjenica> or <źenica> ('pupil of the eye').

Standard Croatian has 12 vowel phonemes: five monophthongs and one diphthong, which can be either short or long. Short vowels tend to be more centralized (Barić, Lončarić, Malić, Pavešić, Peti, Zečević & Znika, 1997). Table 1.2 shows the vocalic phonemes of standard Croatian. Note that the tonal properties of vowels will be described in §2.4.

Table 1.2. Vowel phonemes of standard Croatian (translated from Barić et al., 1997)

	Front	Central	Back
Close	i		u
	i͜e		
Mid	e		o
Open		a	

As already mentioned above, vowel length is phonemic, which the following minimal pairs will demonstrate: /pas/ 'dog' vs. /paːs/ 'waist' or /luk/ 'onion' vs. /luːk/ 'bow'. Vowel length is not encoded in the orthography, which makes such examples as the above indistinguishable in writing: <pas> and <luk>. The diphthong /i͜e/, which will be discussed in further detail in §1.1.4, has two distinct orthographic forms: <je> when phonologically short and <ije> when long. For instance, *sjever* 'north' and *rijeka* 'river'. As in Czech, the sonorant /r/ can also be syllabic (Dankovičová, 1997). Like the vowels, syllabic /r̩/ has a short and long form:

/br̥katiː/ ‘mustached, m.’ and /br̥ːkati/ ‘to mix up, inf.’, both written as <brkati>. Nevertheless, since there is no opposition between syllabic /r̥/ and other sounds, it is not considered a phoneme of Croatian and is not included in Table 1.2. The various properties of this sound will be discussed separately in subsection §2.4.3.5.

1.1.3 Dialect groups

The basis for the classification of any dialect of Serbo-Croatian, including the standard varieties, lies in its dialect groups. This term does not refer to a specific dialect, but rather to a supradialectal set of features, which together with pronunciation variants (see §1.1.4), is used to determine the linguistic characteristics of any given dialect of Serbo-Croatian. The names of the dialect groups are based on the form of the interrogative pronoun ‘what’. Thus, there are three main dialect groups in Serbo-Croatian: a) Štokavian or *štokavski – što?/šta?* (Western Štokavian/Eastern Štokavian), b) Kajkavian or *kajkavski – kaj?* and c) Čakavian or *čakavski – ča?*. Some authors also name a subgroup of Štokavian: Šćakavian or *šćakavski*, so called because the consonant cluster <št> is pronounced as <šć> (Ivić, 1985). The Torlakian dialect group, spoken in southeastern Serbia and in neighboring regions of Bulgaria and Macedonia, has quite a complicated status. For example, Ivić (1985) considers it to be Serbian, calling it the Prizren-Timok dialect, while Bulgarian and Macedonian dialectologists define it as a part of their respective languages. In any case, since Torlakian has lost all tonal contrasts (Lisac, 2003), it is of no significant interest to this dissertation, in which only the three above-mentioned dialect groups will be considered.

Of all dialect groups in present-day Croatia, Štokavian is the most widespread. However, evidence shows that this was not always the case and that the region was mostly dominated by Kajkavian and Čakavian. Starting in the 15th century and lasting until the 20th, great waves of migration (also known as “*seoba naroda*” or ‘peoples’ migration’), which were precipitated by the Ottoman invasions, began to drastically alter the linguistic landscape of Croatia. Štokavian speakers from modern-day Serbia and Macedonia began resettling in Čakavian and Kajkavian areas, eventually pushing these dialect groups back to where they are spoken today (Ivić, 1985; Barić et al., 1997). Figure 1.1 on the next page shows a reconstruction of the dialect zones in the Balkans before the migration period.

The onset of migration and the subsequent demographic changes initiated a new era in which Štokavian gradually gained importance and acceptance among the general Croatian population, eventually becoming the standard dialect group. During this time, Kajkavian and Čakavian continued to evolve, with several attempts at standardization. The first half of the

19th century saw the rise of the Illyrian movement, so called because its members considered all South Slavs to be descendants of the ancient Illyrian tribes. The Illyrian movement was a political and cultural campaign of Croatian intellectuals whose main goal was to unite all South Slavs, especially Croats, under one banner and one language. The Illyrians' most famous member, Ljudevit Gaj, who was originally a Kajkavian speaker himself, eventually realized that if a common Croatian/Serbian language was to be developed, it would have to be based on the Štokavian dialect group, which was at the time the prevalent form in all of Serbia and most of Croatia (which was still under Austro-Hungarian rule). Somewhat earlier and across the border in independent Serbia, the self-taught linguist and folklorist Vuk Stefanović Karadžić published his monumental *Serbian dictionary* (1818). This work was the first step in promoting Karadžić's native Štokavian Eastern Herzegovinian dialect, as opposed to Slavonic-Serbian, which was heavily influenced by Russian and used mainly by the intellectual elite in Serbia. Vuk Karadžić and his works will be discussed and analyzed in §2.4.1. Karadžić and his follower Đuro Daničić, together with representatives of the Illyrian movement, attended and signed the Vienna Literary Agreement in 1850, which was in a way a spiritual precursor to the Novi Sad Agreement. The Vienna Agreement proposed a common Štokavian basis and the implementation of various orthographic and phonological norms (most of them originating in Karadžić's previous works), and is considered the beginning of the standardization of the Serbo-Croatian language. These implementations, strengthened by the unification of the South Slavic peoples in the Kingdom of Yugoslavia (1918-1939) and later the SFRY (1945-1992), lead to the establishment of the Štokavian dialect group as the basis of the literary standard Serbo-Croatian language in general and Croatian in particular (Barić et al., 1997; Moguš, 2009).

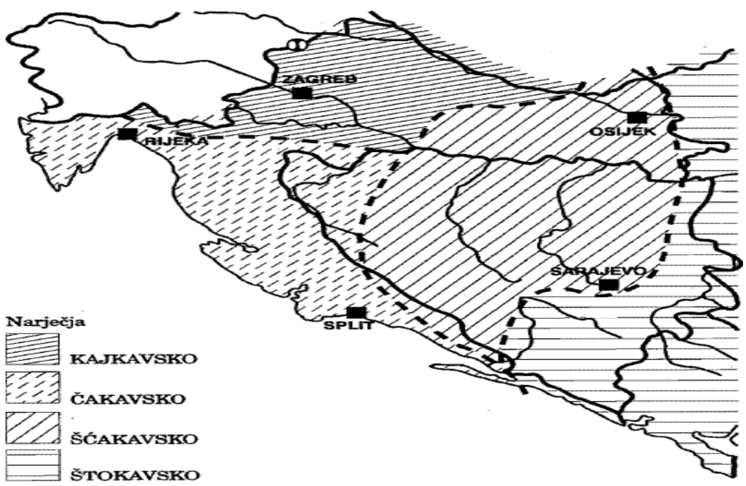


Figure 1.1. Distribution of dialect groups in the Balkans before the migration period in the 15th century. Modern state borders are shown in bold black lines (Lončarić, 1996, p. 38)

Having briefly explained the standardization process of the Štokavian dialect group and its tremendous role in the standard Croatian language, I will now turn to its prominent phonological (prosody will be discussed in §2.4) and grammatical features, which will be explained in the next subsection. Following Štokavian, Kajkavian will be discussed in §1.1.3.2 and Čakavian in §1.1.3.3.

1.1.3.1 The Štokavian Dialect Group – Primary Features

Štokavian is the most widespread dialect group not only in Croatia, but also in most of the former Yugoslav republics. It is spoken in all of Bosnia and Herzegovina, Montenegro and most of Serbia. The geographical distribution of Štokavian is presented in Figure 1.2.

Figure 1.2. Geographical distribution of the Štokavian dialect group. Color coding of separate dialects: yellow - Eastern Herzegovinian, orange – Zeta-South Sandžak, light green – Eastern Bosnian, light blue – Šumadija-Vojvodina, cyan – Smederevo-Vršac, dark blue – Kosova-Resava, violet – Prizren-South Morava, pink – Svrljig-Zaplanje, purple – Timok-Lužnica, red – Younger Ikavian, dark green – Slavonian, striped – dialects with an unchanged *jat* (Kapović, 2015, pp. 40-41[4])

[4] This map originally appeared in Brozović & Ivić (1988), pp. 160-161. This version was used here because it has a much higher resolution. Figures 1.3 & 1.4 are also taken from the same source.

The most common method to categorize the Štokavian dialects is according to their prosodic system. Namely, linguists distinguish between Old Štokavian and New Štokavian (henceforth Neo-Štokavian) dialects, based on the number of accents retained. Old Štokavian dialects can have one (short falling), two (short falling and long falling) or three (short falling, long falling and acute) accents. Okuka (2008) designates one-accent dialects as Middle Štokavian, with the Torlakian dialect group being a prime example. However, I will continue to refer to these dialects as Old Štokavian. The oldest accentual system, which can originally be found in Old Serbian and Old Croatian (and in some modern dialects), had three accents. The next stage, Old Štokavian proper, came to be after the acute was lost, which left only the short falling and long falling accents. Neo-Štokavian appeared as a result of the so-called Neo-Štokavian accent shift in the 15th century (see §2.4.1 for further detail), which moved all non-initial falling tones one syllable towards the beginning of the word, thus creating two additional accents: short rising and long rising (Ivić, 1985). According to this definition and Brozović & Ivić (1988), the Neo-Štokavian dialects are: Eastern Herzegovinian, Šumadija-Vojvodina and Younger Ikavian. Old Štokavian is comprised of: Zeta-South Sandžak, Eastern Bosnian, Smederevo-Vršac (often considered a subdialect of the Kosovo-Resava dialect), Kosovo-Resava, Prizren-South Morava, Svrljig-Zaplanje, Timok-Lužnica and Slavonian. Note that the Prizren-South Morava, Svrljig-Zaplanje and the Timok-Lužnica dialects form the Torlakian dialect group. Most authors agree on the geographical distribution and the features of the Štokavian dialects, but some variation exists as to their names. For the most part, I will use the terminology just presented throughout this dissertation.

As mentioned earlier, the most defining characteristic of the Štokavian dialect group is the use of *što* or *šta* for the pronoun 'what'. Apart from that, there are several other defining features in the phonology, morphology and lexis, which will be listed presently (Ivić, 1985; Lisac, 2003 & Okuka, 2008).

Phonology – a) five monopthong vowels /a e i o u/ with a syllabic /r̩/, b) syllable- and word-final /l/ is vocalized as /o/. Compare kaj. *nosil* and što. *nosio* 'to carry, ppt. m.', c) Proto-Slavic (shortened to PS) *čr-* clusters are pronounced as *cr-*, like in *crn* 'black, adj. m.' d) posttonal length is present in most dialects, e) PS *-tj-* and *-dj-* turned into *ć* and *đ*, compare PS *bratja* and što. *braća* 'brothers', f) lack of final obstruent devoicing, as opposed to most Slavic languages.

Morphology – a) case syncretism: the plural forms of the dative, locative and instrumental cases are all *-ma*, b) most monosyllabic masculine nouns have an additional *-ov-*/*-ev-* form in the nominative plural: *vuk* 'wolf, nom. sg.' and *vukovi* or *vuci* 'wolves, nom. pl.', with the longer form being much more common, c) the accusative and genitive singular form of masculine and neuter adjectives is realized as *-og(a)*, compare kaj. *dobreg* and što. *dobrog(a)* ‘good, adj. acc./gen.’, d) the aorist and, to a much lesser degree, the imperfect past tenses are retained.

Lexis – there is an abundance of Turkish and Arabic loanwords in most Štokavian dialects, especially the ones spoken in Bosnia and Herzegovina: *sat* ‘hour, clock’, *jastuk* ‘pillow’, *kapija* ‘gate’ and *čelik* ‘steel’, to name but a few.

1.1.3.2 The Kajkavian Dialect Group – Primary Features

Kajkavian is spoken mainly in northern Croatia, most of all in the regions of Zagorje and Međimurje. Kajkavian is also spoken to a certain degree in the Croatian capital Zagreb, which has traditionally been considered a Kajkavian-speaking area, but this is slowly changing due to the influx of Štokavian speakers (Kapović, 2006). For the geographical distribution of Kajkavian, see Figure 1.3.

Figure 1.3. Geographical distribution of the Kajkavian dialect group. Color coding of separate dialects: orange – Zagorje-Međimurje, blue – Križevci-Podravina, yellow – Turopolje-Posavina, purple – Prigorje, pink – Lower Sutla, green – Gorski Kotar (Kapović, 2015, p. 46)

Mutual intelligibility with the standard Štokavian varieties is relatively low, especially in the more peripheral dialects near the border with Slovenia. In fact, Kajkavian is so different than standard Croatian that some linguists consider it a separate language. This has been met with limited success when the International Organization for Standardization (ISO) gave Kajkavian the status of a historic literary language, which was in use until the 19th century (Bešker, 2015). Besides the word *kaj* (*ke*, *kej*, *koj* and *kuj* appear as variants) for 'what', the most distinctive grammatical feature is its radically different way of forming the future tense. There are several ways to form the simple future tense (also called *Futur I*) in standard Croatian, all of which use *htjeti* 'to want' as an auxiliary verb. The simplest method usually involves the infinitive (without the final *-i*) and a finite clitic form of *htjeti* (1st person *ću-ćemo*, 2nd person *ćeš-ćete*, 3rd person *će-će*), such as in *pokazat ću* 'I will show' or *pit ćeš* 'you (sg.) will drink'. Kajkavian, on the other hand, replaces *htjeti* as an auxiliary verb with the subjunctive form of *biti* 'to be' (1st person *bu(de)m-bu(de)mo*, 2nd person *bu(de)š-bu(de)te*, 3rd person *bu(de)-buju*) and instead of the infinitive, the past participle is used, compare kaj. *bum pokazal* and *buš pil* with the above examples. Note that in Kajkavian the auxiliary comes first, which in standard Croatian, unless preceded by a personal pronoun or a noun, is considered an error. Other prominent characteristics of Kajkavian are listed below (Lončarić, 1996; Okuka, 2008).

Phonology – a) richer vowel system than in Štokavian. The basic vowel phonemes of Kajkavian (varies according to dialect) are /i e ɛ ə a ɔ o u/ and a syllabic /r̥/, b) syllable and wod-final /l/ is retained, a feature otherwise present only in Russian, Slovene, Czech and Slovak (Sussex & Cubberley, 2006), compare kaj. *bil* 'to be, ppt. m.' and *došel* 'to come, ppt. m.' with što. *bio* and *došao*, c) no distinction between post-alveolar and alveolo-palatal affricates, both sets are pronounced intermediately, transcribed using the traditional Serbo-Croatian system as /ǯ̍/ and /č̍/ (no IPA equivalent), d) PS *čr-* retained, as in *črn* 'black, adj. m.' or *črez* 'through', e) final devoicing of obstruents is present, as opposed to Štokavian, f) syllable-initial /u/ receives an additional /v/, compare kaj. *vuho* and *vusna* with što. *uho* 'ear' and *usna* 'lip'.

Morphology - a) as in Russian, genitive plural endings are usually formed with *-ef*/*-of* (masculine and neuter nouns) or -∅, compare kaj. *bregov* 'hills' or *glav* 'heads' with što. *bregova* and *glava* (orthographically identical to the nominative singular), b) plural dative, locative and instrumental endings are realized as *-mi*, compare kaj. *kravami* and što. *kravama* 'cows, pl. dat./loc./inst.', c) the comparative is formed with *-š-* instead of the Štokavian labialization or -*j*-, compare kaj. *bolši* and *stareši* with što. *bolji* ‘better, m.’ and *stariji* ‘older, m.’, d) use of -*me* to denote 2nd person plural verb endings, as opposed to što. -*mo*, e) diminutive forms of masculine and neuter nouns are constructed with -*ek* or -*ec*, compare kaj. *sinčec* and *pesek* with što. *sinčić* ‘son’ and *psić* ‘dog’ (Marešić, 2015).

Lexis – Kajkavian shares many lexemes with other Slavic languages which are either different or have another meaning in standard Croatian. For example, *život* means ‘life’ in standard Croatian, but ‘stomach’ in Kajkavian, as in Russian. On the other hand, the verb *srditi se* ‘to be angry’ (a Russian cognate), is replaced by *ljutiti se* in Croatian. There is also a relatively high amount of Germanisms, such as *fest* ‘hard, firm’, *šarafciger* ‘screwdriver’ (originally *Schraubenzieher*) or *cop(e)rnica* ‘witch’, comprised of the German *cop(e)r*- (originally *Zauber* ‘magic’) and the Croatian -*nica*, which turns nouns feminine. Most Croatians are familiar with these Germanisms, but they are used more often in Kajkavian.

1.1.3.3 The Čakavian Dialect Group – Primary Features

Čakavian today is spoken mainly in Istria, the Dalmatian coast and the Adriatic islands, with several enclaves in the region of Lika (roughly between Istria and Bosnia and Herzegovina). Figure 1.4 demonstrates where the Čakavian dialects ares spoken.

Figure 1.4. Geographical distribution of the Čakavian dialect group. Color coding of separate dialects: purple – Buzet, orange – Southwestern Istrian, green – Northern Čakavian, yellow – Middle Čakavian, blue – South Čakavian, pink – Lastovo (Kapović, 2015, p. 46)

Comparing Figure 1.1 with Figure 1.4 shows that the Čakavian-speaking area has substantially decreased over the past several centuries. Moreover, despite what Figure 1.4 shows, the biggest cities on the Dalmatian coast can no longer be considered fully Čakavian-speaking zones. Much as in Zagreb, the Rijeka urban speech has lost all tonal contrast and aside from Čakavian lexical influence, is mostly Štokavian. Although the local dialects of Zadar, Šibenik and Split use the ikavian pronunciation variant (which is more readily associated with Čakavian), they are still very much different from the true Čakavian dialects one can still hear on the Adriatic islands or in Istria. For instance, the pronoun *ča* (*ca* or *ce* exist as variants), from which Čakavian gets its name, is very rarely used on the coast (Kapović, 2004). Further characteristics of Čakavian are listed below (Moguš, 1977; Lisac, 2009).

Phonology – a) most dialects have five monophthong vowels /a e i o u/ and a short syllabic /r̩/, b) syllable and word-final /l/ is pronounced /a/, for example *bia* 'to be, ppt. m' and *radia* 'to do, ppt. m.', c) word-final /m/ such as in the 1st person singular are produced as /n/, compare ča. *vidin* 'I see' or *znan* 'I know' with što. *vidim* and *znam*, d) PS *d'* and *t'* (the apostrophe indicates palatalization) are realized as /j/ and /c/ respectively, whereas in Štokavian they evolved into /d͜ʑ/ and /t͜ɕ/. Compare ča. /meja/ 'border' and /kuca/ 'house' with što. /med͜ʑa/ and /kut͜ɕa/, e) the so-called „cakavism", in which /t͜ʃ/, /ʒ/ and /ʃ/ turn into /t͜s/, /z/ and /s/ respectively. Compare ča. /mat͜ska/ 'cat', /zena/ 'woman, wife' and /musko/ 'male, adj. n.' with što. /mat͜ʃka/, /ʒena/ and /muʃko/.

Morphology – a) disappearance of the aorist and imperfect tenses, b) genitive plural endings are usually -Ø as in Kajkavian, c) *-i* endings for the accusative plural are common, compare ča. *iman lipi brodi* 'I have beautiful ships' and što. *imam lijepe brodove,* d) unique forms of the auxiliary verb in the conditional mood, appearing in no other Slavic language, 1st person *bin-bimo,* 2nd person *biš-bite* and 3rd person *bi-bi*.

Lexis – being under Venetian rule for centuries, Čakavian has adopted a great deal of Romanisms, especially nautical and culinary terms. Several examples include *tramontana* 'northern Mediterranean wind', *bonaca* 'calm sea', *štikadenti* 'toothpick' or *kapula* 'onion'. Interestingly enough, the standard Croatian word for 'onion' is *luk*, which in Čakavian means 'garlic'. Čakavian also has some rare lexemes of Slavic origin, such as *vavlit* 'to yearn, inf.', *opuka* 'tile' or *osuga* 'kerchief'.

1.1.4 Pronunciation Variants

The second most important classifier of dialects in Serbo-Croatian are the pronunciation variants. This term refers to the way the Old Slavic and Old Church Slavonic phoneme *jat* is pronounced in each variant (called „jat reflex“), which is also a feature of all Slavic languages. Jat was written as <ѣ> in Cyrillic and <ě> in Latin and was pronounced as /æ/ in Old Slavic and /e/ in Old Church Slavonic (Izotov, 2001). As the Slavic languages evolved, so did jat change its phonetic realization. For instance, Russian inherited the /e/ variant from Old Church Slavonic, as opposed to the neighboring Ukrainian, in which the sound is produced as /i/ (Suprun, 1989). A similar change occurred in the South Slavic languages, resulting in three different variations: a) ekavian, in which jat became /e/, b) ijekavian with /i͜e/ and c) ikavian with /i/. Orthographically, standard varieties with the ijekavian pronunciation variation mark phonologically short /i͜e/ as <je> and phonologically long as <ije>. The diphthongized realization is quite rare, and can nowadays be found only in Upper and Lower Sorbian (Schaarschmidt, 1997). There are also dialects with an unchanged jat, in which it retained its original monophthongized realization, spoken in several Croatian and Serbian villages in Romania. Due to their very small speaker population, they will not be discussed further (Ivić, 1985).

The pronunciation variations are independent of dialect groups and are inherent only at the dialect level. For example, the original dialect of Rijeka was Čakavian ekavian, until it was replaced by today’s Štokavian ijekavian (Kapović, 2004). Standard varieties also have standard pronunciation variants, with Croatian, Bosnian and Montenegrin all being exclusively ijekavian. Serbian has two official variants: ekavian in Serbia (written in Cyrillic) and ijekavian in Bosnia and Herzegovina (written in Latin). Speakers of standard Serbian may choose freely which variation to use, although it mainly depends on one’s origin, but combining them in speech or writing is considered incorrect (Stanojčić & Popović, 1992). Ikavian is not a part of any standardized South Slavic language. Table 1.3 illustrates the modern pronunciation of jat.

The geographical distribution of the three variations is not uniform and often isolated enclaves of one variation are surrounded by another. Generally speaking, ekavian is heard in most of Serbia, northern Croatia (corresponding to the Kajkavian-speaking area), eastern Istria and parts of Slavonia. The Serbian and Slavonian dialects are Štokavian, the eastern Istrian are Čakavian and the Kajkavian dialects are predominantly ekavian. Ekavian is much more stable in Serbia and parts of northern Croatia, whereas the other regions are under heavy ijekavian influence from the standard language. Thus, the ekavian dialects of Serbia are also known as Eastern Štokavian, and the ijekavian and ikavian of Bosnia and Herzegovina and Croatia are called Western Štokavian (Ivić, 1985). Ikavian is spoken mainly on the Dalmatian coast, Adriatic islands, central and western Bosnia and Herzegovina and northern Serbia, roughly corresponding to the territories of the Čakavian dialect group and the Štokavian Younger Ikavian dialect (Lisac, 2009; Ivić, 1985). Ijekavian, being the standard in most varieties, has the most speakers and can be found in western Serbia, Montenegro, eastern and central Bosnia and Herzegovina and in Lika and Slavonia in Croatia. Due to its official status, ijekavian is additionally spoken by the majority of the population in the aforementioned countries (except Serbia), independently of local dialects (Barić et al., 1997).

Table 1.3. Illustrations of the pronunciation variations. Note how phonemic length is marked orthographically in ijekavian, comparing the first and last two words.

	ekavian	ijekavian	ikavian
milk	mleko	mlijeko	mliko
beautiful	lepo	lijepo	lipo
children	deca	djeca	dica
girl	devojka	djevojka	divojka

It is important to note that the various jat reflexes are not always stable across the entire inflectional paradigm. This is best observed in the written language, especially in the ijekavian variation, which is the only one to orthographically distinguish between phonologically short and long reflexes. As mentioned above, long /i͜e/ is written <ije>, and short as <je>. Depending on its position and accentual pattern, /i͜e/ can be either shortened, such as in *vijek* 'age/era, nom. sg.' and *vjekovi* 'age/era, nom. pl.', or be replaced by <e> altogether, like in *umrijeti* 'to die, inf.' and *umrem* 'to die, 1st person sg. present tense' (Barić et al., 1997). This often leads to confusion and incorrect spelling even among native speakers. I have also observed cases of hypercorrection in Croatia, in which members of a Croatian ethnic minority (known as Janjevci), who emigrated in the 1990s from ekavian Kosovo to ijekavian Slavonia, mispronounce words with <e> to sound more like the locals. For instance, *zijec* 'rabbit' instead of *zec*, *mijeso* 'meat' instead of *meso* and *vjepar* 'boar' rather than *vepar*. However, such cases are quite rare and occur only in situations like the above.

1.1.5 The Eastern Herzegovinian Dialect

Of the many Štokavian dialects of Serbo-Croatian, three stand out in prominence and number of speakers: Eastern Herzegovinian (henceforth EH), Šumadija-Vojvodina and Younger Ikavian. The Šumadija-Vojvodina dialect (marked light blue in Figure 1.2), together with EH (yellow in Figure 1.2), serves as the basis for the literary Serbian language (Stanojčić & Popović, 1992), which removes it from the focus of this dissertation. Modern standard Croatian, on the other hand, is based mainly on Neo-Štokavian Eastern Herzegovinian and Younger Ikavian (marked red in Figure 1.2). Old Štokavian Eastern Bosnian and Slavonian, along with the Čakavian and Kajkavian dialect groups also played a part in the development of literary Croatian (Barić et al., 1997). Since the purpose of this work is to investigate the accents of standard Croatian, it was decided to make the necessary audio recordings using EH, which is the closest dialect to the literary standard. The characteristics and relationship of the Zagreb city dialect and standard Croatian will be shortly explained at the end of this subsection.

As already mentioned earlier, Eastern Herzegovinian not only has the most speakers, it is also the most geographically distributed dialect. Eastern Herzegovinian is also called Eastern Herzegovinian-Krajina (*istočnohercegovačko-krajiški*[5]), but for the sake of brevity, only the former will be used (Okuka, 2008). Geographically speaking, EH can be divided into two main areals: southeastern (or Eastern Herzegovinian) and northwestern (or Krajina). These areals correspond to modern-day northern Montenegro, western Serbia and eastern Bosnia and Herzegovina (also known as Herzegovina, hence the name of the dialect) on the one hand, and western Bosnia and Herzegovina, Lika and Slavonia on ther other. This ijekavian Neo-Štokavian dialect came into prominence during the 15th and 16th centuries, when it was used as the basis for the literary tongue of Dubrovnik, a major cultural and economic center. The 19th century saw a major rise in importance for EH, when Vuk Karadžić (himself originally from Tršić, a town in western Serbia dominated at the time by immigrants from eastern Herzegovina), based his *Serbian dictionary* (1818) on this dialect, thus single-handedly assigning it „official status“ as the literary Serbian standard. This standard would be later modified and to some degree replaced by the more widely spoken Neo-Štokavian ekavian Šumadija-Vojvodina dialect. However, EH will have a bigger and more lasting effect on standard Croatian, and later standard Bosnian and Montenegrin (Ivić, 1985).

[5] *Krajina* roughly translates as ‚frontier‘ or ‚march‘ and, when capitalized, refers to several historic regions encompassing the border area between modern-day Bosnia and Herzegovina and Croatia

Since EH is so widely spread over different geographical, political and ethnic boundaries, many subdialects can be distinguished (16 according to Okuka, 2008). For this reason, I will only list the most important and common features of EH, focusing rather on the Slavonia-Podravina subdialect (*slavonsko-podravski*), spoken mainly in central Slavonia, based upon my own investigations and existing literature.

The vocalic system of EH is the same as in standard Croatian, with five monophthong vowels /a e i o u/, the diphthong /i͜e/ and a syllabic /r̩/. The biggest difference with respect to the standard language can be observed in the realization of the long jat. Bisyllabic [i.je] is characteristic for the southeastern areal, whereas a reduced monophthongized [eː] after sonorants and [jeː] otherwise are prevalent in the north-west. This phenomenon has given rise to the term "jekavian", as opposed to ijekavian. Short jat often leads to an iotization of a preceding coronal consonant, where, for instance, standard /dje/ is pronounced as [d͜ʑe]. This so-called new iotization is quite advanced in EH and affects even fricatives, assimilating /s/ and /z/ into [ɕ] and [ʑ]. Examples include *klasje* [klaːɕe] 'ears of corn' and *izjesti* [iʑesti] 'to eat away, inf.' (Lisac, 2003). This is considered most typical for Montenegro, which is one of the reasons it has been incorporated into the standard language (see §1.1.2). Vocalic reductions are generally quite typical for EH. The final /i/ of the infinitive suffix is almost always deleted, resulting in *bježat* instead of *bježati* 'to run away, inf. perfective aspect' or *pobjeć* for *pobjeći* 'to run away, inf. imperfective aspect'. The *-ao* ending of the past participle is reduced in most cases to *-o*, like in *došo* 'to come, ppt. m.' or *reko* 'to say, ppt. m.'. These reductions are typical not only for EH, but for almost all Štokavian dialects (Okuka, 2008). The phoneme /x/ is rarely found in EH, mostly being replaced by /ʋ/ like in *gluv* 'deaf, adj.' (which is also the standard Serbian form) or deleted altogether, as in *rana* instead of *hrana* 'food'. Intervocalic *-že-* is replaced by *-re-* in most subdialects, giving *more* instead of *može* 'to be able to, 3rd person sg.'.

As mentioned earlier in this subsection, the accompanying audio recordings in this investigation (see Chapter 3 for more information) were made in central Slavonia, one of Croatia's historical regions, located in the east of the country. The recordings were done in the city of Slatina ([slâtina]) and the municipality of Čačinci ([t͜ʃăt͜ʃiːn͜tsi]), both of which are parts of the Virovitica-Podravina County. Slatina, which was called Podravska Slatina until 1992, had 10,120 residents as of 2011 and is located approximately 18 km north-west of Čačinci (see Figure 1.5), which has a population of 2,110, with at least 85% being ethnic Croats (Central Bureau of Statistics, 2011). The majority of the population speaks the Slavonia-Podravina subdialect of EH, which is bordered on the north and south by the ikavian and ekavian Slavonian dialect. Although Slavonian has mostly been replaced by EH, these dialects' proximity to each other has given rise to several features being exchanged. Another important factor to consider is internal migration from other dialect areas. Both Slatina and Čačinci demonstrate most of the Slavonia-Podravina features, but there is also a number of phenomena specific to both or one of these places which I have taken note of over the years.

Although essentially (i)jekavian, the Slavonia-Podravina dialect has some exceptions in the pronunciation of the jat reflex, mainly due to influence from the neighboring Slavonian dialect and migrants from ikavian and ekavian regions.

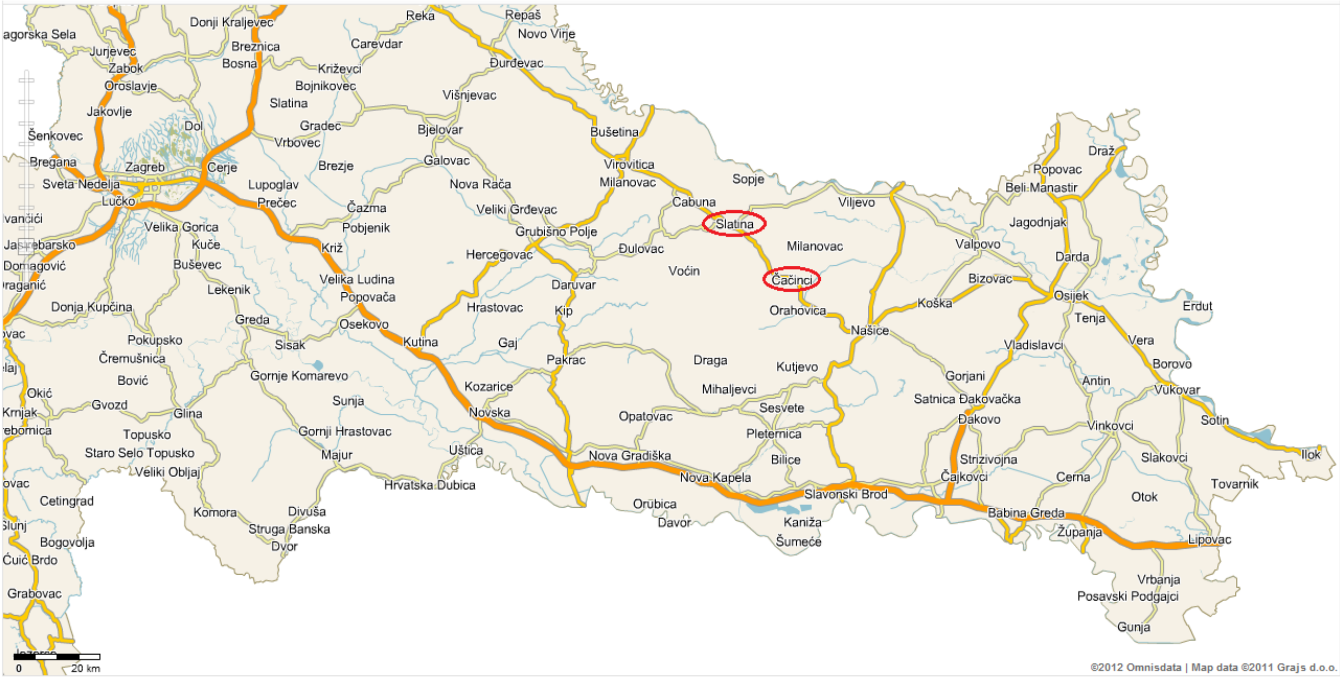


Figure 1.5. Slatina and Čačinci in Croatia. Slavonia is in the center, with the capital Zagreb in the west (Omnisdata, 2012)

Jekavisms, or the monophthongized pronunciation of the long jat reflex, are common to most dialects in the northwestern areal of EH (Okuka, 2008). There are two main allophones in the Slavonia-Podravina dialect: a) after the alveolar sonorants /l/ and /n/, long jat is pronounced as [eː] with accompanying iotization, shifting the preceding consonant to the palatal place of articulation, so that *lijep* 'beautiful, adj. m.' and *nijem* 'deaf, adj. m.' are realized as [ʎeːp] and [ɲeːm] instead of [li͜ep] and [ni͜em], b) after all other consonants, the pronunciation is reduced to [jeː], as in [bjeːsan] 'furious, adj. m.' and [tjeːlo] 'body' (written as *bijesan* and *tijelo*). Čačinci, which was originally an ethnic German village, experienced a wave of migrations from ikavian Dalmatia and ekavian Zagorje, especially between the two World Wars. After the second World War, the German population in Slavonia was expelled, which drastically changed the ethnic and linguistic landscape of the region, thereby increasing the migrants' percentage of the overall population (Okuka, 2008). For example, the village of Bukvik (located approximately 2 km south of Čačinci), was mainly populated by immigrants from Dalmatia, and one can still hear ikavian being spoken there, even among younger speakers. Paušinci, 7 km from Čačinci, has a high concentration of ekavian speakers, originating from the Kajkavian Zagorje. As a result, several ekavian pronunciation variants entered the common speech, such as *nedelja* 'Sunday' or *ponedeljak* 'Monday', instead of *nedjelja* and *ponedjeljak*. In Čačinci, which has a larger ikavian influence than Slatina, forms like *vidit* and *di* instead of *vidjeti* 'to see, inf.' and *gdje* 'where' are quite common. On the other hand, speakers from Slatina and several neighboring villages (Ćeralije, Voćin or Jorgići, for instance) tend to have a more pronounced iotization after a short jat, resulting in *međed* or *đe* instead of the standard *medjved* 'bear' or *gdje*. Common for Slatina are also reductions of post-accentuated vowels (especially /i/), which is also shared by dialects spoken in Bosnia and Herzegovina, causing even the name of the city to be pronounced as [slatna] or *planina* as [ˈplanːa] instead of [plaˈnina] 'mountain' (note the accent shift). A rather extreme but common example of these reductions and contractions is the phrase *što ćeš popiti?* ('what will you drink?'), realized in Slatina as [ʃtaʃ popt] instead of standard [ʃto t͜ɕeʃ popiti]. Typical for both places, and EH in general, is the absence of the phoneme /x/, which is usually deleted. This gives forms like *oću, naranit* or *gra* instead of *hoću* 'I want/I will', *nahraniti* 'to feed, inf.' or *grah* 'beans'. The merge of the post-alveolar affricate series with the alveolo-palatal mentioned in §1.1.2 is usually relevant for ethnic Croatian speakers, whereas Serbs are largely unaffected by it.

Syntactically and morphologically, the Slavonia-Podravina subdialect is almost identical to the standard language. Several differences, however, can be observed. There is a growing tendency for the genitive case to replace the accusative when it is used to indicate the direct object. For instance, forms like *za čega?* instead of *za što?* 'for what?' (*što* is the accusative form and *čega* is the genitive of the pronoun) or *idem po novaca* rather than *idem po novce* 'I'm going to get the money' are becoming more common. The combination -*nuti*, which indicates a perfective action, is almost always changed to -*nit*, such as in *skinit* 'to take off, inf.' or *maknit* 'to remove, inf.'.

Despite these differences, Eastern Herzegovinian is still by far the closest dialect to standard Croatian. The Zagreb city dialect, on the other hand, is anything but standard. Lying on the boundaries between the Zagorje-Međimurje and Turopolje-Posavina dialects, Zagreb has been traditionally considered a Kajkavian-speaking area. However, diachronically, this has long been changing. Šojat (1979) investigated the speech of outlying villages (which are now parts of Zagreb proper) in the early 1960s and has noticed a significant shift towards Štokavian. A more recent investigation (Kapović, 2006), shows that the 'Common Zagreb Speech' (*općezagrebački govor*) has undergone significant changes and is in effect a Štokavian-Kajkavian hybrid. The Zagreb Kajkavian described by Šojat (1979) is mostly restricted to the old city center and several outlying villages. Moreover, the "traditional" Kajkavian elements of the common Zagreb speech are actually facultative, depending heavily on the speaker himself, his origin (more than 50% of the local population was born outside Zagreb, and those that were usually have at least one parent who originates elsewhere) and various sociological factors. Even so, these Kajkavian elements are usually limited to the use of the pronoun *kaj* and the subjunctive forms of *biti* as an auxiliary verb for forming the simple future tense. The biggest and most relevant difference in the speech of Zagreb is its prosodic system, in which tonal and vowel length contrasts were lost in favor of a dynamic accent with medial-length vowels (Smiljanić & Hualde, 2000; Smiljanić, 2003, 2006). The prosodic systems of Eastern Herzegovinian, Younger Ikavian and the common Zagreb speech will be discussed in further detail in §2.4.2.

1.1.6 Outline of Dissertation

The chapters of this dissertation are organized as follows: Chapter 2 starts by giving theoretical background information on the different types of prosodic prominence. Following the theoretical introduction, the pitch accent systems of Yucatec Maya, Lithuanian and Limburgian are presented. Finishing the chapter is an in-depth overview of the history, system, phonology and phonetics of pitch accent in Serbo-Croatian and Croatian, along with the working hypotheses of this dissertation. Chapter 3 explains the methodology used in this dissertation, pertaining to speakers recorded, materials used and measurements made. Chapter 4 presents the results and statistical analysis of this investigation, starting with monosyllabic words and moving on to di-, tri- and quadrisyllabic words. Chapter 5 concludes and discusses the results in Chapter 4.

2

PITCH ACCENT SYSTEMS IN THE LANGUAGES OF THE WORLD AND IN SERBO-CROATIAN

The languages of the world can be divided according to their systems of prosodic prominence into two major groups: stress languages and tonal languages. Depending on the typology, pitch accent languages (such as Swedish) can either be a third separate group or a subgroup of the tonal languages. In any case, I will refer throughout this dissertation to any language with lexical tone features as a "tonal language". Languages which predominantly use tonal features to mark lexical distinction (such as Mandarin Chinese) will be referred to as "true tonal languages" (henceforth TTL), as opposed to pitch accent languages. Before the subtleties of tone and pitch accent can be discussed, stress must first be reviewed.

According to Reetz and Jongman (2009), "Stress is a property of a syllable that serves to make it relatively more prominent." (p. 210). Generally, three levels of stress are distinguished: primary stress, secondary stress and unstressed, such as in the English word *validation*: [ˌvæ.lɪ.ˈde͡ɪ.ʃən]. Articulatorily, the increased prominence of a stressed syllable (compared to an unstressed one) is produced by greater physical effort, such as with a higher laryngeal muscle activity, increased subglottal air pressure or an adjustment in spectral tilt. More importantly, the four most common acoustic properties of stress are: fundamental frequency, duration, intensity and formant frequency pattern (vowel quality). A sudden change in fundamental frequency is usually a cue for stress. Stressed syllables also show a longer duration and a higher intensity. On the other hand, vowels in unstressed syllables tend to be reduced, i.e. to have more centralized formant values (Reetz & Jongman, 2009). Compare the Russian word pair *му́ка* /ˈmu.kə/ ('torment') and *мука́* /mu.ˈka/ ('flour') and note the reduction of the second, unstressed vowel in the first word.

Many languages, such as English or German, are referred to as stress-timed languages. On the other hand, languages like Spanish or Italian are characterized as syllable-timed languages. Generally, so-called syllable-timed languages tend to have no vowel reduction and simpler syllable inventories (Nespor, Shukla & Mehler, 2011). Accordingly, structurally simpler syllables imply a proportionally longer vocalic duration, referred to as %V. Subsequently, a higher %V implies in turn a lower variation (SD) in consonantal duration, called ΔC. Thus, syllable-timed languages are characterized by a relatively low ΔC and high

%V, which is reversed in stress-timed languages. Furthermore, stress-timed languages have two subcategories: fixed stress and variable stress. In the former kind, stress falls almost always on the same syllable in a word. The location of the stressed syllable varies across languages: first syllable in Czech or Finnish, ultimate in Armenian, penultimate in Polish and antepenultimate in Macedonian, to name a few examples (Sussex & Cubberley, 2006; Dum-Tragut, 2009). Stress in variable stress-timed languages such as English or German follows complex language-specific rules and varies across words (Reetz & Jongman, 2009). For more information on this disputed subject, see Nespor et al. (2011).

The key terms which are most relevant to a discussion of tonal languages are fundamental frequency, pitch and tone. Fundamental frequency is an acoustic term measured in Hertz, referring to the number of vocal fold vibrations per second in the speech signal. The way fundamental frequency is perceived (e.g. high or low, falling or rising) is referred to as pitch. Finally, tone is a linguistic term for pitch when it is used as a distinctive feature at the lexical level (Yip, 2009). Furthermore, the term ‘intonation’ is used when tone functions at the sentence level, differentiating, for instance, between interrogative or declarative intonation (Lehiste, 1970).

According to Yip (2009, p. 1) as much as 60-70 percent of the world’s languages exhibit tonal features. Several regions have an especially high number of tonal languages: South-East Asia, Africa, the Pacific and the Americas. However, Europe also has its fair share of tonal languages: Serbo-Croatian, Swedish, Norwegian, Slovene, Lithuanian, Latvian, Limburgian, as well as several dialects of Basque. Of these languages, Lithuanian will be discussed in §2.2 and Limburgian in §2.3.

The most widely attested type of tonogenesis is a historical loss of the voicing contrast in prevocalic obstruents. Due to differences in larynx height (Hombert, Ohala & Ewan, 1979), the pitch of a vowel after an unvoiced obstruent is higher than after a voiced one. In this way, when a language loses its voicing contrast, a high tone appears after historically voiceless obstruents and a low tone appears after the voiced ones (Hombert, 1978).

Hyman (2006, p. 229) defines a tonal language as follows:

(2.1) A language with tone is one in which an indication of pitch enters into the lexical realization of at least some morphemes.

In other words, a language in which prescribed differences in perceived fundamental frequency serve to distinguish between morphemes on a lexical and grammatical level can be considered a tonal language. Accordingly, tone can be lexical (distinguishing between different words) or grammatical (distinguishing between grammatical categories).

Acoustically, there are two types of tone: level and contour. A level tone, or a register tone, is one in which the pitch is sustained at a specific level (depending on the speaker's vocal range) throughout the relevant speech signal. Most tonal languages usually have two or three level tones: high (H), low (L) and in case of a third tone – mid (M). The minimal amount of tones required for a language to be considered tonal is one. This tone is usually H, whereas the other unmarked syllables are phonologically toneless, which is usually realized phonetically as L or M. Some languages differentiate as much as four or five levels with the addition of extra high and extra low tones. However, the existence of an underlying fifth level is still controversial and has been attested in very few languages (Yip, 2009). An example of how three level tones contrast different words can be seen in (2.2). Note that high tones are usually marked with an acute accent, mid tones with a macron and low tones carry a grave accent. These markings are not to be confused with the traditional method of transcribing tone in Serbo-Croatian (cf. §1.1).

(2.2) Three level tones in Cemuhi (Hyman, 2001, p. 1369)

tíí 'destroy'

tīī 'harvest'

tìì 'write'

The realization of contour tones involves pitch movements in different directions, usually rising or falling, marked with a caron and a circumflex accent, respectively. More complex patterns are also possible: falling-rising (concave) or rising-falling (convex). Underlying or naturally occurring contour tones are found mostly in South-East Asia. On the other hand, contour tones in many African tonal languages are only surface realizations of underlying sequences of different level tones. For instance, underlying HL and LH sequences in bisyllabic Yoruba words are realized phonetically with falls and rises, respectively: /rárà/ - [rárâ] 'elegy' and /àlá/- [àlǎ] 'dream' (Yip, 2009, p. 9).

Clearly differentiating between stress, TTL and pitch accent languages has proven rather difficult. Most sources agree that the common tradition of defining languages based on a continuum with 'pure stress languages' on one end and 'pure tonal languages' on the other (with pitch accent languages being somewhere in between) is quite inaccurate (Fox, 2000; Hyman 2001, 2006, 2009). A closer inspection of the various systems of prosodic prominence around the world will quickly show that some universal definitions of stress, tone and pitch accent (such as obligatoriness or culminativity) do not hold for all languages. This way, according to Hyman (2009, p.213), "the goal of prosodic typology is not to classify languages, but rather the properties of their subsystems." Furthermore, not all languages are truly ‘pure’ in the sense that they implement only tonal or only stress features. Most so-called pitch accent languages, in fact, are a hybrid system, in which stress and pitch are either codependent or are in some kind of a subordinate relation to one another. In the case of Swedish, which is a stress-timed language like English or German, stressed syllables can manifest two tonal patterns, traditionally referred to as Accent 1 and Accent 2. This restriction goes even further: while Accent 1 can appear in mono- and polysyllabic words, Accent 2 can be found only in the latter (Gussenhoven, 2004b). It is this type of distributional restriction which can serve to distinguish the different kinds of prominence systems from one another. Mandarin Chinese, which has long been considered a prototypical tonal language (TTL, in the case of this dissertation), does not have such restrictions. The vast majority of Mandarin Chinese syllables (which are at the same time morphemes) is lexically specified for one of four tones, which are illustrated in (2.3) below. There is no distinction between heavy, light, stressed or unstressed syllables, and each one can carry a lexical tone. Note that the tonal transcriptions on the left side are made with Pinyin, the official romanization system for Standard Mandarin Chinese. The first tone is high level, the second mid-rising, the third falling-rising and the fourth high-falling.

(2.3) The four tones of Mandarin Chinese (McCawley, 1978, p. 20)

1. mā ‘mother’ ˥
2. má ‘hemp’ ˧˥
3. mǎ ‘horse’ ˨˩˦ when phrase final, ˩ when not phrase final.
4. mà ‘scold’ ˥˩ when phrase final, ˥˧ when not phrase final.

According to Woo (1969), the third tone is phonologically a level low tone, and the rise at a phrase-final position is caused by a phonological rule. Accordingly, the four tones can be represented as a sequence of H and L tones, with the first tone being HH, the second LH, the third LL and the fourth HL. There is also a so-called “fifth tone”, which is underlyingly toneless, as in *ma* ‘question particle’. As a language with both stress and tone, unstressed syllables exhibit somewhat different tonal patterns. The pitch can be predicted based on the surrounding syllables, as seen in (2.4):

(2.4) Pronunciation of unstressed syllables in Mandarin Chinese (McCawley, 1978, p. 20)

An unstressed syllable is pronounced
˧ when preceded by first or second tone and followed by first or fourth
˨ when preceded by first or second tone otherwise
˩ when preceded by fourth tone
˩ when preceded by third tone and followed by first or second
˦ when preceded by third tone otherwise.

Tones in Mandarin Chinese remain underlyingly constant throughout what little derivation there is in the language. However, phonological rules such as assimilation and dissimilation do change the underlying form of some tones. There are two rules of tone sandhi: a third tone becomes a second when followed by another third tone, and a second tone becomes a first tone between a first or second tone and a stressed syllable. It is also important to note that each tone is produced *within* its corresponding syllable and there are little to no coarticulation effects between syllables, with the exception of tone sandhi and stressed/unstressed surface differences. For an illustration of the phonetic realization of tones in Mandarin Chinese, see Figure 2.1 below.

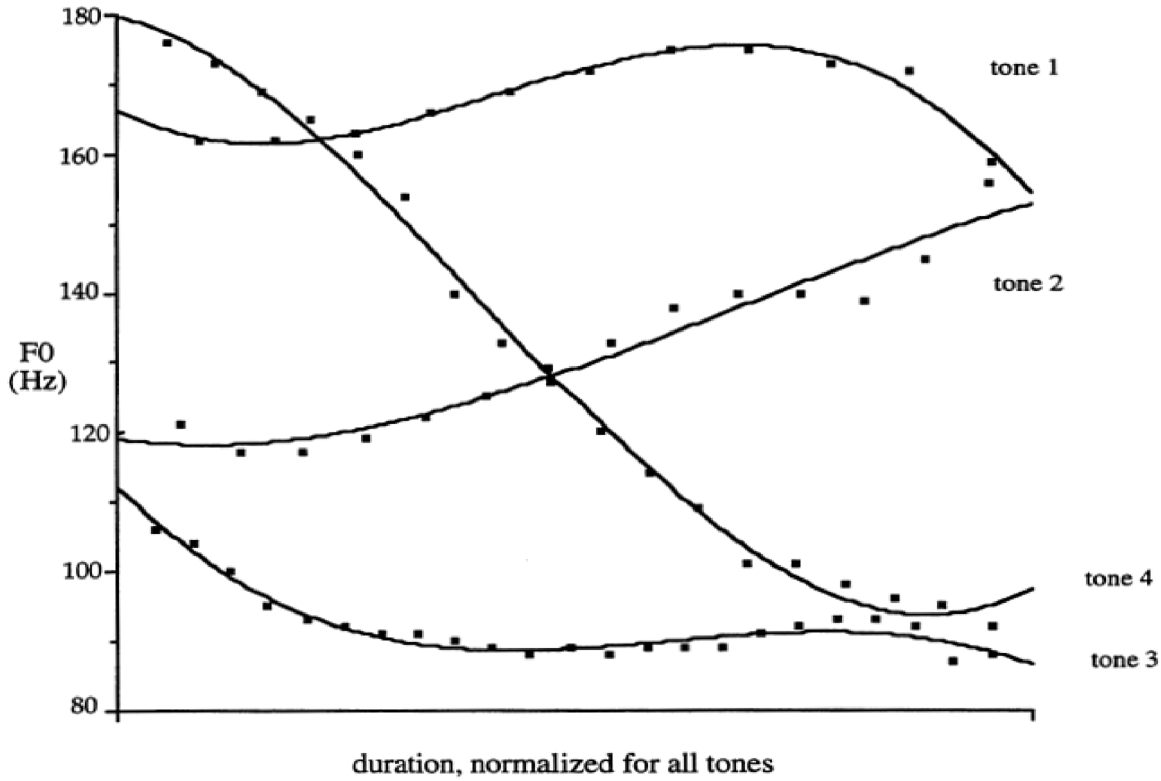


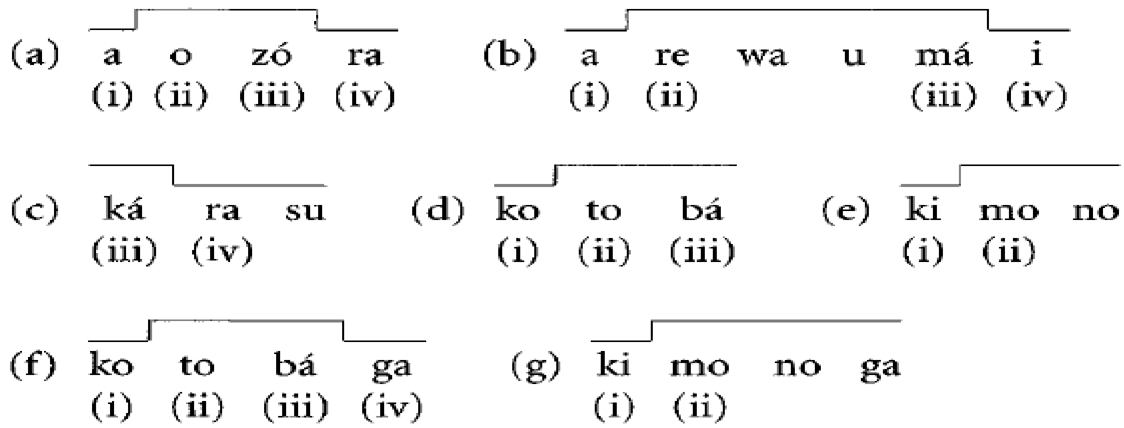
Figure 2.1. Stressed citation tones in Mandarin Chinese (Moore, 1993, p. 90)

The above figure shows that the surface production of tones corresponds to the underlying descriptions presented in (2.3). The first tone remains relatively stable and high throughout, the second starts in the middle of the vocal range and rises to the top, the third tone is the lowest and is actually a level tone and the fourth tone starts the highest and rapidly falls towards the bottom. Moore (1993) also compared the duration of stressed and unstressed syllables and found that the stressed syllables were significantly longer for all tones. In addition, the effect of stress on the fundamental frequency was found to be significant: F_0 range was narrower in unstressed syllables and expanded when stressed. Unstressed syllables retained the tonal properties of their corresponding tones, whereas the fifth tone showed more diffuse F_0 values which were highly dependent on the surrounding tones. Finally, the fifth tone does not trigger tone sandhi like the lexical tones do.

In order to illustrate the crucial differences between TTL's and pitch accent languages, I will now turn to standard Japanese, which has long been considered a prototypical pitch accent language. Unlike the stress-timed and syllable-timed languages mentioned earlier in this section, Japanese is a mora-timed language (Lee, 2015). Prosodic prominence, or pitch accent, appears only once in an accentual unit, which in this case is a phrase. This accent is realized phonetically as a H tone on the accented mora (usually marked with an acute accent) and a L tone on the following mora, resulting in a sharp fall, also called an "accentual fall". Words with a final accent end with H. In the case of heavy syllables (CVV or CVn), the accent is associated with the first mora of that syllable. All morae before the accent are also high, except for the first one in the phrase, which is produced with a low tone, also called a boundary tone (marked as %L). Following the accentual fall, all subsequent morae are low. Japanese can also have unaccented words, which do not contain this accentual fall, with all morae but the first carrying a H tone. In this way, a word with two morae like *hana* can be realized in three different ways: a) unaccented with a LH tonal pattern, meaning 'nose', b) with an initial accent (HL) and meaning 'Hana (woman's name)' and, c) with a final accent (LH), meaning 'flower'. As can be seen, spoken in isolation, Japanese bimoraic unaccented and final-accented words are realized identically. However, adding another element, such as the nominative case particle *-ga*, resolves this ambiguity: unaccented *hana-ga* is pronounced as LHH, initial accent as HLL and final accent as LHL (Fox, 2000; Lee, 2015). For a further illustration of Japanese tonal patterns, see (2.5), where the pitch is represented as a continuous line, being high for H and low for L. (i) represents the first, low mora in the phrase, (ii) the first pre-accentual high mora, (iii) the high accented mora and (iv) the post-accentual low mora. For the difference between no accent and final accent described above, compare (d) and (e) with (f) and (g).

Based on the examples below, it becomes clear that pitch in Japanese has a culminative function, and not a distinctive one. That is, high pitch doesn't contrast with its absence (i.e. low pitch), but rather with its occurrence on another mora. In any case, examples (d)-(g) and the distribution of H show that it is not high pitch alone which is the correlate of accent, but the H+L combination on the accented and the following mora.

(2.5) The tonal patterns of Japanese pitch accent (Fox, 2000, p. 140)



As already mentioned above, there can only be one accent per phrase, which is the accentual unit. The pitch accent is assigned to the first accentable unit in the phrase. This way, the phrases *usi-ga* 'the cow' (LHH) and *inú-ga* 'the dog' (LHL) can be combined with *imásu-ga* '…is here' (LHLL) to create single phrases with totally different accentual patterns (the accented morae are underscored): *usi-ga-imásu-ga* (LHHHHLL) and *inú-ga-imasu-ga* (LHLLLLL) (Fox, 2000). To summarize, one needs only to know the location of the accented mora in a word (found in prescriptive dictionaries), assign L tones to all morae after it and to the first mora, and make all the morae in between H. Simply put, following the above algorithm, pitch can be predicted for every mora in the phrase. Figure 2.2 on the next page shows the fundamental frequency of four trimoraic words with different accent locations. Capitalized syllables are accented, the numbers at the bottom represent syllables and the first and last two sections are parts of the unaccented carrier phrase (so that the accent will always fall on the target word) in which the words were embedded. The time scale is normalized and the vertical axis shows F_0 in Hertz. As Lee's (2015) investigation shows, there are two main acoustic parameters which are most important for pitch accent in Japanese: F_0 scaling - the way the pitch peaks and valleys relate to each other, and pitch peak alignment – the location of the peaks and valleys within the accentual unit. As can be seen, accented words have a significantly higher pitch peak and a lower pitch valley. The closer the accent is to the beginning of the word, the higher the pitch peak and the lower the pitch valley. This also means that when the accent is found earlier in the word, the accentual fall is also greater. Examining the curves of *ménami* and *naname* reveals that the pitch rise begins in the accented mora, but the peak is actually found in the next one. Lee confirms that the location of the accent in relation to word length has a significant effect on pitch peak alignment: the closer the accent is to the end of the word, the earlier the pitch peak, with final-accented words realizing the peak on the accented mora. Since Japanese has no stress, duration and intensity did not distinguish between accented and unaccented segments.

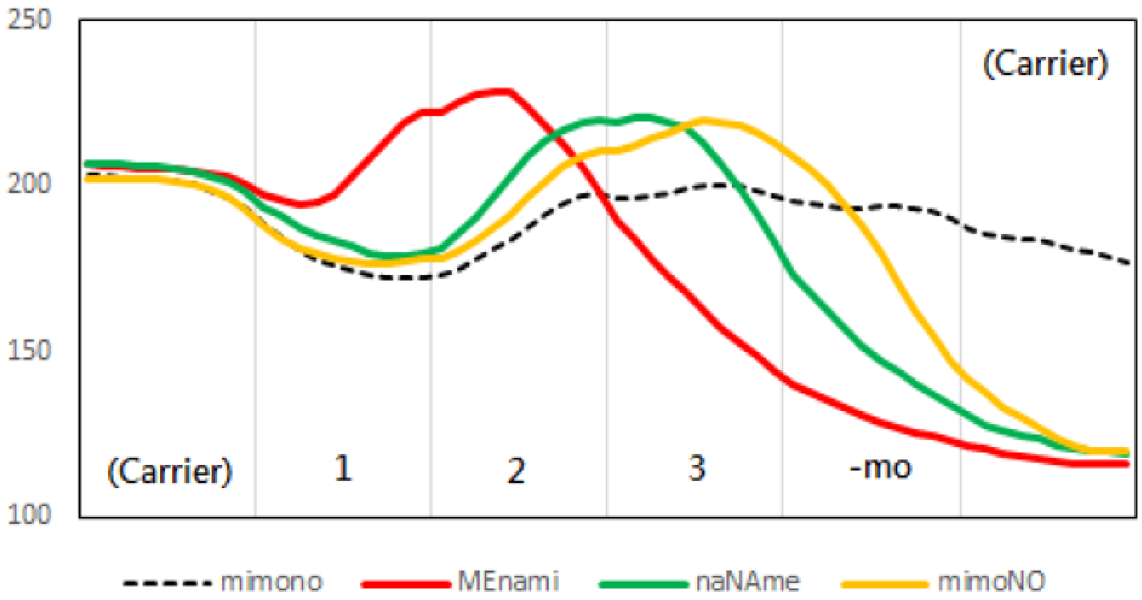


Figure 2.2. Fundamental frequency in four differently accented trimoraic Japanese words (Lee, 2015, p. 33)

Based on the above data from Japanese and Mandarin Chinese, significant differences can be observed between TTL's and pitch accent languages, which I have summed up in five categories: 1) number of tones, 2) distribution of tones, 3) domain of tone, 4) underlying form vs. surface realizations, 5) rigidity and predictability of tone. Note that these observations are based largely on the above two languages, even though most of these properties can be considered characteristic of the two systems.

1) Number of tones: TTL's have a larger tonal inventory. Compare the five (toneless syllables included) tonal possibilities in Mandarin Chinese with the two (or rather just one – the accentual fall) of Japanese. Larger (more than four tones) tonal inventories are usually found in South-East Asia, whereas the African TTL's usually have only two underlying tones: high and low (Hyman, 2006). In any case, pitch accent languages normally distinguish between two categories: high vs. low or falling vs. rising.

2) Distribution of tones: TTL's have a very high tonal density compared with pitch accent languages. Languages such as Mandarin Chinese or Navajo have lexical tones on almost every syllable (McDonough, 1999), while pitch accent languages can have not only unaccented syllables, but whole words.

3) Domain of tone: in TTL's it is the syllable in which tone is realized, whereas the accentual unit is usually the word (Swedish) or the phrase (Japanese) in pitch accent languages.

4) Underlying form vs. surface realizations: tone in TTL's is more susceptible to assimilation and dissimilation based on phonological rules, such as tone sandhi in Mandarin Chinese or the appearance of contour tones on sequences of HL or LH in Yoruba. Variations in surface realizations of tones in pitch accent languages are linked with phonetic factors such as word length and accent location or post-lexical effects like intonation or the speaker's emotional state.

5) Rigidity and predictability of tone: the tones of Mandarin Chinese are, so to speak, set in stone and do not change (with the exception of tone sandhi) with the derivation. Japanese, on the other hand, has much more dynamic tonal patterns, based solely on the location of the accented mora. In Serbo-Croatian paradigms, for instance, the accent can change not only its duration (long vs. short), but also its contour (rising vs. falling) and location (see §2.4.2 for more details). Japanese tone is fully predictable once the location of the accent is known, while Chinese tones must be learned for every syllable.

The next sections present a review of the tonal systems and prominent phonetic investigations in four pitch accent languages from different areas of the world, which will show the abundant variation present in this field. Yucatec Maya will be discussed in §2.1, Lithuanian in §2.2 and Limburgian in §2.3. Finally, section §2.4 will deal more thoroughly with tone in Serbo-Croatian in general and Croatian in particular and will also include the working hypotheses of this dissertation.

2.1 Pitch Accent in Yucatec Maya

Yucatec Maya (henceforth YM) is a member of the Yucatecan branch of the Mayan language family, spoken by about 700,000 people in Mexico, mainly in the states of Yucatán, Quintana Roo and Campeche, which corresponds to the Yucatán Peninsula (Frazier, 2009a). YM is also related to Ch'orti', which is in turn directly descended from Classic Maya, the language of the magnificent hieroglyphs of the ancient Maya civilization (Houston, Robertson & Stuart, 2000).

The basic structure of a YM syllable is CV(V)(C). Stops and affricates are distinguished by phonation type, with a voiceless and an ejective series. There is also a voiced bilabial implosive /ɓ/ (the only voiced stop in the language), which has no analogue in the alveolar and velar places of articulation. Glottal stops (orthographically marked as <'>) are contrastive in both syllable onset and coda position. Even if a word orthographically starts with a vowel, it will always be preceded by a glottal stop, since a syllable onset is obligatory. The vowel inventory is quite simple, with only five canonical vowel qualities - /i, e, a, o, u/. YM vowels can manifest four different contrastive sets of suprasegmental features: short, long low, long high and long glottalized (also called "rearticulated"). Using Frazier's (2009a, 2009b) terminology, each contrastive combination of suprasegmental features (length, pitch and glottalization) will be referred to as a "vowel shape". For an illustration of the possible vowel shapes, see table 2.1 below.

Table 2.1. The vocalic phonemes of Yucatec Maya (Frazier, 2009a, p. 19).

quality:		shape (applies to any vowel quality):	
i	u	v	SHORT: short, unmarked for tone, modal voice
e	o	v̀v	LOW TONE: long, low tone, modal voice
	a	v́v	HIGH TONE: long, high tone, modal voice
		v́v̰	GLOTTALIZED: long, high tone followed by creaky voice

Minimal quadruplets which distinguish between all vowel shapes can also be found, as seen in (2.6) below. Note that the high tone is orthographically marked with a double vowel and an acute accent above the first letter, glottalized with an apostrophe in the middle and the low tone only has two vowels.

(2.6) Minimal quadruplet for vowel shape in Yucatec Maya (Frazier, 2009a, p. 19)

SHORT	*chak*	'red'	[tʃak]
LOW TONE	*chaak*	'boil'	[tʃàak]
HIGH TONE	*cháak*	'rain'	[tʃáak]
GLOTTALIZED	*cha'ak*	'starch'	[tʃáa̰k]

According to Frazier (2009a), stress is noncontrastive in Yucatec Maya. As a general rule, heavy syllables attract stress. If there are no heavy syllables in a word then the leftmost syllable is stressed. Since words with two neighboring long vowels are quite rare, predicting stress in YM is relatively simple. Moreover, Kidder (2013) found no strong pattern for stress placement cued by fundamental frequency or duration in her investigation. Phonologically long vowels were indeed longer than short vowels, but they did not receive any word level prominence which would correspond to stress as explained in the beginning of this chapter. Tone in YM is not only lexical (as seen in the examples above), but also grammatical, which is mostly prevalent in the verbal system. Transitive verbs can be inflected for four voices: active, antipassive, middle and passive, with each voice having a different underlying vowel shape. The active voice is associated with the underlying form of the verb (e.g. *kin p'ejik* 'I chip it'), antipassive with low tone (*kin p'eej* 'I chipped'), middle with high tone (*ku p'éejel* ‘it gets chipped’) and passive with glottalized tone (*ku p’e’ejel tumeen ten* ‘it is chipped by me’) (Frazier, 2009a). However, Avelino, Shin & Tilsen (2011) present empirical evidence to the contrary. In their investigation of the relationship between grammatical voice and surface pitch contours it was found that the underlying prototypical pitch contour (low for low tones, high for high tones and falling for glottalized tones) of the word persists throughout all four voice categories. The only change in surface realization and thus, confirmation of the grammatical information above, was found for words with an underlying low tone in passive voice, which had a falling contour. Additionally, there was a difference in the production of the middle and antipassive voices between males and females. The middle voice (underlyingly high) had a higher overall F_0 than the antipassive (underlyingly low) for males, whereas for the females the situation was reserved. Avelino et al. (2011) state that it is therefore inconclusive whether pitch height can serve as a distinguishing cue between grammatical voice categories in YM. For a summary of their results, see table 2.2 below.

Table 2.2. Pitch contours of grammatical voice categories (Avelino et al., 2011, p. 10)

		Active	Antipassive	Middle	Passive
/Low/	Female	Low	Low	Low	Falling
	Male	Low	Low	Low	Falling
/High/	Female	High	High	High	High
	Male	High	High	High	High
/Rearticulated/	Female	Falling	Falling	Falling	Falling
	Male	Falling	Falling	Falling	Falling

In their investigation of the effects of prosodic context on tonal realizations in YM, Gussenhoven and Teeuw (2008) have found that the high and glottalized tones have different forms, depending on their position in the phrase. High tones in phrase-final position are produced with a sharp fall, while the contour is rising in all other positions. Glottalized vowels start with high pitch and sharply fall in all positions, but have creaky phonation in phrase-final position, as opposed to a full glottal stop reported in most of the phonological literature available. The short vowels and low tones are relatively stable in all positions and have a low level tone. Generally, phrase-final utterances had a lower fundamental frequency than non-final occurrences. Representative data from one speaker can be seen in Figure 2.3 on the next page. Following the acoustic analysis of different prosodic constructions (initial, penultimate and final phrase position), Gussenhoven and Teeuw explain the difference between high and glottalized tones and their allophony by stating that both have a pre-linked H tone, with the Tone Bearing Unit (henceforth TBU) being the syllable for high and low tones and the mora for glottalized. In other words, high and low tones can only carry one lexical tone, whereas glottalized can carry two. The variability in the peak location (early peak – falling contour and late peak – rising contour) of the high tones is due to the presence of low initial or final boundary tones, which are post-lexical tones that set the boundaries of the intonational phrase. A phrase-initial low boundary tone followed by a syllable-linked H tone (as is the case in high tones) results in a rise, while the same H tone followed by a phrase-final low boundary tone results in a falling contour. Similarly, the mora-linked H's of glottalized tones are always followed by a L tone linked to the second empty mora of the syllable, which is a boundary tone when phrase-final or a default inserted L tone otherwise, thus giving a fall in all contexts. Additionally, evidence of downstep in YM has also been found, which has been otherwise attested in many African languages. Downstep arises from underlying HLH sequences, where the second H has a lower fundamental frequency (most often phonetically realized as M) than the first one due to interference from the L tone in the middle (McCawley, 1978). Downstep is triggered by an underlying H tone, which explains why syllables with a high or glottalized tone preceded by the same vowel shapes were produced with lower F_0 than after short vowels and low tones. The difference between the two groups was as high as 25 Hz in some cases (Gussenhoven & Teeuw, 2008).

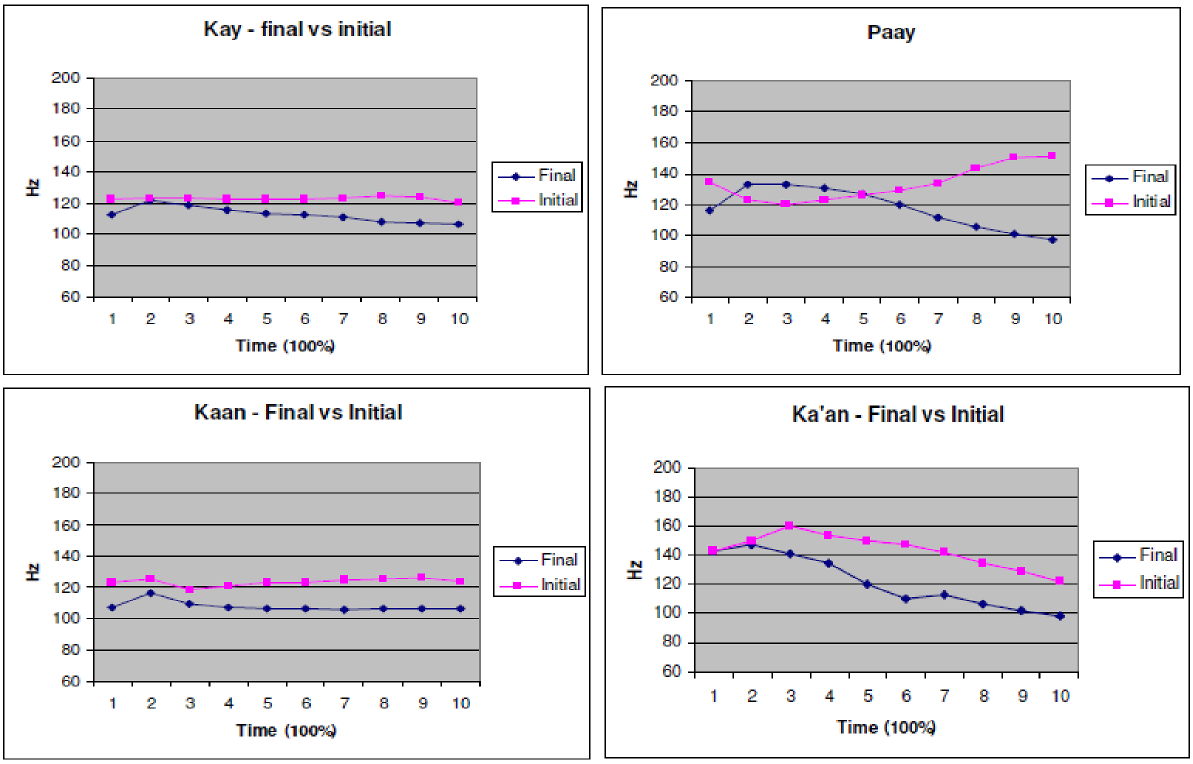


Figure 2.3. Mean F_0 tracks of the rhymes of *kay*, *páay*, *kaan* and *ka'an* in phrase-initial and phrase-final positions on a normalized time scale (Gussenhoven & Teeuw, 2008, p. 56)

Frazier (2009a) investigated the four different vowel shapes of YM in both monosyllabic words spoken in isolation and in mono- and bisyllabic words spoken in carrier phrases with various positions, much like Gussenhoven and Teeuw (2008). Having recorded speakers from both western and eastern Yucatán, several dialectal differences were discovered: while the results of the western dialect group (the towns of Santa Elena and Mérida) correspond to Gussenhoven and Teeuw (2008) and to the phonological literature, there was very little contrast between the high and low tones in the eastern dialect (the towns of Sisbicchén, Xocén and Yax Che) with respect to fundamental frequency, which would make a tonal merger seem quite plausible. However, high tones in the eastern dialect had a significantly higher duration than low ones, with the glottalized tone in the middle. The glottalized tone tended to be the longest in the western dialect, followed by high and low tones and finally, short vowels. Short vowels were produced in an analogous manner in both dialects.
Frazier (2009a & 2009b) has also made a fascinating discovery with regards to the interaction between pitch, glottalization and gender. In order to be able to compare speakers of different genders or different pitch spans, Frazier modified a method used by Pierrehumbert in her doctoral dissertation *The Phonology and Phonetics of English Intonation* (1980), calling it "semitones over the baseline" (s/b). Pierrehumbert found that peaks in an intonational contour were relative to the pitch of the final low boundary tone. This pitch value is referred to as a baseline and is calculated individually for every speaker – (pitch - baseline)/baseline. Frazier took the averaged pitch value in the middle portion of low-toned vowels since it was both low and relatively stable. Pitch values were first measured in Hz and then converted into s/b, using the following formula: $s/b = 12*\log_2(Hz/baseline\ Hz)$. Thus, a value of 3.4 s/b denotes a pitch value that is 3.4 semitones above that specific speaker's baseline. A comparison of Hz and s/b in high tones is shown in Figure 2.4.

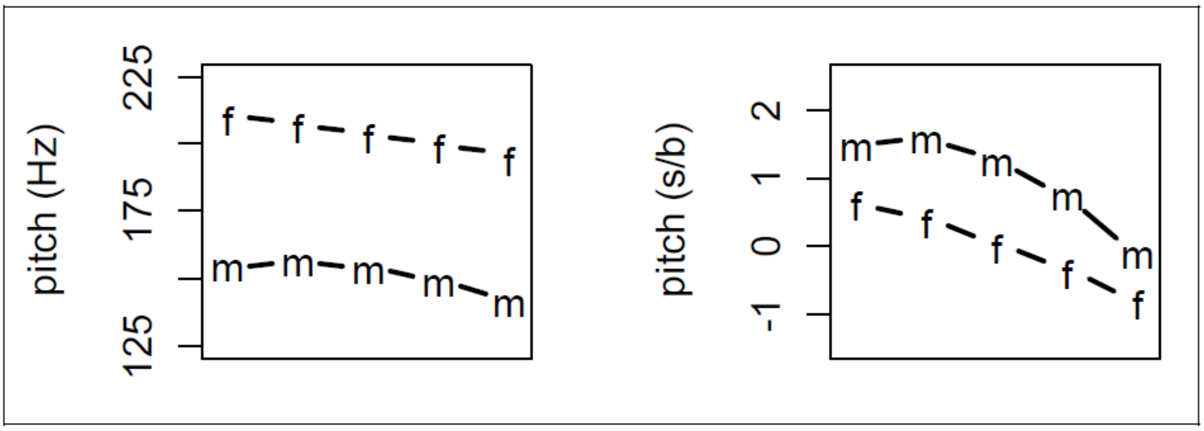


Figure 2.4. Average pitch contours of high tone vowels. f – female, m – male (Frazier, 2009b, p.120)

Substantial differences between male and female speakers can be seen on the Hz scale on the left side of the Figure, making comparison between the two somewhat difficult. On the other hand, the s/b scale does not only make the comparison more meaningful, it also clearly shows that male speakers' production of high tones is higher above their baselines than the females'. However, the s/b scale shows vastly different results when applied to glottalized tones actually produced with some kind of glottalization (as opposed to modal voice), defined by Frazier as either creaky voice (at the beginning, middle or end of the vowel), weak glottalization (indicated by a brief dip in intensity in the middle of the vowel) or a full glottal stop. A comparison of the two scales and genders can be seen in Figure 2.5.

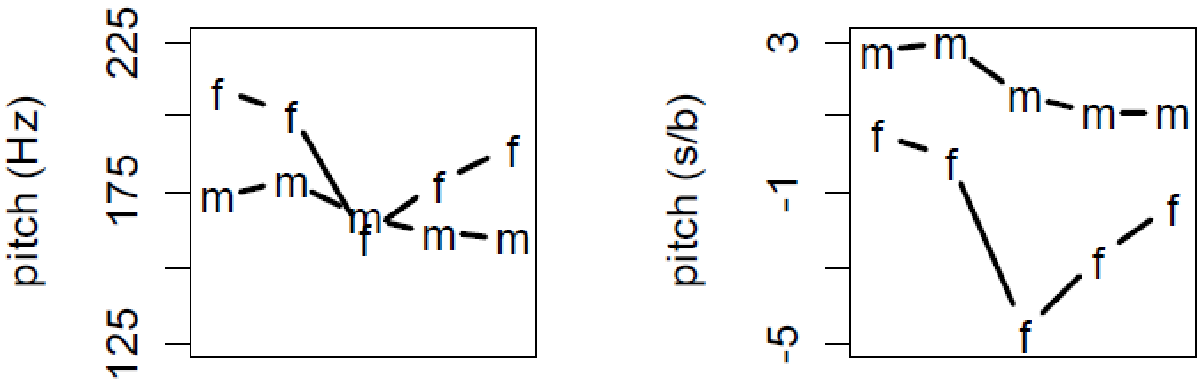


Figure 2.5. Average pitch contours of glottalized tone vowels. f – female, m – male (Frazier, 2009b, p. 121)

The Hz scale shows almost identical pitch values for males and females at the middle of the vowel, where glottalization usually occurs. Comparing this with Figure 2.4 also indicates higher male Hz values in glottalized tones than in high ones, which is in turn represented by higher values on the s/b scale. The pitch values required for glottalization are far below the female speakers' baseline, which causes the sharp fall at the middle portion, also lowering all other surrounding values. Since the males' baseline is naturally lower, glottalization does not precipitate a fall and their s/b values remain well above their baselines. These findings are further confirmed by the fact that female speakers produced glottalization more often (60% of all glottalized tone tokens) than the males (44% with glottalization). On the other hand, pitch contours of glottalized tones produced with modal voice only are practically identical in males and females on the s/b scale. This gives strong indications of a gender-specific interaction between phonation and pitch: glottalization in YM causes females to lower their pitch to well beneath the baseline (i.e. modal voice), whereas males are almost unaffected by it.

2.2 Pitch Accent in Lithuanian

Lithuanian is a member of the Baltic branch of the Indo-European languages and is spoken by roughly 3.5 million people, mainly in Lithuania. The other surviving member of the Baltic branch, Latvian, is spoken in neighboring Latvia and has several common features with Lithuanian, including a system of pitch accent (Ambrazas, Geniušienė, Girdenis, Sližienė, Tekorienė, Valeckienė & Valiulytė, 2006).

Unlike Yucatec Maya, stress in Lithuanian is distinctive. Consider the following minimal triplet, in which the different words are distinguished from one another solely by the position of stress (indicated by a grave accent): *lìkime* 'to remain, 1st person pl. imperative', *likìme* 'fate, voc. sg.' and *likimè* 'fate, loc. sg.'. As can be seen from these examples, stress in Lithuanian is also free. However, unlike other languages with free stress, syllables in unstressed position do not undergo vowel reduction (like in Russian) in Lithuanian (Ambrazas et al., 2006). Stressed vowels are pronounced with greater articulatory effort, longer duration and higher pitch. Interestingly enough, the neighboring Latvian has fixed stress on the first syllable (Girdenis, 2003).

Pitch accent in Lithuanian has a very similar distribution to Yucatec Maya. Heavy syllables – ones with either long vowels, so-called „semi-diphthongs" - short vowels with a tautosyllabic sonorant coda (/m, n, l, r/) or pure vocalic diphthongs – can manifest one of two distinct tones: acute (marked with an acute accent) or circumflex (marked with a tilde), as illustrated in (2.7). Tones occur only on stressed heavy syllables since the tonal contrast is neutralized in unstressed position. Note that the acute accent of semi-diphthongs is indicated by a grave accent, which is not to be confused with stress as in the examples above.

(2.7) Tonal minimal pairs in Lithuanian (Ambrazas et al, 2006, p. 55)

šáuk!	'shoot!'	*šaũk!*	'shout!'
gìnti	'to defend'	*giñti*	'to drive off'
klóstė	'(he) spread out'	*klõstė*	'frill'
týrė	'(he) explored'	*tỹrė*	'mush'

Evidently, Lithuanian has two parallel systems of prosodic prominence, which can function either separately or at the same time: pitch accent limited to stressed heavy syllables and dynamic stress found in all other contexts. A syllable can be stressed and toneless, but a syllable with tone cannot be unstressed. In this way, words can contrast not only based on the location of stress or type of lexical tone, but also on whether tone is present at all. The orthographically identical (stress and pitch accent are generally left unmarked in everyday use) *šìrdis* ‘heart, acc. pl.’ and *širdìs* ‘heart, nom. sg.’ are a good example. The former word’s first syllable is stressed and carries acute tone, whereas the second syllable is both unstressed and toneless. In the latter word, it is the second syllable which is stressed, although both are toneless. Figure 2.6 illustrates the distribution of tone in Lithuanian vowels. Note that “-VR-“ refers to semi-diphthongs.

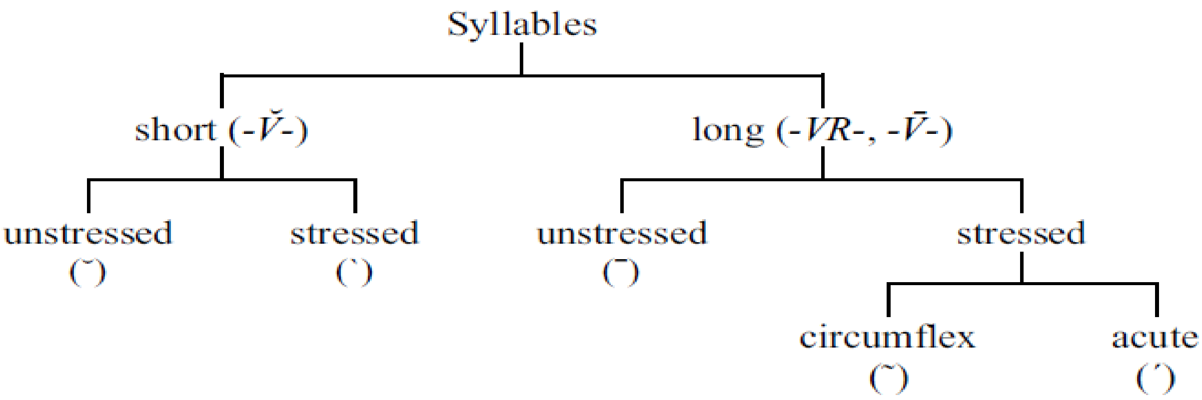


Figure 2.6. Prosodic properties of Lithuanian vowels (Girdenis, 2003, p. 294)

As seen above, prosodic prominence in Lithuanian is very fluid and can change its location, type and contour across the paradigm. However, based on several factors, accent in Lithuanian is also predictable. Each word stem is defined not only tonally (acute vs. circumflex [which includes stems with short vowels]), but accentually: strong stems (marked as “A” in the literature) are accented[6] before any grammatical ending and weak stems (marked as “a”), which only carry an accent before weak endings. Accordingly, there are also strong endings (E), which are accented only after weak stems, and weak endings (e), which are always unaccented. A word’s accentual value (i.e. accentuation paradigm) can usually be determined by its dative plural or genitive plural forms (both strong endings), where strong stems are always accented and weak stems are unaccented. Compare *píev-oms* ‘meadow, dat. pl.’ (accented strong stem and unaccented strong ending – **A**E) with *dien-óms* ‘day, dat. pl.’ (unaccented weak stem and accented strong ending – a**E**). Furthermore, there are certain grammatical endings (nom. sg. or acc. pl., for instance) referred to as “attractive endings”, which can also be strong or weak (È or è). While attractive endings following acute stems are accented according to the general rules described in this paragraph, circumflex stems always relinquish their accent to the ending, also known as de Saussure and Fortunatov’s Law. Based on the possible combinations of strong/weak and acute/circumflex stems, Lithuanian has four accentuation paradigms, simply referred to by number and usually indicated in dictionaries or

[6] I use this term here to denote any kind of prosodic prominence, be it dynamic stress or pitch accent.

linguistic investigations (Ambrazas et al, 2006). The accentual paradigms of Lithuanian are demonstrated below in Table 2.3.

Table 2.3. Accentual paradigms of Lithuanian (Ambrazas et al., 2006, p. 80)

		1	2	3	4
Sg.	Nom.	*várpa* (**Á**È)	*rankà* (ÃÈ -> A**È**)	*galvà* (á**È**)	*kalvà* (ã**E**)
	Gen.	*várpos* (**Á**E)	*rañkos* (**Ã**E)	*galvõs* (á**E**)	*kalvõs* (ã**E**)
	Dat.	*várpai* (**Á**E)	*rañkai* (**Ã**e)	*gálvai* (**á**e)	*kal̃vai* (**ã**e)
	Acc.	*várpą* (**Á**e)	*rañką* (**Ã**e)	*gálvą* (**á**e)	*kal̃vą* (**ã**e)
	Instr.	*várpa* (**Á**è)	*rankà* (Ãè -> A**è**)	*gálva* (**á**è)	*kalvà* (ãè -> a**è**)
	Loc.	*várpoje* (**Á**E)	*rañkoje* (**Ã**E)	*galvojè* (á**E**)	*kalvojè* (ã**E**)
	Voc.	*várpa* (**Á**e)	*rañka* (**Ã**e)	*gálva* (**á**e)	*kal̃va* (**ã**e)
Pl.	Nom./Voc.	*várpos* (**Á**e)	*rañkos* (**Ã**e)	*gálvos* (**á**e)	*kal̃vos* (**ã**e)
	Gen.	*várpų* (**Á**E)	*rañkų* (**Ã**E)	*galvų̃* (á**E**)	*kalvų̃* (ã**E**)
	Dat.	*várpoms* (**Á**E)	*rañkoms* (**Ã**E)	*galvóms* (á**E**)	*kalvóms* (ã**E**)
	Acc.	*várpas* (**Á**è)	*rankàs* (Ãè -> A**è**)	*gálvas* (**á**è)	*kalvàs* (ãè -> a**è**)
	Instr.	*várpomis* (**Á**E)	*rañkomis* (**Ã**E)	*galvomìs* (á**E**)	*kalvomìs* (ã**E**)
	Loc.	*várpose* (**Á**E)	*rañkose* (**Ã**E)	*galvosè* (á**E**)	*kalvosè* (ã**E**)

Paradigm 1 has a strong acute stem, paradigm 2 a strong circumflex stem, paradigm 3 a weak acute stem and paradigm 4 is characterized by a weak circumflex stem. The tonal property of a stem is usually determined by its accusative singular form.

Nevertheless, tonal contrast in standard Lithuanian has become far less prominent (Ambrazas et al., 2006). While Girdenis (2003) states that the tonal opposition in monophthong long vowels has become optional in the eastern and southeastern dialects (also known as Aukštaitian), Švageris (personal communication, May 15, 2016) maintains that it is mostly gone in favor of dynamic stress. There is still phonetic contrast between acuted and circumflexed diphthongs and semi-diphthongs, but this is manifested mainly as different vowel qualities, stress location and quantity. The first minimal pair in (2.7) illustrates the differences between acute and circumflex in diphthongs: *šáuk* [ʃɑˑ͜ʊk] and *šaũk* [ʃɐ͜uːk]. The acute accent causes the first segment of the diphthong to be pronounced more prominently, while the circumflex does the same for the second part. Similar differences can be found in semi-diphthongs, such as in the following minimal pair: *káltas* [kɑˑɫtɐs] 'chisel' and *kal̃tas* [kɐɫˑtɐs] 'guilty' (Ambrazas et al., 2006).

The phonetic nature of the two tones is still disputed. The acute has often been described as a falling contour tone, or otherwise as "abrupt" or "strong-initial" (which would be explained by the two minimal pairs above). The circumflex is considered to be rising, and has been referred to as “smooth” or “strong-final” (Girdenis, 2003). Dogil & Möhler (1998) investigated pitch accent in long monophthongs, diphthongs and semi-diphthongs as produced by two female speakers of a south-west Aukštaitian dialect. They have found that the acute accent is phonetically much more invariant than the circumflex. Acuted syllables (F_0 was also measured in the second mora in case of diphthongs and semi-diphthongs) always had a falling contour and a much broader averaged pitch range (79.3 Hz) than the circumflex (16 Hz). The contour of the circumflex, although quite variant, can be tentatively described as partially rising. The falling pitch movement of acuted syllables usually started at the middle of the first mora and ended in the middle of the second, a parameter which is referred to as “accent alignment”. Due to its narrow pitch range and inconsistent contour, accent alignment could not be calculated for the circumflex. This leads Dogil and Möhler to conclude that the difference between the two accents is not one of rising vs. falling contour, but rather variance. The acute accent can be clearly defined using acoustic parameters such as alignment, pitch range or contour (i.e. low variance), whereas the circumflex is so unstable it cannot be described using the same methods (high variance).

Unlike the Aukštaitian dialects, the tonal contrast between acute and circumflex is still quite present in the Žemaitian (also called Samogitian) dialects spoken in the north-west of Lithuania (Girdenis, 2003). Evaldas Švageris (2015) investigated pitch accent in monophthong long vowels of the Telšiai subdialect in northern Samogitia and the Valmiera subdialect of central Latvia. Even though only one of the Telšiai speakers (the older one) recorded produced contrast between acute and circumflex, Švageris’s results definitely show a tendency which is worth further investigation. Circumflex vowels were slightly longer than acute ones (roughly 250 and 220 ms, respectively), although this difference was not statistically significant. Generally, absolute pitch values had about the same effect on differentiating the tones as duration. Similarly to Dogil and Möhler (1998), the circumflex’s pitch contour was quite variable, showing two distinct free allotones: one rising and one falling. The acute, on the other hand, was not as invariable as in the previous investigation, also having two allotones: one with a rising contour (identical to the rising circumflex) and another rising-falling. For each tone, both allotones (referred to simply as A or B) had the same distribution (roughly 50%/50%) and ocurred independantly of context. For an illustration of these contours, see Figure 2.7 below.

Similarly, nonsignificant results using other measurements (such as intensity or pitch range), have led Švageris to conclude that a different approach is necesarry to distinguish the two tones from one another, namely relative duration measurements. In order to calculate the average rate of pitch change, Švageris measured pitch in semitones (converted from Hz) in every accented vowel every 10 ms, with each such point receiving a label – a1, a2, a3, etc. A series of subtractions is made for every analyzed vowel (a2 - a1, a3 – a2 and so on), which are calculated with no minus signs, since it is the rate of pitch change, and not its direction, which is important.

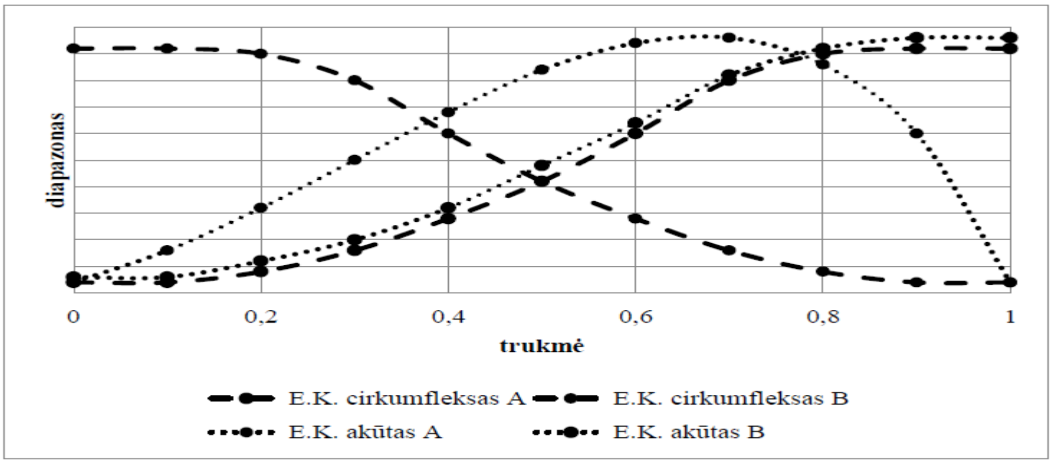
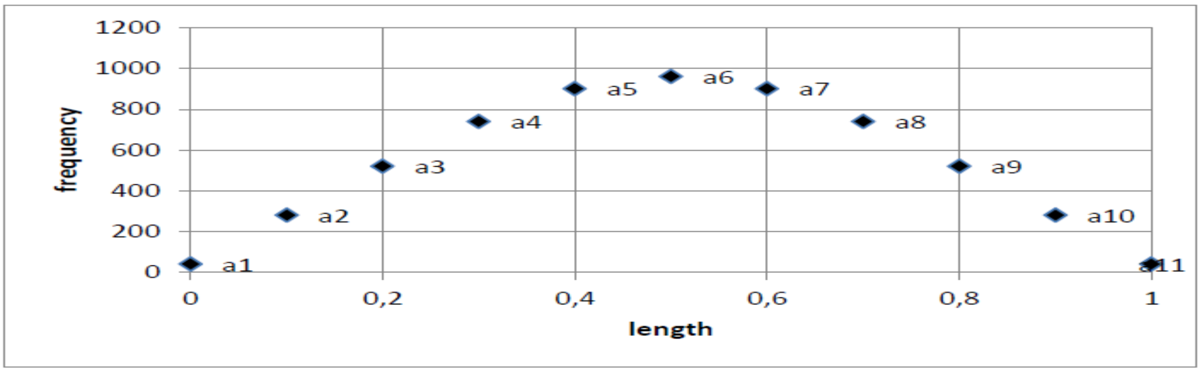


Figure 2.7. Pitch contours of Lithuanian speaker E.K. The horizontal axis shows duration on a normalized scale (0 is the beginning of the vowel and 1 is the end) and the vertical axis presents a normalized pitch range (Švageris, 2015, p. 76)

The absolute value of the above subtractions is divided by the number of intervals (i.e. number of subtractions) and, in order to derive the relationship between the obtained value and the measurement step between consecutive points, the entire formula is then divided by 0.01 seconds. Thus, a value of 59.2 means that the average rate of pitch change with respect to the distance between measurements (always 10 ms) is 59.2 semitones per second. Figure 2.8 displays the measuring method and the formula used to calculate the average rate of pitch change.



$$\frac{|a2 - a1| + \ldots + |a_n - a_{(n-1)}|}{a_n - 1} \Big/ 0.01s$$

Figure 2.8. Calculation of average rate of pitch change. Note that the denominator should read “*n-1*”, since “a_n – *1*” is the value in Hz, and not the number of intervals (Švageris, 2015, pp. 13-14)

Using the average rate of pitch change to distinguish between the two tones did prove to be successful, but only to a limited degree. However, a correlation between average rate of pitch change and absolute pitch range (in a specific vowel) on the one hand, and that specific vowel's duration on the other, was found. To calculate the first parameter, the average rate of pitch change was divided by the absolute pitch range (F_0-Maximum - F_0-Minimum). A higher value of this so-called "relative rate of pitch change" denotes a slower change in pitch, relative to the pitch range. A visualization of this correlation is shown below in Figure 2.9. Note that only speaker E.K. (blue – acute, red – circumflex) produced statistically significant differences between the two tones.

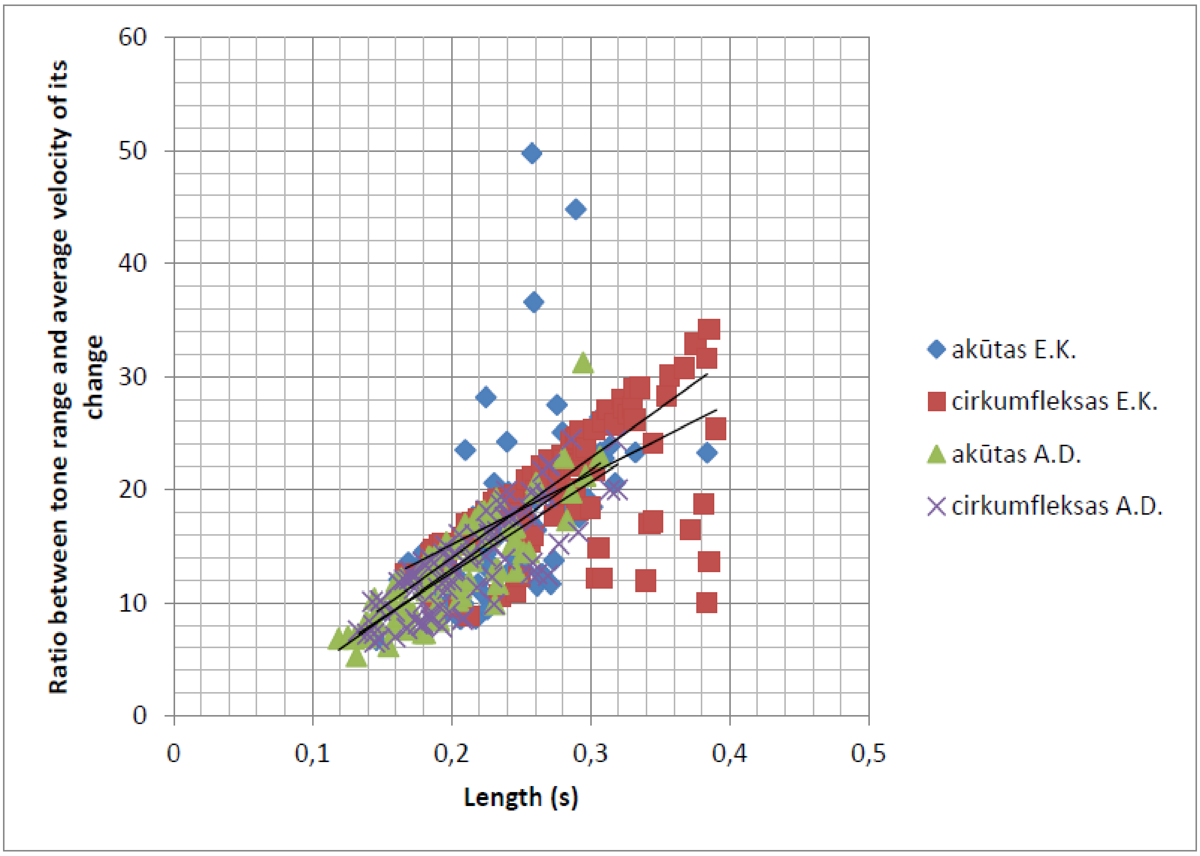


Figure 2.9. Correlation between relative rate of pitch change and vowel duration (Švageris, 2015, p. 91)

The figure above shows that the longer the duration of the vowel, the slower the relative rate of pitch change, and vice versa. Circumflex vowels tend to have a longer duration than the acute ones, which in turn makes their relative rate of pitch change smaller, since their pitch range is also narrower. Following these findings, Švageris proposes two distinct acoustic models, one for each tone. The narrow pitch range of circumflex vowels prevents an abrupt and fast change in pitch rate, while their extended duration lowers it even further, resulting in a more level and longer contour. On the other hand, the acute's shorter duration and wider pitch range create a favorable environment for a more intense and abrupt change in pitch.

2.3 Pitch Accent in Limburgian

Limburgian is a part of the South Low Franconian and Central Franconian tone accent area, which encompasses the Belgian and Dutch provinces of Limburg, the northeast part of the Belgian province of Liège, the southwest of North Rhine-Westphalia and the north of the Palatinate in Germany (Peters, 2007). Linguistically speaking, this areal covers the Limburgian dialects of Dutch and the Ripuarian and Moselle Franconian dialects of German, which are all parts of the Dutch-German continuum (Hermans, 2012). Although Peters (2007) also includes Luxemburg in the tone accent area, there is some evidence that the tonal contrast in that language has completely disappeared (Goudailler, 1987).

Limburgian has a lexical tone contrast between the so-called Accent 1 and Accent 2, which is quite similar to the contrast found in Swedish and Norwegian (Gussenhoven, 2004b). Lexical tone appeared in the Central Franconian dialect of Cologne around the year 1300, spreading outwards to encompass the area described above. The origin of this contrast is still controversial, but Gussenhoven (2004a) proposes the following hypothesis: nouns like /wex/ 'road, sg.' and its plural form /weɣə/ underwent a process known as Open Syllable Lengthening, which caused short vowels in open syllables in Middle High German and Middle Dutch to become bimoraic, ie. /we.ɣə/ to /weː.ɣə/. In order to compensate for the long vowel in the plural, which was a violation of the relation between morpheme and phonological form, the short vowel in the singular was also lengthened, so that /wex/ became [weːx]. Assuming another phonological process, this time an apocope, which deleted the final /ə/ in the plural thereby causing the /ɣ/ to become a /x/ due to final devoicing, the singular and plural forms both became [weːx]. However, the lengthening of the vowel in the singular in Central Franconian was only phonetic, as opposed to the phonological lengthening in the plural. As a result thereof, the pitch fall observed in utterance-final words was somewhat truncated, which left a high pitch in the last part of the vowel, whereas the phonologically long vowels in the plural were unchanged and pronounced with a falling contour. As can be seen on the left side of Figure 2.10, both forms had the same tonal pattern for utterance-final position: H* L_i. H* marks the post-lexical (intonational) pitch accent, which is associated with a focused word, while L_i refers to a boundary tone, appearing at the end or beginning of an Intonational Phrase (IP) or an utterance. The high pitch at the end of the singular vowels became a lexical H tone, attaching itself to the second mora and resulting in H* H L_i, which contrasts with the H* L_i of the plural. The forms with the lexical H tone later became known as Accent 2 (or *sleeptoon* 'dragging tone') and the ones without a lexical tone as Accent 1 (or *stoottoon* 'push tone'). Throughout this section, a slight variation[7] of the traditional method of marking accent with a superscript after the accented syllable will be used, such as in /dɔɔx²/ 'day, sg.' and /dɔɔx¹/ 'day, pl.' (Peters, 2007).

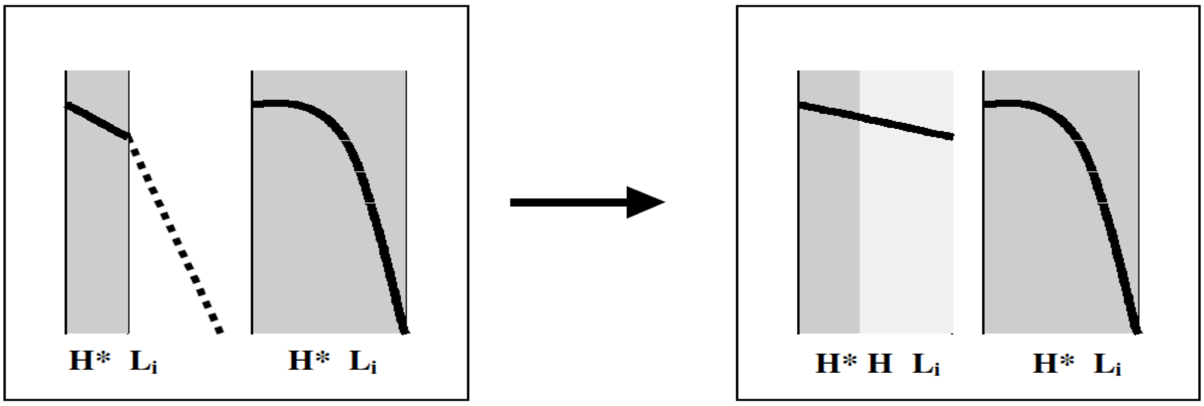


Figure 2.10. Hypothesized phonetic lengthening of singular forms (left side of each panel), leading to a tonal interpretation of the difference between singular (H*H L_i) and plural (H* L_i) forms (Gussenoven, 2004a, p. 231)

Investigations of tone in Limburgian traditionally differentiate between East and West Limburgian dialects. Moreover, most of these works focus on the dialect of a single town or city, such as the East Limburgian dialects of Venlo (Gussenhoven & Van der Vliet, 1999) and Roermond (Gussenhoven, 2000) or the West Limburgian dialects of Borgloon (Peters, 2007) and Hasselt (Peters, 2008). The eastern and western dialects vary in two respects. First, the TBU in East Limburgian is the sonorant mora of the accented syllable (hence the traditional method of marking accent type described at the bottom of this page), while it is the accented syllable itself in West Limburgian. Second, East Limburgian sequences the tones of the post-lexical pitch accent to the left of the lexical tone, whereas West Limburgian sequences them to the right (Gussenhoven, 2012). The differences between the two accents and the realization of lexical tone in different prosodic contexts will be illustrated here on the basis of the East Limburgian dialect of Venlo.

From a typological point of view, the dialect of Venlo is quite rare in its prosodic complexity. As a general rule, tonal languages have simpler intonation systems than non-tonal languages like English (Maddieson, 1984). In their investigation of tone and intonation in the Venlo dialect Gussenhoven and Van der Vliet (1999) have found 23 distinct tonal patterns,

[7] The traditional method puts the superscript after the nucleus of the accented syllable, e.g. /dɔɔ²x/ 'day, sg.' but for the sake of uniformity, the above method is used.

comprising of four intonational melodies (declarative, interrogative, continuation[8] and surprised question), three positional variations (focused nonfinal, focused final and nonfocused final) and two lexical tones (Accent 1 and Accent 2). The interrogative intonation is not used in final focused position with Accent 1. The dialect of Venlo owes its prosodic complexity to its geographical position between the non-tonal Dutch dialects in the north and west and the tonal dialects to the south. A graphical and phonological representation of the tonal patterns can be seen in Figure 2.11.

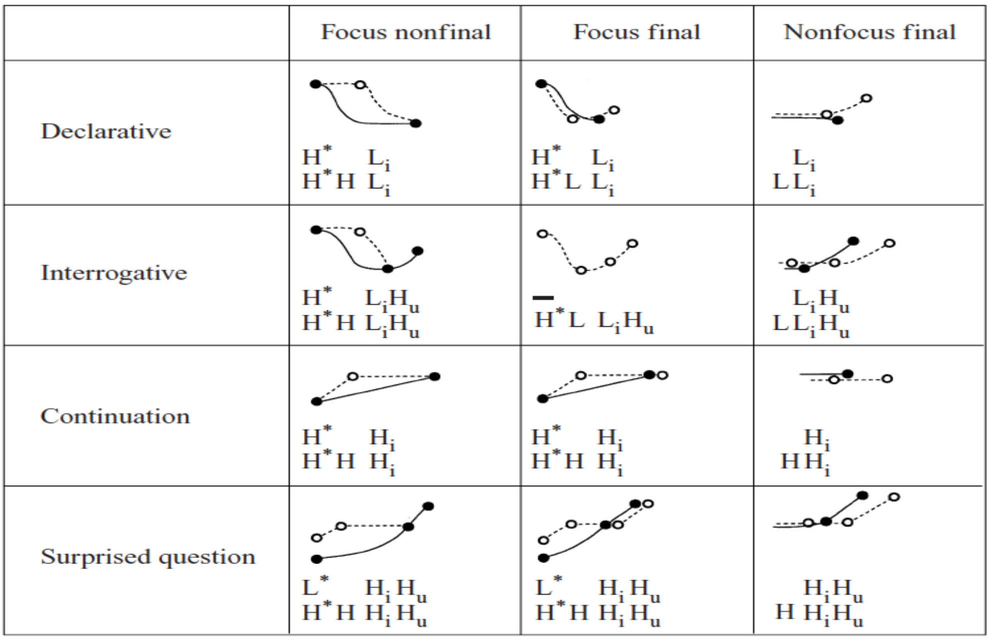


Figure 2.11. The tonal patterns of Venlo Limburgian. Solid contours represent Accent 1 and interrupted contours stand for Accent 2. The tonal representation of Accent 1 is found in the top row of each cell, while that of Accent 2 is in the bottom row. Open dots show pitch targets for Accent 2 and closed dots represent targets for Accent 1, or both if their targets coincide (Gussenhoven & Van der Vliet, 1999, p. 131)

In the dialect of Venlo, as in the other East Limburgian dialects of Maasbracht and Roermond, the contrast between Accent 1 and Accent 2 is only possible on stressed syllables with two sonorant morae, i.e. a long vowel, a diphthong or a short vowel and a sonorant consonant (/m, n, ŋ, l, ʀ/), which is very similar to the distribution found in Lithuanian (see §2.2). Furthermore, in order for the tonal contrast to be realized, the stressed syllable and its sonorant morae must be either focused or IP-final. In other words, words which would otherwise be produced with Accent 1 or Accent 2 are realized without lexical tone in pre- or postfocal and IP-nonfinal position.

As can be seen in the first column of Figure 2.11, the contours of Accent 2 are consistently higher than those of Accent 1. This difference is explained by the presence of a lexical H tone

[8] Gussenhoven and Van der Vliet (1999) define this intonation as the one used for the Word *A* in a sentence such as ‘First I say "A", and then I say "B"’.

(L in the case of final declarative and interrogative contexts) on the second sonorant mora of Accent 2 syllables and its absence in Accent 1. Thus, the lexical tone contrast in Venlo Limburgian is a privative one, in which the TBU can be defined either as lexically H (Accent 2) or lexically toneless (Accent 1). This also means that monomoraic words, which are not viable TBUs, have contours similar to Accent 1. Much like standard German or Dutch, Venlo Limburgian has a focus-marking pitch accent which must appear at least once in every utterance. This pitch accent is a single H* tone, which is prelinked to the first sonorant mora of the primary stressed syllable of a focused word. The focal tone is realized as L* in the surprised question intonation of Accent 1 in focused final and nonfinal position. This way, the stressed syllable of a focused Accent 1 word is defined as having only a focal H* tone on its first mora, whereas the same syllable would have H* on the first mora and the lexical H on the second one in Accent 2 words. Additionally, the four intonational melodies are phonologically defined as boundary tones which appear at the end of an IP or an utterance. The declarative intonation has an IP-final L_i tone, interrogative is a sequence of L_i and an utterance-final H_u, continuation has a single IP-final H_i tone and surprised question exhibits a combination of H_i and H_u (a subscripted 'i' is IP-final and a 'u' stands for utterance-final). Intonational phrases, as in many other languages, begin with a L_i boundary tone. As a result, a fully specified one-word utterance may contain up to five tones, such as in the interrogative intonation of an Accent 2 word like /ˈɛʀ^{2}ɣəʀə/ ('annoy, inf.'): L_i H*H L_iH_u. Subsequently, the different pitch contours seen in Figure 2.11 can be explained by the various combinations of lexical tones (or lack thereof), focal tones and the different boundary tone sequences of each intonational melody.

Focused and nonfinal syllables in declarative and interrogative intonations realize the contrast between the accents as a difference in F_0 timing: Accent 1 exhibits a fall after the first mora and Accent 2 after the second, as illustrated in Figure 2.12.

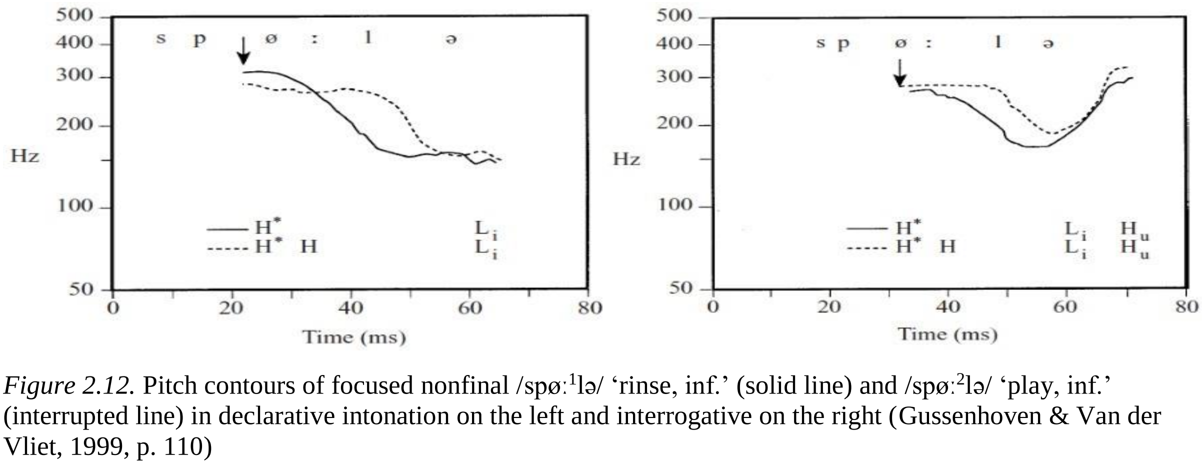


Figure 2.12. Pitch contours of focused nonfinal /spøː^{1}lə/ 'rinse, inf.' (solid line) and /spøː^{2}lə/ 'play, inf.' (interrupted line) in declarative intonation on the left and interrogative on the right (Gussenhoven & Van der Vliet, 1999, p. 110)

The fall observed between the H* focal tone and the IP-final L_i boundary tone is delayed by the presence of the lexical H tone in Accent 2, generating high level pitch in the nonfinal accented syllable. Since Accent 1 is lexically toneless, the fall occurs at the beginning of the syllable. Its steepness is accounted for by Leftward Tone Spreading, in which L_i spreads to the unoccupied mora of the accented syllable, thus creating a further low target. The realization of Accent 1 in focused final context is almost identical to the nonfinal position, since their tonal patterns are the same. However, Accent 2 in final position is quite different than nonfinal, exhibiting an earlier fall with a slight rise at the end. Gussenhoven & Van der Vliet (1999) suggest that the lexical H tone is assimilated by the L_i, resulting in H*L L_i instead of the expected H*H L_i. Furthermore, the final rise is explained by assuming that L_i is not associated with a mora, thus receiving a target slightly higher than the assimilated lexical L, as seen in Figure 2.13.

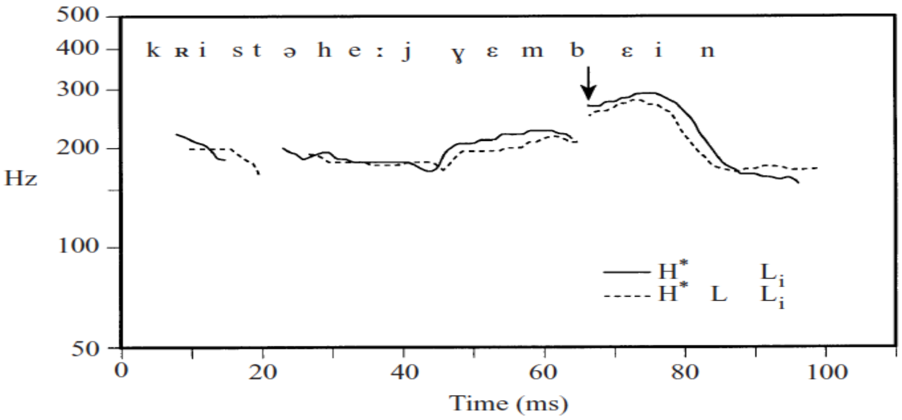


Figure 2.13. Pitch contours of focused final /bɛin^1/ ‘leg, pl.’ (solid line) and /bɛin^2/ ‘leg, sg.’ (interrupted line) in declarative intonation. The arrow indicates the beginning of voicing in the focused syllable. Note the longer duration of /bɛin^2/ (Gussenhoven & Van der Vliet, 1999, p. 113)

When asked to produce a focused final Accent 1 word with interrogative intonation, the one speaker recorded in the investigation failed to realize the expected sequence of H* L_iH_u, pronouncing it instead with a melody referred to as “Surprised Question” (L* H_iH_u). Thus, Venlo Limburgian forbids the use of the interrogative L_iH_u intonational melody on focused final syllables unless there is a lexical tone present. The usual option for speakers when faced with tone crowding would be to lengthen the syllable, however, this would cause Accent 1 words to be too similar to Accent 2, since syllable lengthening is its phonetic cue (see Figure 2.13), hence the shifting to the surprised question intonation. Nonfocused final syllables, having no focal H* tone, have pitch contours very similar to the second half of their focused final counterparts, differing only in duration.

2.4 Pitch Accent in Serbo-Croatian

This section deals with tonogenesis and the history of tonal investigations of Serbo-Croatian in the 19th and early 20th centuries (§2.4.1), the tonal system and its associated processes (§2.4.2) and finally, the phonetics of tone based on experimental investigations of the 20th and 21st centuries (§2.4.3).

2.4.1 Tonogenesis and History

The appearance of contrastive lexical tone in Serbo-Croatian dates back to the end of the 15th century in a process known as the Neo-Štokavian accent shift (Bethin, 1998). All Štokavian dialects at the time had only two falling accents in free distribution: one short (̏) and one long (̂). Besides unstressed brevity (̆), unstressed length (̄) was also part of the accentual system and could occur either on the first pretonic or on any posttonic syllable. By the end of the 15th century, as a result of the accent shift, all non-initial falling accents had been transferred one syllable towards the beginning of the word. Initial falling accents remained unchaged, whereas the shifted accents received a rising contour (̀). Phonemic length remained in place and accents retracted onto long syllables not only changed their contour, but also became long (́) (Sredojević & Subotić, 2011), as illustrated in (2.8).

(2.8) The appearance of rising accents in Neo-Štokavian

rūkȁ 'hand, nom. sg.' ⟶ *rúka*

rūkê 'hand, gen. sg.' ⟶ *rúkē*

ženȁ 'woman, nom. sg.' ⟶ *žèna*

ženê 'woman, gen. sg.' ⟶ *žènē*

môre 'sea, nom. sg.' ⟶ *môre*

Before the accent shift, falling contours could also be observed on pretonic syllables in the case of non-initial accents. However, the onset of accented syllables was still higher than the offset of pretonic syllables. The pitch of the pretonic syllable gradually rose to the level of the stressed syllable during the accent shift. At the same time, the pretonic syllable also became longer and more intense, thereby becoming more prominant than the actual stressed syllable. This, in effect, completed the accent shift by not only retracting dynamic stress one syllable towards the beginning of the word, but also creating a rising contour therein, which would contrast with the falling accents left on initial syllables (Sredojević & Subotić, 2011). A further consequence of the Neo-Štokavian accent shift was the retraction of initial falling accents to a proclitic, in a process known as proclitic accent shift (henceforth PAS). Since proclitics (prepositions, conjunctions and particles) have no accent of their own, they form a phonological word with the following word, as in *u ràt* ‘to war’ or *u kȕću* ‘into (the) house’. For the purposes of the Neo-Štokavian accent shift, these proclitic-word combinations were identical with single words, and thus the falling accents were retracted to the proclitic. Much like the process described above, the retraction also changed the pitch contour from falling to rising, so that *u kȕću* became *ù kuću* (Kapović, 2015). This phenomenon, also known as weakened accent shift, since the retracted falling accent loses some of its prominence to the syllable it was retracted from by becoming rising, is especially common with the particle *ne* ‘not’: combinations like *ne znâm* ‘I don’t know’ or *ne râdī* ‘it doesn’t work’ are almost always pronounced as *nè znām* and *nè rādī*. This pronunciation is in fact so widespread that incorrectly writing "neznam" or "neradi" instead of "ne znam" or "ne radi" has become increasingly common. Another form of PAS, originating in Proto-Slavic and known as unweakened accent shift, retracts the accent onto the proclitic without changing its contour: *grâd* - *ȕ grād*. Initial rising accents are unaffected by PAS, so that <ne želim> ‘I don’t want’ remains *ne žèlīm*, and not **nè želīm*. PAS is much more consistent and stabile in Bosnian than in Croatian or Serbian (Kapović, 2015).

The Neo-Štokavian accentual system spread throughout the Balkans as a result of the migration waves of the 15th century. Dialects which did not undergo the accentual shift later became known as Old Štokavian (see §1.1.3). Thus emerged the two most defining characteristics of Serbo-Croatian accentology: 1) falling accents are restricted to initial syllables and, 2) rising accents can appear on any syllable but the last. Additionally, unstressed length disappeared from pretonic syllables and became strictly posttonic. As in most cases, exceptions to these two rules can be found in colloquial speech, which will be discussed in §2.4.2.3.

The first meaningful investigation of Serbo-Croatian accentology dates back to Luka Milovanov’s *Opit nastavlenja k srbskoj sličnorečnosti i slogomjerju ili prosodii* (‘An attempt at teaching the Serbian synonymity and syllabification or prosody’), written in 1810 but published posthumously in 1833 with the help of Vuk Karadžić. This was the first attempt at classifying the Serbo-Croatian accents, and the symbols used to mark them today can be traced to this book. Milovanov distinguished only three accents, making no difference between the two short ones: ` was referred to as *accentus elevans* (‘elevating accent’), ˆ as *accentus superelevans* (‘super-elevating accent’) and ˊ was named *accentus prolongans* (‘prolonging accent’). Furthermore, Milovanov used the superfluous ˆ (naming it *accentus superprolongans*, ‘super-prolonging accent’) to denote a sequence of ˊ and posttonal length.

Vuk Stefanović Karadžić, the father of the modern literary Serbian language, used Milovanov's symbols and terminology (with which he was intimately familiar) in his *Grammar of the Serbian language*, published in 1814. Karadžić developed the terminology further by adding rather vague descriptions of the characteristics of the different accents, stating that in vowels with ` "the voice is slightly raised and pronounced quickly" (Lehiste & Ivić, 1996, p. 15), for instance. Four years later, in his *Serbian dictionary*, Karadžić uses a wholly different terminology: ` is pronounced "sharply", with ˆ "the voice is spread out as if round", and "the voice just stretches" in vowels with ´. Milovanov's ˆ is still present, but there is also the addition of ̏, which is "sharper" than ` (Karadžić, 1818, p. XXXVI). Karadžić uses ` to denote both short accents, writing ̏ only in the case of minimal pairs, such as *òra* 'nut' and *ȍra* 'the right time'. This is the first account of the four traditional accents of Serbo-Croatian as they are used today. In the 1852 edition of his *Serbian dictionary*, Karadžić had improved his notation by consistently distinguishing between ` and ̏. Additionaly, Milovanov's ˆ was now being used to denote PTL, such as in *ljúdî* 'people, gen. pl.' instead of *ljûdi.* It is very important to note that Karadžić based his entire grammar, and more crucially, the accentuation, on his native Eastern Herzegovinian dialect of Tršić, a village in western Serbia near the city of Loznica. For purposes of linguistic standardization, Karadžić single-handedly assigned his own dialect the status of the literary Serbian language. With the unifying aspirations of the Illyrian movement in the 19th century, especially around the signing of the Vienna Literary Agreement in 1850 (see §1.1.3), this status of official language was further extended to all Neo-Štokavian dialects, including the Croatian literary language. While completely absent in the 1818 edition of the *Serbian dictionary*, the ikavian Western Štokavian dialects spoken in Croatia are described in the 1852 edition as having a completely identical prosodic system as in Tršić. Despite heavy criticism, Karadžić's accentuation was eventually adopted by several leading linguists, such as Tomislav Maretić in his *Grammar and stylistics of the Croatian or Serbian literary language*, published in 1899 (see below). As tensions between Croatian and Serbian linguists (and politicians) rose in the second half of the 20th century, there was growing discontent with the official Tršić-based accentuation, which was viewed as foreign and artificially imposed outside of, and in some cases, also in Serbia proper. The creation of a standardized Croatian accentuation culminated in 2007 with the publication of *Naglasak u hrvatskome književnom jeziku* ('Accentuation in the literary Croatian language') by Vukušić, Zoričić and Grasselli-Vukušić, work on which had already begun in 1982. This monumental work will be discussed in further detail in §2.4.2. Continuing and often defending Karadžić's work, Đuro Daničić (Karadžić's closest disciple) wrote a series of articles between 1851 and 1872, which were published together as one book posthumously in 1925 with the title *Srpski akcenti* (‘Serbian accents’). These articles present an in-depth and systematic description of the various accentual paradigms, divided according to parts of speech, accent, accent place and syllable number. Thus, for instance, the first article written in 1851 has an entry for feminine nouns ending with *-a* with a long rising accent on the first syllable, and so on. As described earlier in this section, Daničić’s *Serbian accents* soon became the standard for both Serbian and Croatian.

Emanuil Kolarović was the first to introduce the idea of a dichotomy of duration in 1827, dividing the accents into short and long. In other words, he was the first to state that short and long accents have common traits: ̏ and ̑ are described as “finished”, whereas ` and ´ are “hung” and after them “the word continues” (Lehiste & Ivić, 1996, p. 17). This concept of rising accents continuing on into the next syllable will be central in Masing's investigation, which will also be discussed in this section. Marianus Šunjić expanded the classification in 1853 by adding a tonal category to the contrast between the accents. Thus, ̏ was defined as “breviter cum accentu gravi” (‘short with a heavy accent’) or ´ as “sonat longa cum accentu acuto” (‘sounds long with a sharp accent’). This was the first mention of two distinct categories of duration and pitch contour functioning together. An accent can be either short or long *and* heavy (falling) or sharp (rising) at the same time (Lehiste & Ivić, 1996, pp. 18-19). Several years later, in 1859 and 1860, Antun Mažuranić added intensity as a relevant factor by expressing the relation between short and long accents with the following formulas: â = ȁa and á = aà. Mažuranić indicated that the accentual thrust (i.e. intensity peak) of ̑ was to be found in the first half of the syllable, whereas ´ exhibited higher intensity in the second half.

The first scientific and systematic investigation of tones in Serbo-Croatian was the doctoral dissertation of Leonhard Masing, which was published in 1876. Listening to four informants' production of isolated words (in order to avoid intonational interference), Masing transcribed the four accents using a musical notation system. He clearly distinguished two kinds of accents based on their distribution: ̏ and ̑ are monosyllabic, while ` and ´ are bisyllabic. This means that the first syllable of *nȍšeno* ‘worn, adj.’ distinguishes itself from the others with regards to pitch and intensity, which can be said of the first *two* syllables of words like *kràljica* ‘queen’. In other words, the defining characteristic of bisyllabic accents is a high pitch on two consecutive morae found in two different syllables. Masing's work was highly criticized at first, but was partly accepted and modified by later authors, such as Tomislav Maretić, who published *Gramatika i stilistika hrvatskoga ili srpskoga književnog jezika* (‘Grammar and stylistics of the Croatian or Serbian literary language’) in 1899. Maretić uses

Pietro Budmani’s terminology from 1867, designating ̏ as “short strong” or ́ as “long weak”, but using Masing’s bisyllabic model to explain the difference. According to Maretić, ̏ and ̂ are strong because they do not fall apart, staying in the accented syllable, whereas ̀ and ́ are weak because they are realized partly in the accented syllable and partly in the following one, with the first being more prominent (Lehiste & Ivić, 1996, p. 32). However, two years later, in his *Gramatika hrvatskog jezika za niže razrede srednje škole* (‘A grammar of the Croatian language for starting grades of middle school’), Maretić abandons Budmani’s terms in favor of single-word labels: ̏ is now “fast”, ̀ is “slow”, ̂ is “falling” and ́ is called “rising” (Lehiste & Ivić, 1996, p. 36).

As can be seen, there was a great deal of disagreement at the time, with most authors using their own set of labels and descriptions for the different accents. This problem was solved, at least terminologically, when the ministry of education of the Kingdom of Yugoslavia published a brochure called *Gramatička terminologija* (‘Grammatical terminology’) in 1932, attributed to the renowned linguists Aleksandar Belić and Stjepan Ivšić. This brochure, which was to be used in schools all over the Kingdom, prescribed the use of the now commonly accepted terms such as “short rising” or “long falling” when referring to the accents of the Serbo-Croatian language. With very few exceptions, these terms became the norm for all the standardized regional varieties – Serbian, Croatian, Bosnian and Montenegrin.

2.4.2 The Accentual System of Standard Croatian

As described in the previous subsection, the standardization and unification process of the Serbo-Croatian language in the 19th and 20th centuries, especially its accentuation, was based to a very high degree on the works of Karadžić and Daničić. These works were in turn based on the Eastern Herzegovinian dialect of Tršić, thus being closer to the Serbian norm. Although Eastern Herzegovinian was greatly instrumental in the development of the accentual system of standard Croatian, Karadžič and Daničić grossly underestimated the influence and significane of the Younger Ikavian dialect, which together with EH formed the basis of the literary language. The first major investigation of the role of Younger Ikavian in Croatian accentuation was Vukušić’s *Nacrt hrvatske naglasne norme na osnovi zapadnog dijalekta* (‘A draft of the Croatian accentual norm based on the western dialect’), published in 1984. Somewhat similar to Karadžić, Vukušić also based his investigations on his own native dialect of Stinica (located near the city of Senj in the Lika-Senj County), a village even smaller than Tršić. Although sharing many features with the eastern (i.e. Eastern Herzegovinian) accentual norm, the Younger Ikavian dialect does have several significant differences, mainly in the accentuation of verbs (Vukušić et al., 2007). One such difference can be traced back to the deletion of the final *-i* in infinitive forms of verbs in Younger Ikavian, which will be illustrated in this case by *ispeći* ('to bake, inf.'). The original Old Štokavian form *ispeći̋* became *ispȅć* after the final *-i* was lost around the 14th century. During the Neo-Štokavian accent shift, the falling accent on the second syllable moved to the first, becoming rising in the process and producing the form *ìspeć*. During standardization, the final *-i* was "returned" to the infinitive, resulting in *ìspeći*. Eastern Herzegovinian spoken in Serbia, on the other hand, did not lose the *-i* in the infinitive, and thus had only one step between Old Štokavian and Neo-Štokavian: *ispeći̋* turned into *ispèći* as a result of the accent shift (Delaš, 2013). Interestingly enough, the accentual difference in verbs that underwent the above process is found only in the infinitive, with conjugated forms being identical in both Younger Ikavian and Eastern Herzegovinian: *ispèčēš* 'to bake, present tense 2nd person sg.', *ispèkoh* 'to bake, aorist 1st person sg.' or *ispèci* 'to bake, imperative, 2nd person sg.' (Vukušić et al., 2007; Vujanić, Gortan-Premk, Dešić, Dragićević, Nikolić, Nogo, Pavković, Ramić, Stijović, Radović-Tešić & Fekete, 2011). A greater divergence between the two accentual norms can be found in verbs of the third and fourth conjugations. Verbs of the third conjugation have *-ljeti* or *-njeti* (note the short jat in the first syllable) as their infinitive ending, such as *za-žè-ljeti* 'to wish, inf.', while the fourth conjugation has *-iti*, like *po-lòm-iti* 'to break, inf.' (Barić et al., 1997). Since jat is pronounced as /i/ in ikavian, prefixed verbs of the third and fourth conjugation like the ones above merged in the Younger Ikavian dialect into one group not only morphologically, but also accentually, giving the following forms: *zažèlit – zàželīm* 'to want, present tense 1st person sg.' and *polòmit – pòlomīm* 'to break, present tense 1st person sg.'. Standard Croatian, being of the ijekavian pronunciation variant, had the *-ljeti* and *-njeti* (as opposed to *-lit* and *-nit*) ending in the infinitive, but retained the Younger Ikavian accentuation (Vukušić et al., 2007). This merge did not occur in ekavian Serbian, which has distinct accentual paradigms for prefixed verbs of the third (*zažèleti – zažèlīm*) and fourth (*polòmiti – pòlomīm*) conjugations (Vujanić et al., 2011).

The accentual system of standard Croatian is comprised of two separate norms: paradigmatic and typological. Paradigmatic accentual norms are directly linked to the derivational and inflectional morphology, comprising of rules that determine the accent in a specific word and a specific place independently of its typological accentuation. Several of the most prominent paradigmatic norms of Croatian will be explained in §2.4.2.1. Typological accentual norms determine the accentuation of a certain word throughout the entire inflectional paradigm based on factors such as accent, accent place or number of syllables, for instance. Each accentual type and subtype has its own set of typological characteristics. These will be discussed in §2.4.2.2. Subsection §2.4.2.3 will deal with some noteable exceptions in the accentual system, illustrated by the dialect of Zagreb. Finally, Section §2.4.2.4 presents an overview of the intonational phonology.

2.4.2.1 Paradigmatic Accentual Norms

This subsection illustrates the four most common and important paradigmatic accentual norms of standard Croatian: a) positional lengthening, b) posttonal length in the genitive and instrumental cases, c) shortening of the accent in the long plural form and d) collective nouns and other derivational and inflectional morphemes (Vukušić et al., 2007).

a) Positional lengthening: vowels are lengthened before a consonant cluster starting with a sonorant (/j l ʎ m n ɲ r ʋ/). This rule is especially productive in cases where an /a/ in the nominative is deleted in other cases: *stàrac* ‘old man, nom. sg.’ - *stârca* ‘old man, acc. sg.’ or *màgarac* ‘donkey, nom. sg.’ – *màgārca* ‘donkey, acc. sg.’. The vowels are lengthened even when the part of speech is changed due to derivation: *prȁvilo* ‘rule, noun’ and *prȁvīlno* ‘rightly, adverb’. Lengthened vowels in words like *kòkārda* ‘cockade, nom. sg.’ or *Slàvōnka* ‘female Slavonian, nom. sg.’ are a result of positional lengthening and not a part of the accentual typology. There are, however, words with sonorant-initial consonant clusters where the previous vowel is not lengthened, such as in *pràvcat* ‘veritable’ or *dvòrba* ‘waiting (tables)’, but these are governed by their respective typology. Positional lengthening is not implemented when the vowel after the sonorant cluster is long. Compare *Bȕgārka* ‘female Bulgarian’ and *Bȕgārče* ‘Bulgarian, diminutive’ with *Bȕgarčād* ‘Bulgarian, diminutive collective noun’ and *bȕgarskī* ‘Bulgarian, adjective’, since the suffixes -*ād* and -*skī* are always long (see collective nouns and other derivational morphemes below). The only exception is the suffix -*nīk*, which in many cases does not inhibit the implementation of positional lengthening: *nèvjērnīk* ‘disbeliever’ or *nádzōrnīk* ‘supervisor’.

b) Posttonal length in the genitive and instrumental cases: the plural form of the genitive case has a lengthening effect independent of the typology. Nouns that have an -*ā* ending in this form always have a long vowel in the ultimate and penultimate syllable: *národ* ‘a people, nom. sg.’ - *národā* ‘a people, gen. pl.’ or *jȁbuka* ‘apple, nom. sg.’ - *jȁbūkā* ‘apple, gen. pl.’. If the penultimate syllable carries a short falling or short rising accent, it becomes lengthened while keeping its contour, such as in *žèna* ‘woman/wife, nom. sg.’ - *žénā* ‘woman/wife, gen. pl.’ or *kȕća* ‘house, nom. sg.’ - *kûćā* ‘house, gen. pl.’. The genitive plural endings -*ī*, -*ū* and

-*ijū* are also long, except that no lengthening is found on the previous syllable: *gôst* - *gòstī* ‘guest’, *rúka* - *rȕkū* ‘hand’ and *ȍko* - *òčijū* ‘eye’. Note that the change in accent quality and quantity is typological and is specific to every accentual type. Additional vowel lengthening is found in the -*ē* and -*ōm* endings of the genitive singular and instrumental singular cases in feminine nouns of the -*e* declination (also known as the third declination), giving the following paradigms (nom. sg. - gen. sg. - inst. sg.): *knjȉga* - *knjȉgē* - *knjȉgōm* ‘book’ or *mâjka* - *mâjkē* - *mâjkōm* ‘mother’. Posttonal length also has a contrastive function in Croatian, such as in the sentence *idem sa suprugom*, which can have two meanings depending on the presence or absence of PTL in the last syllable: with *sùprugom* (nom. sg. *sùprug*) the sentence would mean ‘I am going with (my) husband’, whereas *sùprugōm* (nom. sg. *sùpruga*) changes the meaning to ‘I am going with (my) wife’. Further examples for the contrastiveness of PTL include *plȁmen* ‘fiery, adj.’ - *plȁmēn* ‘flame, noun’ and *kòze* ‘goat, nom. pl.’ - *kòzē* ‘goat, gen. sg.’.

c) <u>Shortening of the accent in the long plural form</u>: most monosyllabic masculine nouns have two possible endings in the plural, one short and one long. The short form is the usual -*i*, found in almost all masculine nouns, so that *grâd* ‘city’ becomes *grâdi* in the nominative plural. The long plural form not only adds -*ov*- to the short ending, but also shortens the accented syllable, which results in *grȁdovi*. Further examples include *pânj* - *pȁnjevi* ‘tree stump’ (the long form changes to -*ev*- after palatal consonants) and *sîn* - *sȉnovi* ‘son’. The long plural form is by far the one more commonly used (Barić et al., 1997). There is also a small group of nouns that have the same form in the singular but different ones in the plural: *sât* can mean either ‘hour’ or ‘clock’, but the short plural *sâti* is ‘hours’ and the long plural *sȁtovi* is ‘clocks’.

d) <u>Collective nouns and other derivational and inflectional morphemes</u>: bisyllabic collective nouns with the -*je*/-*e* suffix always carry a long falling accent on the first syllable regardless of the typology: *gòra* ‘mountain’ - *gôrje* ‘highlands’ or *stijéna* ‘cliff’ - *stijênje* ‘cliffs’. Collective nouns with more than two syllables always have PTL on the second syllable and a short rising accent on the first, such as in *jȁsēn* ‘ash (tree)’ and *jàsēnje* ‘copse of ash trees’. Bisyllabic collective nouns with the -*ād* suffix have a short falling accent on the first syllable: *mòmak* ‘guy’ - *mȍmčād*, which means either ‘group of guys’ or ‘sports team’, or *ždrijêbe* ‘colt (horse)’ - *ždrȅbād* ‘group of colts’. The -*nje* suffix, which turns verbs into verbal nouns behaves in an analogous fashion: bisyllabic imperfective verbal nouns always have a long rising accent on the first syllable, as illustrated by *prȁti* ‘to wash, inf.’ - *pránje* ‘washing’ or *znàti* ‘to know, inf.’ - *znánje* ‘knowing, knowledge’. Imperfective verbal nouns with more than two syllables retain the accent of the infinitive on the first syllable and lengthen the one after that: *pjȅvati* ‘to sing, inf.’ - *pjȅvānje* ‘singing’ or *pokazívati* ‘to show, inf.’ - *pokazívānje* ‘showing’. Perfective verbal nouns always have a long rising accent on the penultimate syllable regardless of accent type or place, as seen in *ròditi* ‘to give birth, inf.’ - *rođénje* ‘birth’ and *oslobòditi* ‘to liberate, inf.’ - *oslobođénje* ‘liberation’. Similarly, bisyllabic adjectives in the comparative are always accented with a short falling accent and PTL: *drâg* ‘dear, adj. m.’ - *drȁžī* ‘dear, adj. m. comparative’ and *dàlek* ‘far, adj. m.’ - *dȁljī* ‘far, adj. m. comparative’.

2.4.2.2 Typological Accentual Norms

The Neo-Štokavian accent shift, as described in the first part of §2.4.1 and illustrated in (2.8), created the basis for the accentual system of standard Croatian. According to the resulted distribution, the following principles can be listed:

1) monosyllabic words can only have falling accents (*rȍb* ‘slave’, *pâr* ‘pair’)

2) the first syllable of words with two or more syllables can carry any accent (*sȅdam* ‘seven’, *òtac* ‘father’, *prâvda* ‘justice’, *gláva* ‘head’)

3a) falling accents are allowed only on the first syllable of polysyllabic words (*pâmtiti* ‘to remember, inf.’, *pȍlumjesečnīk* ‘bimonthly magazine’)

3b) rising accents can occur on any syllable but the last (*ljepòta* ‘beauty’, *populárnōst* ‘popularity’, *početveròstručīm* ‘to increase fourfold, present tense 1st person sg.’)

4) only accented and posttonal syllables can be long (*pàmēt* ‘mind’, *vatrogásācā* ‘fireman, gen. pl.’, *kamenòrēzācā* ‘stonecutter, gen. pl.’)

Two very important conclusions can be drawn from the above principles: final syllables are not accented (see §2.4.2.4 for exceptions) and tonal opposition between falling and rising accents is found only in the first syllable of a polysyllabic word. As such, there are four prosodic properties which can contrast in this opposition: accent quality (rising or falling), accent quantity (short or long), quality and quantity (short falling, long falling, short rising or long rising) and posttonal length (short or long posttonal syllables). For examples of the contrastiveness of PTL see §2.4.2.1, the rest of the contrasting properties are illustrated below.

1) <u>Accent quality</u>: *pȁra* 'steam' vs. *pàra* 'money' or *dijéte* 'child, nom. sg.' vs. *dijête* 'child, voc. sg.'

2) <u>Accent quantity</u>: *grȁd* 'hail' vs. *grâd* 'city' or *lȕk* 'onion' vs. *lûk* 'bow'

3) <u>Accent Quality and quantity</u>: *kȕpiti* 'to pick up, inf.' vs. *kúpiti* 'to buy, inf.' or *bȉlo* 'pulse' vs. *bílo* 'to be, ppt. n.'

Accent in Croatian can not only change its quality or quantity within the paradigm, but also its place, as can be seen by means of the nouns *ȉme* 'name, nom. sg.' - *ȉmena* (gen. sg.) - *imèna* (nom. pl.) - *iménā* (gen. pl.) and *jùnāk* 'hero, nom. sg.' - *jȕnāče* (voc. sg.) - *junáci* (nom. pl.).
Starting with accentual variability, which is the primary criterion in the accentual typology (Vukušić et al., 2007), two distinct types can be discerned: variable and invariable. The invariable type, in which the accent does not change in quality, quantity or place, is divided into two subtypes: 1) subtype with rising accents - *národ* 'a people' or *zèčić* 'hare, diminutive', and 2) subtype with falling accents - *jârbol* 'foremast' or *mȁčić* 'tomcat, diminutive'. Each subtype has two subgroups as seen in the above examples: short and long. The next step in the typology, accentual units, is defined by the place of the accent: first syllable *národ*, second syllable *Bosánac* 'male Bosnian', third syllable *gradonáčēlnīk* 'mayor' and so on. Note that opposition based on accent place is possible, as in *bràvetina* 'mutton' vs. *bravètina* 'lock, augmentative', but is rather rare. The variable type is characterized by a change in quality, quantity and/or place of accent within the paradigm and can thus be divided into two subtypes according to the place of variation (the examples given here list the nominative and genitive singular, unless stated otherwise): 1) subtype with non-shifting variation, as in *rȍb – ròba* 'slave' or *stôl – stòla* 'table', and 2) subtype with shifting variation, like *žìvot – živòta* 'life' or *mȑtvac – mrtvàca* 'corpse'. The first subtype can be divided further into three accentual units based on the nature of the variation: a) accent quality: *grȁb – gràba* 'hornbeam' or *stûp – stúpa* 'column', b) accent quantity: *prâse - prȁseta* 'piggy' or *ždrijêbe - ždrȅbeta* 'colt (horse)', and c) accent quality and quantity: *kònac* 'thread, nom. sg.' - *kônci* 'thread, nom. pl.' or *lònac* 'kettle, nom. sg.' - *lônci* 'kettle, nom. pl.'. The second subtype encompasses four accentual units which contrast the following: a) only accent place: *màdrac – madràca* 'mattress' or *ljùpčac – ljupčàca* 'lovage (plant)', b) accent place and quality: *jȅzero* 'lake, nom. sg.' – *jezèra* 'lake, nom. pl.' or *rȁme* 'shoulder, nom. sg.' – *ramèna* 'shoulder, nom. pl.', c) accent place and quantity: *kòvāč – kováča*

‘blacksmith’ or *dùšīk* – *dušíka* ‘nitrogen’, and d) accent place, quality and quantity: *vrijéme* ‘time/weather, nom. sg.’ - *vrȅmena* ‘time/weather, gen. sg.’ – *vremèna* ‘time/weather, nom. pl.’ or in the irregular plural forms of nouns like *tijêlo* ‘body, nom. sg.’ – *tjelèsa* ‘body, nom. pl.’. For an illustration of the structure and components of the typological accentual units in Croatian, see Figure 2.14 below.

In order to demonstrate the richness of the Croatian accentual system, four distinct paradigms (one of each subtype) will be presented. Due to reasons of space, only nominal paradigms will be examined since they are the least complicated, having a maximum of 14 possible forms, as opposed to 22 in verbs. For more detailed information, see Vukušić et al. (2007).

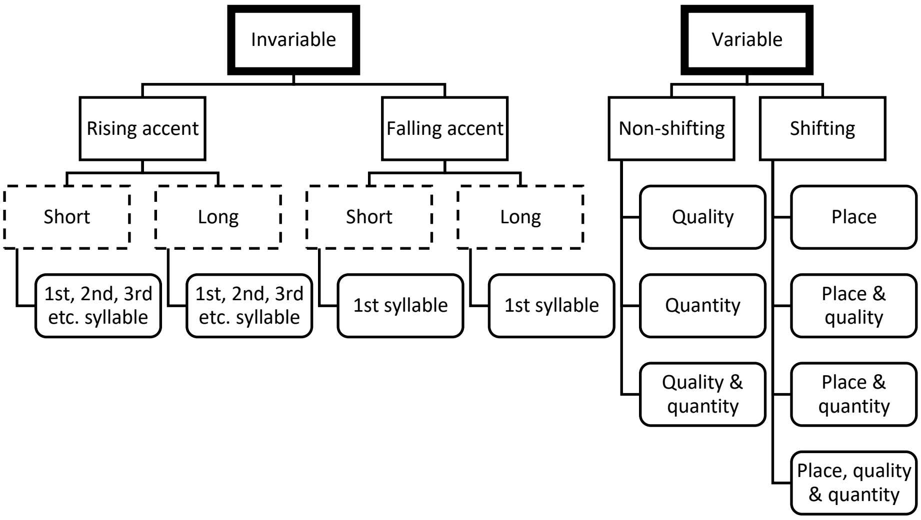


Figure 2.14. The structure of accentual units in Croatian. Bold rectangles are types, normal boxes are subtypes, dashed boxes represent subgroups and rounded rectangles are accentual units

1a) <u>Invariable type – Rising accent subtype</u>

This subtype has a rising accent throughout its entire inflectional paradigm. Being of the invariant type, the rising accent never changes place, quality nor quantity. Table 2.4 presents the accentual paradigm of *hajdúkovac* ‘fan of the Hajduk Split football club’, which belongs to the long subgroup of the invariable rising subtype.

The genitive and accusative singular forms of animate nouns are always the same. Inanimate nouns like *fijáker* ‘carriage’ have identical nominative and accusative forms in the singular. The long postaccentual *ō* in all but the nominative singular and genitive plural is a result of positional lengthening, since it appears before the sonorant-initial consonant cluster -*vc*-, and does not belong to the typology. The final two long vowels in the genitive plural are also paradigmatic.

Table 2.4. Accentual paradigm of *hajdúkovac*

	Singular	Plural
Nominative	*hajdúkovac*	*hajdúkōvci*
Genitive	*hajdúkōvca*	*hajdúkovācā*
Dative	*hajdúkōvcu*	*hajdúkōvcima*
Accusative	*hajdúkōvca*	*hajdúkōvce*
Vocative	*hajdúkōvče*	*hajdúkōvci*
Locative	*hajdúkōvcu*	*hajdúkōvcima*
Instrumental	*hajdúkōvcem*	*hajdúkōvcima*

1b) Invariable type – Falling accent subtype

This subtype is characterized by an invariable falling accent. The accent always falls on the first syllable due to the distributional restrictions of falling accents. Table 2.5 shows the paradigm of *ȍblāk* 'cloud', which belongs to the short subgroup of the invariable falling subtype.

Table 2.5. Accentual paradigm of *ȍblāk*

	Singular	Plural
Nominative	*ȍblāk*	*ȍblāci*
Genitive	*ȍblāka*	*ȍblākā*
Dative	*ȍblāku*	*ȍblācima*
Accusative	*ȍblāk*	*ȍblāke*
Vocative	*ȍblāče*	*ȍblāci*
Locative	*ȍblāku*	*ȍblācima*
Instrumental	*ȍblākom*	*ȍblācima*

A short falling accent on the first syllable and PTL on the second are both typological features of this accentual unit, and they are therefore present throughout the paradigm. The final long *ā* is a paradigmatic feature of the genitive plural.

2a) Variable type – Non-shifting subtype

Words of this type can carry any of the four accents. Variations in accent quality and/or quantity are restricted to one syllable. The accentual paradigm of *gláva* 'head' is shown in Table 2.6.

The long rising accent is retained in the nominative, genitive, dative, locative and instrumental singular and in the genitive, dative, locative and instrumental plural. All other forms change into a long falling accent. Note that the dative singular can carry either the long rising or the long falling accent. The long final vowels in the genitive and instrumental singular are paradigmatic. Bisyllabic feminine and masculine nouns always have a falling accent in the vocative singular when the first syllable is long, which makes the variation in *glâvo* paradigmatic, and not typological.

Table 2.6. Accentual paradigm of *gláva*

	Singular	Plural
Nominative	*gláva*	*glâve*
Genitive	*glávē*	*glávā*
Dative	*glâvi/glávi*	*glávama*
Accusative	*glâvu*	*glâve*
Vocative	*glâvo*	*glâve*
Locative	*glávi*	*glávama*
Instrumental	*glávōm*	*glávama*

2b) <u>Variable type – Shifting subtype</u>

As in 2a, all accents can appear in this type. Characteristic for this subtype is that the accent not only changes in quality and quantity, but also in place. Table 2.7 presents the paradigm of *bùnār* 'well, noun'.

The most defining feature of this accentual unit is a short rising accent on the first syllable and PTL on the second in the nominative singular (and accusative singular if the noun is inanimate). All other forms besides the vocative singular shift and lengthen the rising accent to the penultimate syllable. Place and quantity in the vocative singular are retained, but the accent shifts to a falling one. The variations in this accentual unit are very stabile and independent of the number of syllables, so that all words with SR in the penultimate and PTL in the ultimate syllable behave alike: *bolèsnīk* 'sick person, nom. sg.' – *bolesníka* 'sick person, gen. sg.' or *antikvarìjāt* 'antique store, nom. sg.' – *antikvarijáta* 'antique store, gen. sg.'.

Table 2.7. Accentual paradigm of *bùnār*

	Singular	Plural
Nominative	*bùnār*	*bunári*
Genitive	*bunára*	*bunárā*
Dative	*bunáru*	*bunárima*
Accusative	*bùnār*	*bunáre*
Vocative	*bȕnāru*	*bunári*
Locative	*bunáru*	*bunárima*
Instrumental	*bunárom*	*bunárima*

2.4.2.3 Notable Exceptions and the Dialect of Zagreb

As described in the previous subsection, standard Croatian forbids falling accents on non-initial syllables and any accents on the last syllable. As is often the case, there are several notable exceptions to these rules in the spoken language which will be presented here.
Several nouns often have non-initial falling accents in the genitive plural in coloquial speech, such as *Dalmatînācā* 'Dalmatian' (nom. sg. *Dalmatínac*) or *trenûtākā* 'instant' (nom. sg. *trenútak*). Vukušić et al. (2007) list two further possible forms for each of the above examples (and their respective accentual unit): *Dalmatínācā* or *Dalmàtīnācā* and *trenútākā* or *trènūtākā*. According to the typological norms of standard Croatian, only the forms with rising accents are correct, but in my experience, the falling varieties are almost always preferred by native speakers. Non-initial falling accents are, however, much more common in loanwords and words of foreign origin, such as *Austrâlija* 'Australia' or *elevâtor* 'grain elevator' (Kapović, 2015). The standard forms *Aùstrālija* and *elèvātor* are practically unknown among the general populace and when heard, native speakers actually judge them to be incorrect. Pronouncing *Austrálija* or *elevátor* (which should sound more natural because of the accent place) seems to have the same effect. Quite similarly, many loanwords are pronounced with a falling accent on the last syllable: *asistȅnt* 'assistant' (standard form *asìstent*) or *paradȁjz* 'tomato' (standard form *paràdajz*). Unlike the examples with medial falling accents, words with final falling accents retain them throughout the paradigm in the spoken language, for instance *asistȅntu* (dat. sg.) or *asistȅnātā* (gen. pl.) instead of the standard *asistèntu* or *asistènātā*. Rising accents can also be heard on final syllables, although this is a much rarer phenomenon. Some dialects (including EH), often drop the final *-i* of the 2nd person imperative, so that *pokáži* 'to show', *báci* 'to throw' or *pùsti* 'to let go' become *pokáž*, *bác* and *pùst* (Kapović, 2015). To my knowledge, there are no phonetic investigations of final rising accents in any Serbo-Croatian regional variety, but given the bisyllabic nature of rising accents, this would be a very interesting subject to explore.
As mentioned earlier in §1.1.5, the dialect of the capital city of Zagreb presents an intriguing case: historically Kajkavian-speaking, the city has and still is experiencing an influx of Štokavian-speaking migrants that started in the second half of the 20th century (Šojat 1979). According to Kapović (2006), over 50% of the population of Zagreb was born elsewhere and most of the natives' parents originate from different parts of Croatia. This has given rise to the Common Zagreb Speech (henceforth CZS), which is essentially a Kajkavian-Štokavian hybrid. The most striking difference between CZS and standard Croatian (represented by

speakers of Eastern Herzegovinian in the case of this dissertation) is its prosody: not only is the tonal contrast between rising and falling accents lost, there is also no opposition between phonologically short and long vowels (Kapović, 2006). Using the terms introduced in this entire section, it can be stated that CZS has only one "accent", which is realized as dynamic stress, found in non-tonal languages such as Greek or Spanish (Smiljanić, 2006). This way, standard Croatian *kȑava* 'cow', *sûša* 'drought', *nòga* 'leg' and *rúka* 'arm/hand' are pronounced as *kra̍va*, *su̍ša*, *no̍ga* and *ru̍ka*[9]. Another distinctive quality of CZS is a stress shift one syllable to the right, somewhat reminiscent of the situation in Old Štokavian dialects before the Neo-Štokavian accent shift. Examples of verbs include *dola̍zit* 'to come, inf' and *dola̍zim* 'to come, 1st person sg. present tense' (instead of standard *dòlaziti* and *dòlazīm*) or *zabora̍vit* 'to forget, inf.' and *zabora̍vila* 'to forget, ppt. f.' (as opposed to standard *zabòraviti* and *zabòravila*). This accent shift is also extremely common in nouns, especially in loanwords and words of the shifting subtype as seen in 2b in the previous subsection, so that *bùnār*, *bolèsnīk* and *antikvarìjāt* become *buna̍r*, *bolesni̍k* and *antikvarija̍t*. This leads me to believe that historically long vowels in nouns attract stress in CZS. Native Štokavian speakers are well aware of these prosodic differences and usually try to imitate them when immigrating to Zagreb in order to sound more like the locals. Moreover, I have personally witnessed cases in which workers in Zagreb call-centers originating from Štokavian-speaking areas were instructed by the management to "lose their Štokavian pronunciation and talk like Zagrebians" when speaking with customers.

Phonetic investigations of prosody in the dialects of Zagreb and Belgrade conducted by Smiljanić and Hualde (2000) and Smiljanić (2003, 2006) confirm the lack of tonal contrast in Zagreb Croatian. Smiljanić and Hualde (2000) compared the production of falling and rising accents under broad and narrow focus, using recordings made with speakers of the Zagreb and Belgrade dialects. Two speakers were recorded for each dialect. Bisyllabic target words containing all four accents on the initial syllable were placed at the beginning of equally long sentences, such as in ***Mára*** *je jela bananu* 'Mara ate a banana'. Note that the target word and its accent were not marked in any way in the experiment itself. Broad focus, or neutral declarative intonation, was elicited by the question "What happened this morning?", written on each page above each sentence. Narrow (i.e. contrastive) focus was elicited in the same manner, but using the question "Who ate a banana, was it Peter?" in combination with the

[9] The vertical superscripted bar is used here to indicate dynamic stress (as opposed to pitch accent), as in Kapović (2006).

same sentence as above[10]. The main acoustic parameter used was pitch peak alignment in relation to the end of the stressed vowel. In other words, the highest pitch value in the entire target word was extracted and its temporal relation to the end of the accented syllable was measured in seconds. Positive values were obtained for peaks located on the posttonic syllable and negative values were given for peaks placed within the accented syllable. Representative results of two speakers (one from each dialect) under broad focus are shown in Figure 2.15.

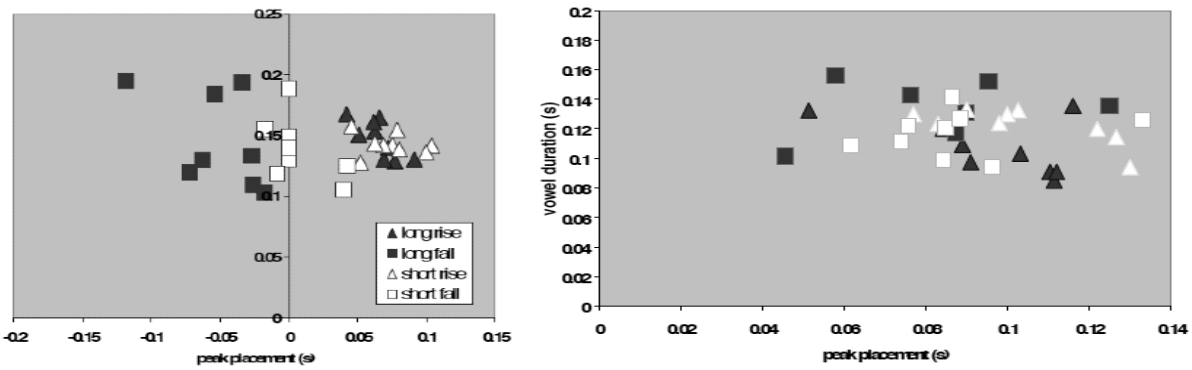


Figure 2.15. Pitch peak alignment of Belgrade (left panel) and Zagreb (right panel) speakers under broad focus. The vertical line in the middle of the left panel represents the edge of the accented syllable and shows vowel duration in seconds (Smiljanić & Hualde, 2000, pp. 476-477)

The above figure clearly shows a difference between the two dialects with respect to pitch peak alignment. All rising accents (triangles) produced by the Belgrade speaker had their peaks on the posttonic syllable, whereas all but two falling accents (squares) were realized with peaks on the accented syllable. The Zagreb speaker, on the other hand, placed all pitch peaks on the posttonic syllable, regardless of the underlying accent. Comparing broad and narrow focus (seen in Figure 2.16) sheds more light on the functions of peak placement in the two dialects.

The pattern of peak placement in the Belgrade dialect under narrow focus remains principally the same as under broad focus: early peaks in the accented syllable for falling accents and late peaks in the posttonic for rising accents. The primary difference between the two pragmatic conditions lies in the timing of the peaks, which are substantially earlier and thus closer to the accented syllable under narrow focus. The Zagreb speaker exhibits the same overlapping of rising and falling peaks as under broad focus, but in the narrow focus condition there is a clear tendency to retract the peaks to the accented syllable. This is a clear indicitaion of the loss of tonal contrast in the Zagreb dialect, which is still present in the dialect of Belgrade.

[10] Initial contrastive focus in this sentence would mean that it was Mara who ate the banana, and not Peter.

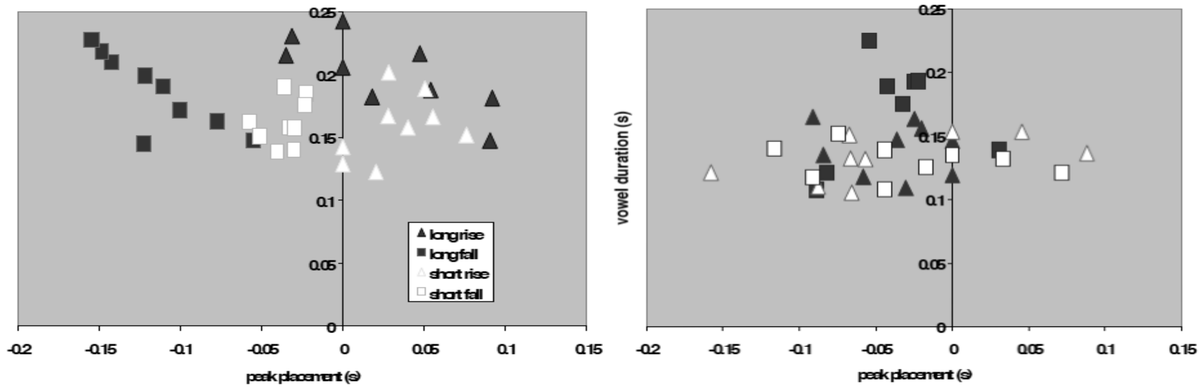


Figure 2.16. Pitch peak alignment of Belgrade (left panel) and Zagreb (right panel) speakers under narrow focus (Smiljanić & Hualde, 2000, pp. 478-479)

Moreover, the pattern produced by Zagreb speakers, which obviously exhibits no difference whether the accent is rising or falling, is very similar to the one found in stress languages like Spanish: early peaks located within the stressed syllable under narrow focus and late peaks placed on the following syllable when under broad focus (Smiljanić, 2006). This shows that the function of pitch peak alignment in the tonal dialect of Belgrade is lexical (falling vs. rising accents), whereas in the non-tonal dialect of Zagreb it is pragmatic (broad vs. narrow focus). This experiment was reproduced under very similar conditions but with different speakers (this time three for each dialect) in Smiljanić (2006). Additionally, narrow focus in sentence-final position was also taken into consideration, which was prompted by writing the question "Did mom see the bridegroom?" above the sentence *Mama je vidjela* **mlâdu** 'Mom saw the **bride**'. As in the previous investigations of 2000 and 2003, pitch peak alignment in the Belgrade and Zagreb dialects showed practically the same patterns under initial broad and narrow focus. Two-way ANOVAs with accent (rising vs. falling) and pragmatics (initial vs. final) as fixed factors showed a significant main effect of accent on peak alignment for all three Belgrade speakers. The same ANOVAs for the Zagreb speakers showed no significant effect for accent, which serves as a further confirmation of the lack of tonal contrast in that dialect. The results of final narrow focus are shown below in Figure 2.17.

Figure 2.17. Pitch peak alignment of Belgrade (left panel) and Zagreb (right panel) under final narrow focus (Smiljanić, 2006, p. 508)

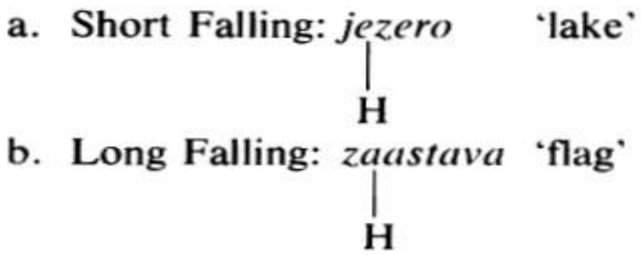
Since no tonal contrast could be established for the Zagreb speakers in initial position, rising and falling tokens were collapsed in that dialect. Much like in the initial position, the peaks were retracted to the stressed syllable and were aligned significantly earlier under final narrow focus in the production of two out of three speakers. All Belgrade speakers, on the other hand, maintained the tonal contrast between long rising and long falling accents in the final position, which was also confirmed statistically in two-way ANOVAs. The most striking difference between initial and final narrow focus in the Belgrade dialect was that the peaks of the rising accents were clustered around the end of the accented syllable, which was statistically significant as well.

2.4.2.4 Intonational Phonology

As shown in the descriptions of Yucatec Maya (§2.1) and Limburgian (§2.3), intonation, defined as „The use of tonal features to carry linguistic information at the sentence level" (Lehiste, 1970, p. 95), has very palpable effects on pitch and tone. In order to fully understand the interaction between intonation and tone, the phonology of these two phenomena must first be described. Following in this subsection is a review of two well-established phonologic models of tone and intonation in Serbo-Croatian made by Inkelas and Zec (1988) and Godjevac (2005).

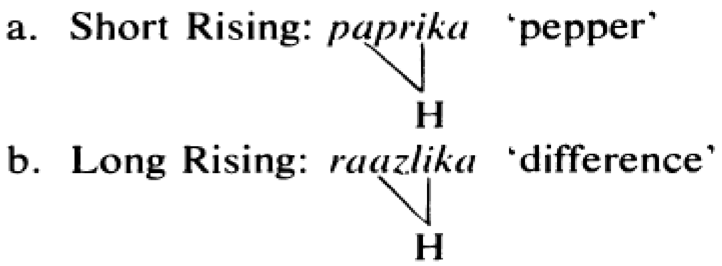
Inkelas and Zec (1988) begin with stating that the TBU in Serbo-Croatian is the mora. Based on the distributional rules described earlier, they define falling accents as a H tone linked to the first mora in a word, as demonstrated in (2.9). Note that long vowels are marked as geminates.

(2.9) Underlying representation of falling accents (Inkelas & Zec, 1988, p. 230)



Pitch contours within the accented syllbale are produced on the surface when a L tone is inserted into the second mora of a long vowel. Since only one tone is allowed per mora, Inkelas and Zec (1988) state that, despite evidence from numerous phonetic investigations to the contrary (which will be presented in the subsequent subsection), there are no contours on accented short syllables. Since rising accents stretch over two syllables, they require a H tone linked to the accented and posttonic syllables. For the underlying representation, however, only one H tone on the posttonic is needed, which is then spread to the left onto the accented syllable, as shown in (2.10). Note that the H tone is attached to the second mora of a long vowel when spread.

(2.10) Underlying representation of rising accents (Inkelas & Zec, 1988, p. 231)

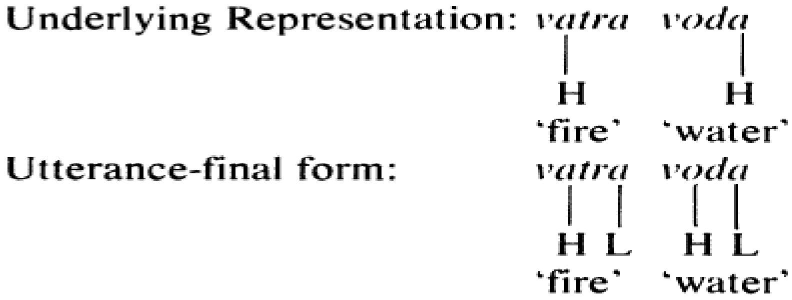


Having defined falling accents underlyingly as a H tone linked to the first mora of the first syllable and rising accents as a leftward-spreading H tone on the posttonic (HH), Inkelas and Zec (1988) explain the resulting surface realization as falling and rising contours through Default Low Insertion: a L tone is attached to the unoccupied mora, so that syllables with a H first mora (falling accent) become HL on the surface and a syllable with a H second mora (rising accent) is realized as LH. Short rising syllables are thus realized as H (lexical tone) and short falling as L (Default Low Insertion).

Inkelas and Zec (1988) identify three distinct intonation contours in Serbo-Croatian: Declarative, Prompting and Vocative Chant. The Vocative Chant is used when calling someone from a distance and is characterized by high pitch word-medialy with a final drop to middle. Prompting intonation is implemented when speakers „want their interlocutor to repeat or elaborate on some part of the preceding discourse." (Inkelas & Zec, 1988, p. 241). This is defined as a series of H tones which spread rightwards from the posttonic syllable, ending with a sharp rise. Note that only the declarative intonation will be discussed in detail in this subsection since it is the only one relevant to this dissertation.

The most defining characteristic of the declarative intonation is Final Lowering, in which a L tone is attached to the final mora of an IP or utterance. If a final mora already has a previously linked L tone, as in falling accents, it will merge with the final L tone. However, if the final mora has a doubly linked H tone, which is defining of rising accents, the final L tone will simply replace it in a process known as Tone Absorption. This process would explain why certain falling/rising distinctions are neutralized in final position in favor of the falling accents, also reported by Lehiste (1970). Final Lowering, Tone Absorption and the subsequent neutralization are demonstrated in (2.11).

(2.11) Neutralization of tonal contrast in final position (Inkelas & Zec, 1988, p. 240)



Thus, the underlying H on the second mora of *vòda* spreads to the left, and together with the final L attached to the end, a HHL tonal pattern emerges. Since the H tone is doubly linked, Tone Absorption deletes it from the second mora, which is realized as HL on the surface. The phonologically identical HL pattern of *vȁtra* is achieved by adding a L tone to the second mora either by Default Low Insertion (non-final position) or Final Lowering (final position). Contradicting their earlier statement of a maximum of one tone per mora, Inkelas and Zec (1988) demonstrate how falling contours are possible on short accented syllables with the help of Final Lowering. Since monosyllabic words with a short vowel have only one mora, its prelinked H tone cannot spread leftwards, which prevents Tone Absorption from being implemented. This single mora in final position has a prelinked H lexical tone and an attached final L tone, which creates a falling contour on the accented short syllable.
Godjevac (2005) not only expands the work of Inkelas and Zec (1988) by using more modern and concise terminology, systematically cataloguing the tonal inventory of Serbo-Croatian and describing two additional intonation contours (sintactically marked yes-no questions and continuation), she also offers a fundamentally different approach to the phonology of lexical tone. In an earlier but very much related paper, Godjevac proposes a switch of perspective: instead of thinking of the accents in terms of monosyllabic vs. bisyllabic, i.e. falling vs. rising, she focuses on the number of tonal targets required to realized said contours (Godjevac, 2000). According to her, the accents of Serbo-Croatian are bitonal sequences, in which only one tone is anchored (associated) to the stressed syllable. Falling accents have a H*+L sequence, in which the H* is anchored to the stressed syllable and the L tone (also called 'trailing tone') may or may not be realized within the same syllable. Subsequently, rising accents are defined as L*+H, where the trailing H tone is usually realized on the posttonic syllable, thus accounting for their bisyllabic character. This model is supported empirically for the dialect of Belgrade by the works of Smiljanić and Hualde (2000) and Smiljanić (2003, 2006) discussed in the previous subsection. The starred H tone of falling accents is realized phonetically as an early peak within the stressed syllable, whereas the

trailing H tone of rising accents is produced as a late peak on the posttonic. This also solves the problem of contours on short syllables in Inkelas and Zec (1988), since this way, more than one tone can be associated with a single mora. Phonologically, Godjevac (2000, 2005) contrasts not four accents, but only two accent types, falling and rising. The division of accents into short vs. long is a segmental property of the syllable, as witnessed by the presence of posttonal length, which is not directly associated with the pitch accent. Although this phonological two-way contrast is shared by several other authors, it nevertheless does not contradict the existence of a four-way phonetic contrast, which is the primary subject of this dissertation. Confirming this concept, Godjevac (2005) goes on to explain that the difference between the short and long falling accents is also phonetic and is manifested in the realization of the fall (i.e. location of the L trailing tone or pitch peak alignment): long falling accents have an observable fall during the second half of the stressed syllable, whereas for the short falling it is realized on the posttonic in non-final condition and within the stressed syllable in final condition or monosyllabic words. Short and long rising accents differ in the length of the stressed syllable. Combining the initial %L word boundary tone, which is found at the beginning of every phonological word, with the underlying lexical bitonal sequences gives distinct surface representations for all four accents, as seen in Figure 2.18 below.

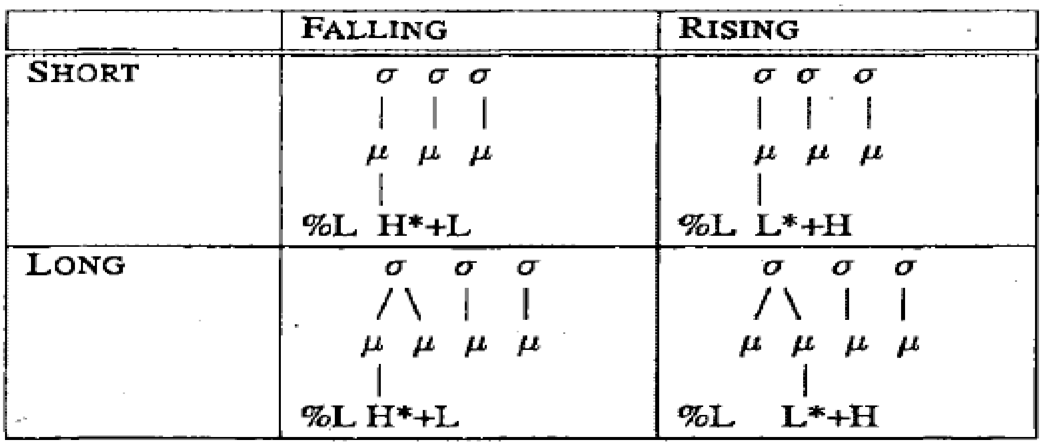


Figure 2.18. Surface representations of tones in trisyllabic words with initial accent (Godjevac, 2000, p. 101)

Besides the %L word boundary tone mentioned above, which delineates phonological words from each other, Godjevac (2005) also posits a %H word boundary tone. This word boundary tone marks a word with contrastive or narrow focus, thereby raising the pitch range for the entire word. Of the three intonational contours described by Inkelas and Zec (1988), only the vocative chant is analyzed in a comparable way by Godjevac (2005): it is defined as a bitonal HL% boundary tone, creating a mid-fall and stretching over the last two syllables of the word. The declarative and prosodic question (analogous to Inkelas and Zec's Prompting) intonation have been reanalyzed as combinations of phrase accents (of which there are two) and boundary tones. Phrase accents are defined as tonal targets that attach themselves to metrically strong positions (stressed syllables), whereas boundary tones are tonal targets that appear at the edges of a phrase (first or last syllable). Since phrase accents target stressed syllables just like lexical tones, they often override them, as opposed to boundary tones which do not compete for the same targets. The first phrase accent, ∅-, is associated with the focused constituent in the case of narrow focus or the rightmost constituent of an IP when under broad focus. As opposed to the LH- phrase accent, ∅- does not have a tonal target, instead compressing the pitch range of the following constituents, which is best observed in non-final narrow focus. The declarative intonation, therefore, is defined as a combination of the ∅- phrase accent and the IP-final L% boundary tone. This L% tone is not analogous to Inkelas and Zec's (1988) Final Lowering, since it doesn't replace the tone in the final mora of the word. Consequently, lexical tones in final position are not neutralized as reported in previous investigations, but merely modified. F_0 of words with falling accents keeps falling until it eventually reaches laryngealization. The rising accents remain level instead of having the characteristic higher-pitched posttonic syllable as in non-final condition. Schematic representations of rising and falling accents delineated by L% can be seen in Figure 2.19.

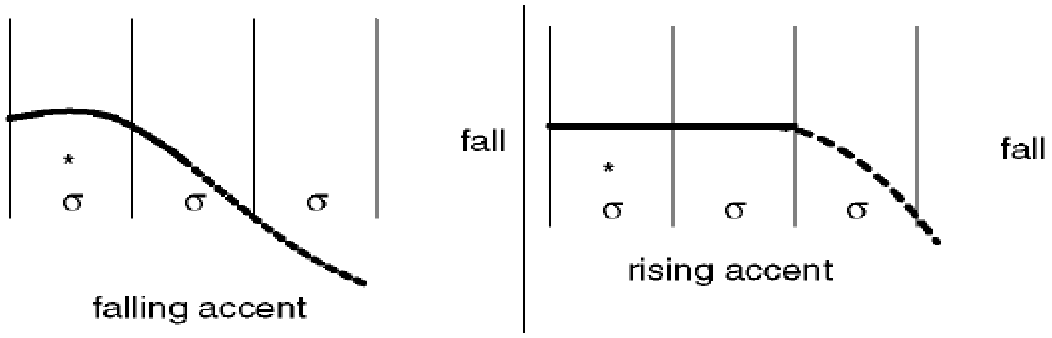


Figure 2.19. Schematic representations of a falling and rising accent realized with a L% final boundary tone (Godjevac, 2005, pp. 151-152)

Finally, the two types of interrogative intonation, prosodic question and syntactically marked yes-no question, both have the LH- phrase accent on the focused constituent, but their IP-final boundary tones differ: prosodic questions are combined with H% and syntactically marked yes-no questions with L%.

Independently of all intonational contours, phrase accents and boundary tones, Serbo-Croatian downsteps the pitch range in each subsequent phonological word. In other words, each phonological word has a lower, more compressed pitch range than the previous one. However, when the IP has more than five phonological words, a pitch range readjustment usually occurs, slightly resetting the downstepping. A readjusted phonological word has a pitch range which is equal to or greater than the previous one. This downstepping and readjustment are illustrated in Figure 2.20.

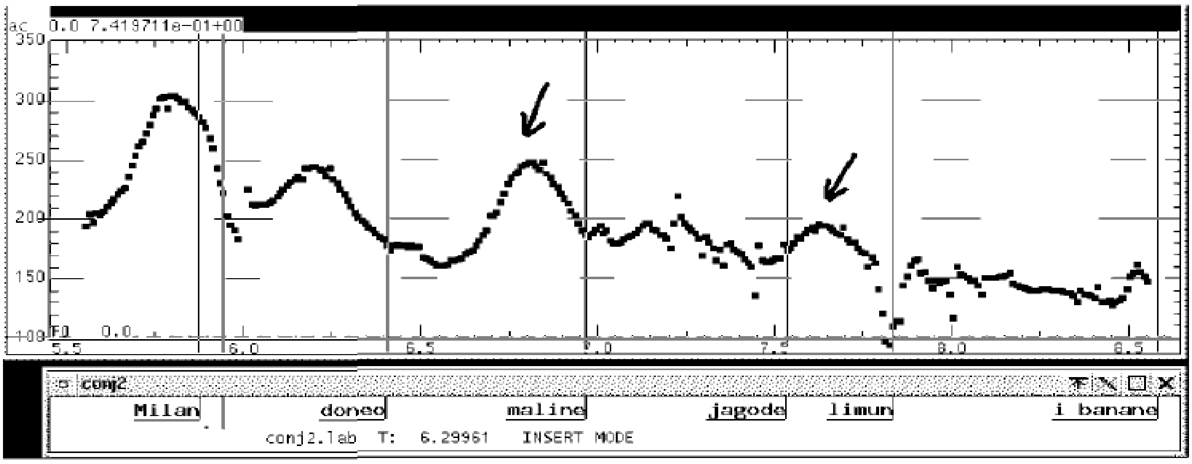


Figure 2.20. F_0 track of the sentence *Milan je doneo maline, jagode, limun i banane* ‘Milan brought raspberries, strawberries, a lemon and bananas’. The arrows indicate the place of the pitch range readjustment (Godjevac, 2005, p. 157)

To conclude this subsection, the major features and differences between the phonological models of Inkelas and Zec (1988) and Godjevac (2005) are listed below in Table 2.8.

Table 2.8. Major features and differences between the phonological models of Inkelas and Zec (1988) und Godjevac (2005)

	Inkelas & Zec (1988)	Godjevac (2005)
Pitch accent	Falling: H tone on first mora Rising: leftward spreading H tone on posttonic (HH)	Falling: H*+L Rising: L*+H
Intonational inverntory	3 intonational contours	5 intonational contours, 5 boundary tones, 2 phrase accents
Post-lexical effects	Applied through phonological rules	Combination of phrase accents and boundary tones
Contours on short syllables	Only some utterance-final falling accents	Possible in all contexts
Final tonal neutralization	Complete neutralization in certain contexts	Tonal contrast preserved

2.4.3 Phonetic Characteristics of Pitch Accent in Serbo-Croatian and Croatian

This section presents a review of the most notable and relevant phonetic investigations of pitch accent in Serbo-Croatian and Croatian. The first two investigations discussed are the works of Lehiste and Ivić (1996), then Purcell (1973), which deal with pitch accent in Serbo-Croatian. Following these two works will be investigations of lexical tone in Croatian, one written by Pletikos (2008), and the unpublished Master's thesis of Zintchenko Jurlina (2013). Additionally, an investigaion of syllabic /r̥/ as by Gudurić and Petrović (2006) will be presented. A summary and critique of the first four investigations concludes this subsection.

2.4.3.1 Ilse Lehiste & Pavle Ivić (1996) – Prozodija reči i rečenice u srpskohrvatskom jeziku 'Word and sentence prosody in the Serbo-Croatian language'

As mentioned earlier at the beginning of this dissertation, *Word and sentence prosody in the Serbo-Croatian language* (1996) is a Serbian translation of the 1986 book *Word and sentence prosody in Serbocroatian*, which is in itself a compilation of over twenty years of work by Ilse Lehiste and Pavle Ivić, comprising of material published between 1962 and 1986. This monumental work is considered to be a classic of Serbo-Croatian accentuation and almost all phonetic investigations of lexical tone in Serbo-Croatian or one of its regional varieties refer to it. Lehiste and Ivić examine the production of pitch accent not only in standard Serbo-Croatian, but also in Old Štokavian (Slavonian dialect), Čakavian and Kajkavian. Furthermore, the production of tone in different sentential contexts as well as the perception thereof are also thoroughly described. This subsection will handle only the production of tone in standard Serbo-Croatian words and sentences.

For the investigation of word prosody, two sets of recordings were made. The first set was recorded in 1961 at the University of Michigan by one of the authors, Pavle Ivić. Ivić, who described his speech as standard Serbo-Croatian with certain regional features characteristic of his native dialect of Vojvodina in northern Serbia (Šumadija-Vojvodina dialect), recorded a set of 464 words with an uneven distribution of the four Serbo-Croatian accents, for a total of 877 items. All words had one of the accents on the initial syllable and were spoken in the middle of a short carrier phrase. Although pretonal syllables were not directly examined (mostly due to a small sample size), Lehiste & Ivić (1996) report that their pitch is much lower than accented but much higher than posttonal syllables. Besides accent type, the recorded material was further divided into unevenly distributed twelve accentual patterns in order to investigate different combinations of syllable number and posttonal length. An overview of the accentual patterns recorded by Pavle Ivić is given in Table 2.9, where V stands for vowel. The second set of recordings was made in 1962 in the recording studio of Radio Novi Sad in northern Serbia. For these recordings, a rather heterogeneous group of twelve speakers was recruited. Half of the speakers was male and the other was female, with six originating from Novi Sad and the rest of Vojvodina, three from Western Štokavian ijekavian dialect zones in Bosnia and Herzegovina and Croatia and the rest from central Serbia. Moreover, six of the people recorded were professional speakers in Radio Novi Sad. The recorded corpus was slightly smaller than Ivić's, with 116 carrier phrases and a total of 462 tokens. This set comprised of only six accentual patterns: V̏ V̆, V̏ V̆ V̆, V̀ V̆, V̀ V̆ V̆, V̂ V̆ and V́ V̆.

Table 2.9. Accentual patterns recorded by Pavle Ivić with number of tokens in parentheses (Lehiste & Ivić, 1996, p. 54)

	Bisyllabic words	Trisyllabic words
Short Falling	V̏ V̆ (102) V̏ V̄ (28)	V̏ V̆ V̆ (41) V̏ V̄ V̆ (24)
Short Rising	V̀ V̆ (71) V̀ V̄ (32)	V̀ V̆ V̆ (49) V̀ V̄ V̆ (25)
Long Falling	V̂ V̆ (94)	V̂ V̆ V̆ (41)
Long Rising	V́ V̆ (88)	V́ V̆ V̆ (38)

The results of the twelve speakers were split into three groups according to their fundamental frequency: six speakers with a generally low F_0, three speakers with an intermediate F_0 and three speakers with a high F_0. Since the production of tone of the twelve speakers was very compatible with that of Pavle Ivić (see Figure 2.21 below), it was decided by the authors to concentrate mainly on them. It is also important to note that besides calculating average values, no other methods of statistical analysis were implemented.

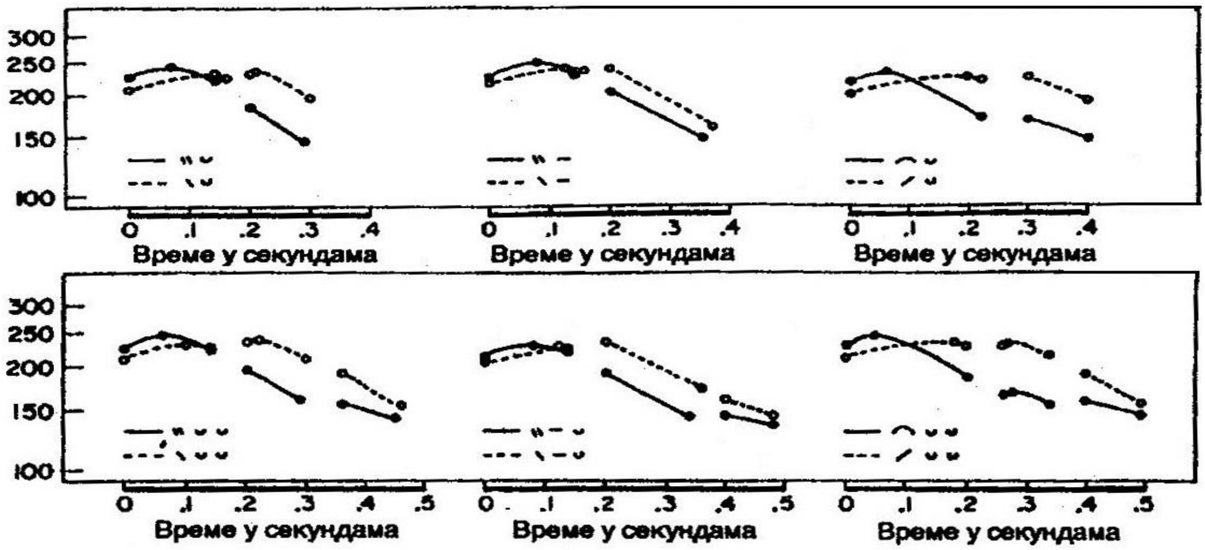


Figure 2.21. F_0 tracks of twelve different accentual patterns as produced by Pavle Ivić. The horizontal axis represents time in seconds and the vertical axis a logarithmic frequency scale in Hz. Full lines are falling accents and dotted lines are rising (Lehiste & Ivić, 1996, p. 56)

F_0 measurements were made at the beginning, end and peak (indicated by a full circle on the F_0 track in the figure above) of each syllable nucleus. Comparing the F_0 tracks of the short accents in the first two columns of Figure 2.21 shows that SF has a rising-falling contour in the accented syllable, whereas SR is consistently rising. SF also shows higher F_0 throughout almost the entire syllable. The distribution of pitch peaks, which can be seen in Figure 2.22, likewise serves to distinguish between the different accents.

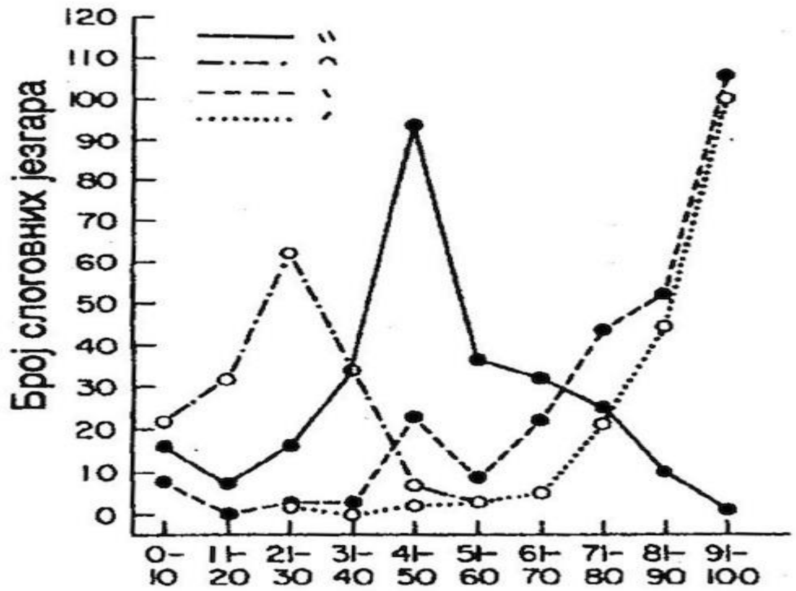


Figure 2.22. Position of pitch peaks within the accented syllable in % of the nucleus duration as produced by Pavle Ivić. The vertical axis represents the number of nuclei found in each percental position (Lehiste & Ivić, 1996, p. 57)

Most SF tokens exhibit a pitch peak at around the middle of the accented syllable (41%-50%), while the majority of SR peaks occur at the end of it (91%-100%). The F_0 contours of the long accents are more true to their name, with LF having an early short rise (peak at 21%-30% position) accompanied by a rapid fall. Lehiste and Ivić (1996) also report numerous cases of LF without the initial rise, starting instead directly with the steep fall and a pitch peak at the 0%-10% position. LR is quite similar to SR, with a consistently rising contour throughout much of the syllable nucleus and a peak at 91%-100%. However, the most prominent differences between falling and rising accents can be observed in the posttonic syllable. Posttonic syllables of rising accents usually have an equal or higher F_0 than the accented syllable, while being substantially lower for falling accents. In order to quantify this relation, the F_0 peak of the accented syllable was divided by the same peak in the posttonic for every word, and so a value less than 1.0 indicates a higher peak in the accented syllable, whereas a value greater than 1.0 means a higher posttonic peak. On average, the values for rising accents were between 0.901 and 1.0, which means that the posttonic peaks were higher than or equal to the ones in the accented syllable. Falling accents had higher accented peaks with an average value of 1.1. Pitch contours of posttonic syllables were all characterized by a falling movement, with rising accents usually exhibiting a short initial rise, like the one witnessed in accented vowels carrying LF. Long posttonic syllables generally had a straightforward falling contour and were also shorter in duration than long accented syllables. Concerning nucleus duration, the following observations could be made: accented SR syllables were consistently longer than ones with SF, whereas the same syllables with LF were longer than ones with LR. Long posttonic syllables of words with short accents were slightly longer than their accented syllables and nucleus duration tended to be generally shorter the more syllables a word had. Additionally, nucleus intensity in dB was measured in the same manner as F_0. Of all the measurements made, only the peak intensity was briefly discussed. Seven of the thirteen speakers showed slightly smaller intensity differences between consecutive nuclei with rising accents, but this trend was so inconclusive that even the authors themselves doubted its significance.

In order to investigate the interaction between sentence and word prosody in Serbo-Croatian, a set of 272 sentences were recorded by Pavle Ivić in 1961 and another female speaker in 1964. As in the section concerning word prosody, preference was given to the recordings made by Ivić. The recorded sentences represented ten different prosodic and pragmatic conditions, such as simple declarative intonation or interrogative intonation with narrow focus on the final constituent. Every condition had several examples with each of the four accents. Being the most relevant for this dissertation, only the realization of lexical tone in the declarative-initial and declarative-final positions will be discussed. It is also important to note that these sentences comprised of words that all had the same accent, as in *Mârko grâdi prâvu bârku* ‘Marko is building a real boat’ or *Dànas màgla lèti sèlom* ‘the fog is flying around the village today’, which probably had a relatively large effect on the pronunciation. In the latter sentence, for example, the word *dànas* ‘today’ would be analyzed in sentence-initial position and *sèlom* ‘village, inst. sg.’ in sentence-final. The most defining characteristic of sentence-final position is its falling pitch movement, often reaching the bottom of the speaker's pitch range, and a subsequent laryngealization, shown in Figure 2.23.

The combination of falling pitch and frequent laryngealization occurring at the end of words in final position regardless of accent type leads in many cases to a complete neutralization of the tonal contrast. However, laryngealization occurs much more frequently in words with falling accents. This leads Lehiste and Ivić (1996) to believe that the difference between falling and rising accents in final declarative position can be expressed in terms of creaky voice in the former and the absence (or at least less frequently) thereof in the latter.

F_0 in declarative-initial position is distinguished by a much higher pitch range than final or medial position and by a protraction of pitch peaks towards the end of the accented syllable.

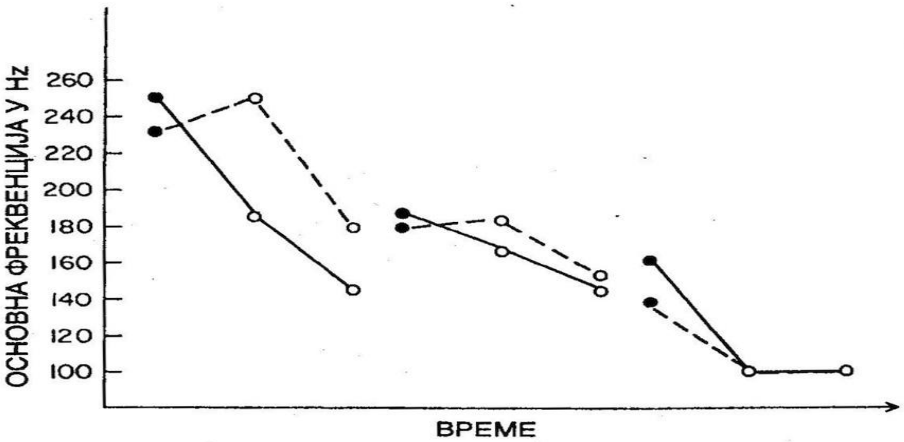


Figure 2.23. F_0 tracks of two sentences with declarative intonation on a normalized time scale as produced by Pavle Ivić. The vertical axis shows the frequency in Hz. The full line represents long falling accents and the dotted long rising, the middle circles were measured at the pitch peak (Lehiste & Ivić, 1996, p. 227)

As opposed to final position, no laryngealization was observed in initial position. The steady compression of pitch range towards the end of the sentence can be explained by the downstepping reported by Godjevac (2005). Table 2.10 shows the percental position of pitch peaks in the accented syllable of six accentual patterns spoken in three sentential positions. Comparing the Medial and Final columns in the table shows that for words uttered in declarative-final position the pitch peaks are retracted to roughly the same place around the beginning of the accented syllable regardless of accent, thereby neutralizing the tonal contrast with regards to pitch peak alignment. Initial position, on the other hand, causes the pitch peaks of all accentual patterns except V̀ V̆ V̆ and V́ V̆ to be realized significantly later in the accented syllable, while still retaining the contrast between falling and rising accents.

Table 2.10. Pitch peaks in accented syllables of six accentual patterns in three sentential positions as produced by Pavle Ivić. Values are given as a percentile of the syllable's duration (adapted from Lehiste & Ivić, 1996, p. 219)

	Initial	Medial	Final
V̏ V̆	68	48	7
V̏ V̆ V̆	78	45	9
V̀ V̆	100	78	8
V̀ V̆ V̆	58	72	8
V̂ V̆	60	25	6
V́ V̆	82	90	6

2.4.3.2 Edward T. Purcell (1973) - The Realizations of Serbo-Croatian Accents in Sentence Enviroments

In his investigation of the realization of tone accent in various sentence enviroments, Purcell (1973) recruited five speakers of standard Western Štokavian from Bosnia and Herzegovina. Most speakers were ethnic Croats from the vicinity of the town of Ljubuški in the region of Herzegovina near the modern Croatian border. The recordings were made in 1969 at the informants' homes in Chicago. The informants' ages ranged from 29 to 66 years and all reported using predominantly Serbo-Croatian in their daily life, with a weak command of the English language at best. The recording material consisted of 50 mono-, bi- and trisyllabic target words with an initial accent arranged into ten accentual patterns (five items per pattern), which were very similar to the ones recorded by Lehiste and Ivić (1996) in their investigation of word prosody: V̏, V̏ V̆, V̏ V̆ V̆, V̀ V̆, V̀ V̆ V̆, V̂, V̂ V̆, V̂ V̆ V̆, V́ V̆ and V́ V̆ V̆. Basically, these are the same patterns seen in Table 2.9, with the exception of posttonal length and the inclusion of monosyllabic words with SF and LF. Additionally, each target word was produced in six different sentential positions: declarative-initial, declarative-medial, declarative-final, interrogative-initial, interrogative-medial and interrogative-final. In order to record a more natural sounding pronunciation, the author devised a very interesting method of elicitation: a brief dialogue was written with each target word embedded into short sentences which were constructed in such a way as to allow them to be pronounced in the different sentential positions listed above. As shown in Table 2.11, sentences four, eight and eleven were designed to elicit an interrogative intonation. Sentences two, six and thirteen (after *nego*) were to be produced with declarative intonation. Sentences four and six call for narrow focus on the underlined target word, and the rest was produced with broad focus.

Table 2.11. Short dialogue written for eliciting different sentential environments (Purcell, 1973, pp. 24-25)

Number	Original text	English translation
1.	*Janko govori prijatelju.*	Janko says to a friend.
2.	*"Vidim ... tamo."*	"I see ... over there."
3.	*Prijatelj se čudi.*	His friend is amazed.
4.	*"... vidiš tamo?"*	"You see ... over there?"
5.	*Janko potvrđuje uvjereno.*	Janko affirms confidently.
6.	*"... vidim tamo."*	"I see ... over there."
7.	*Tada Janko zapita drugog prijatelja.*	Then Janko asks his friend.
8.	*"Vidiš li tamo ...?"*	"Do you see ... over there?"
9.	*"Ne," odgovara on.*	"No," he answers.
10.	*Zatim on zapita trećeg prijatelja.*	After that he asks another friend.
11.	*"Vidiš li ... tamo?"*	"Do you see ... over there?"
12.	*"Ne," odgovara on.*	"No," he answers.
13.	*Prijatelji mu razjasne, da on vidi ne ..., nego ....*	The friends explain to him that he sees not ..., but ....

This short dialogue was read 50 times (each time with a different target word) by each speaker. Additionally, a seventh condition, which was in medial position in a carrier phrase, was investigated to allow comparison with Lehiste and Ivić (1996). Thus, each speaker produced 350 target words for a total of 1750.

F_0 measurements were made, similarly to Lehiste and Ivić (1996), at the beginning, end and pitch peak locations within every vowel of every target word, with the addition of a measurement at the middle of the vowel. The duration of each vowel and the distance from its beginning to the pitch peak were measured as well. Intensity was also calculated but will not be discussed here. The only statistical analysis conducted was a measurement of means.

Purcell's results are generally quite similar to the ones seen in Lehiste and Ivić (1996). Within the accented vowel F_0 is higher at the beginning for falling accents than it is for rising accents. An exception is found in trisyllabic words with long accents, in which this relationship is reversed. The end of accented vowels shows a pattern quite like the exception just described: rising accents have a higher F_0 than the corresponding falling accents. Much as in the other investigations described in this dissertation, the pitch peak was found closer to the start of the accented vowel for falling accents than for rising ones. Rising accents had a higher F_0 in all posttonic vowels throughout their entire duration. To summarize, an accented vowel with a falling accent starts higher, peaks earlier and ends lower than a corresponding rising accent. The first posttonic vowel bearing the same falling accent starts and ends lower than a corresponding vowel with a rising accent. Furthermore, accented and posttonic vowels bearing rising accents were on average 20% longer than ones bearing falling accents.

Comparing the different sentential environments (only declaratives will be discussed in this subsection), Purcell (1973) summarizes the differences in terms of earlier vs. later pitch peak and higher vs. lower global F_0. Independently of accent, the pitch peak within the accented vowel was closest to its end in initial position, closest to the start in final position and somewhere in between in medial position. Monosyllabic words had the highest final F_0 value within the accented vowel in initial position, then followed by medial and final, as illustrated in Figure 2.24.

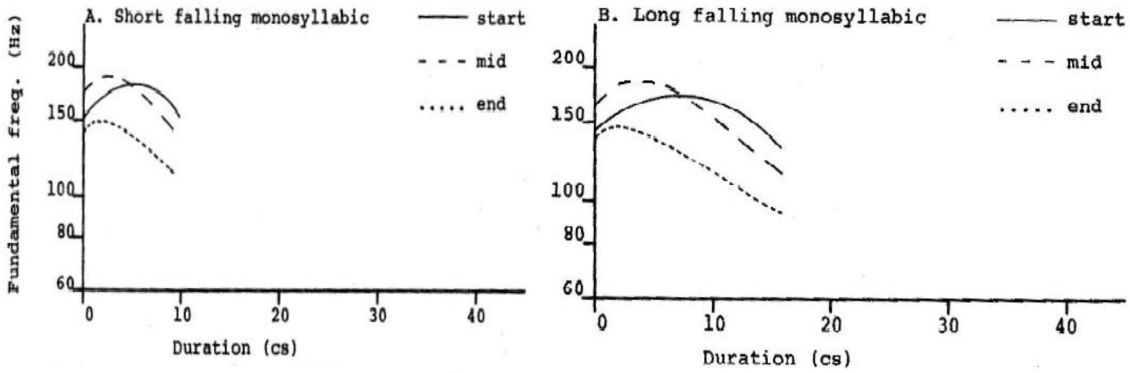


Figure 2.24. F_0 tracks of monosyllabic words with short and long falling accents in three different sentential environments (Purcell, 1973, pp. 140, 142)

Accented vowels carrying falling accents had the highest terminal point in initial position and the lowest in final. For the rising accents, however, the highest terminal point was found in medial position, with the lowest being in final position. For all accents, posttonic syllables were highest at the beginning, middle and end in initial position, followed by medial and final, as shown in Figure 2.25.

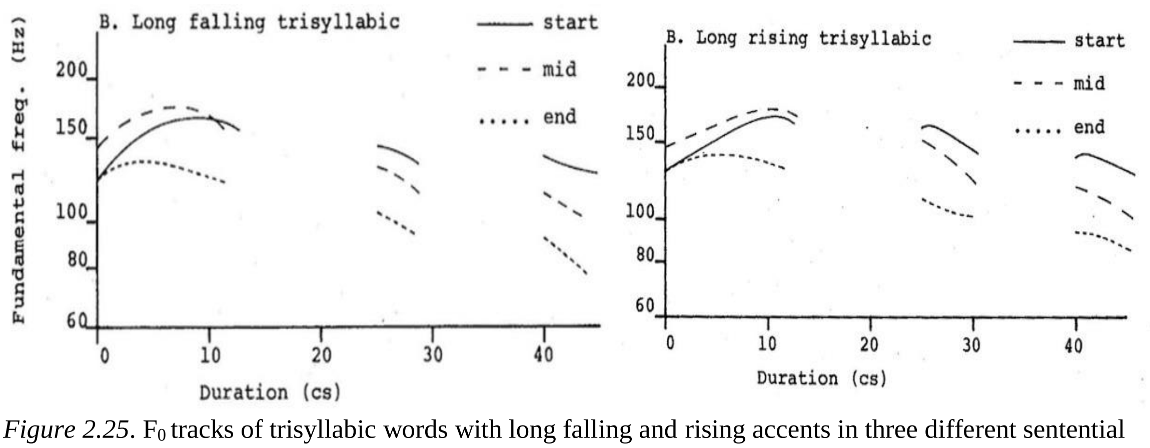


Figure 2.25. F_0 tracks of trisyllabic words with long falling and rising accents in three different sentential environments (Purcell, 1973, pp. 143, 144)

Even though the final neutralization of the tonal contrast was not specifically addressed in Purcell (1973), Figure 2.26 does give a clear picture of the realization of tone in that position. Comparing the F_0 tracks of falling and rising accents shows that the tonal contrast in final position is preserved with regards to the two basic characteristics of F_0 investigated by Purcell. Falling accents start with a higher F_0 in the accented vowel and have their pitch peaks earlier than rising accents, which is best observed in long accents, seen on the right panel of the figure. Posttonic syllables of rising accents are, much like in other positions, consistently higher than corresponding syllables with falling accents. Additionally, rising accents have a slightly longer duration.

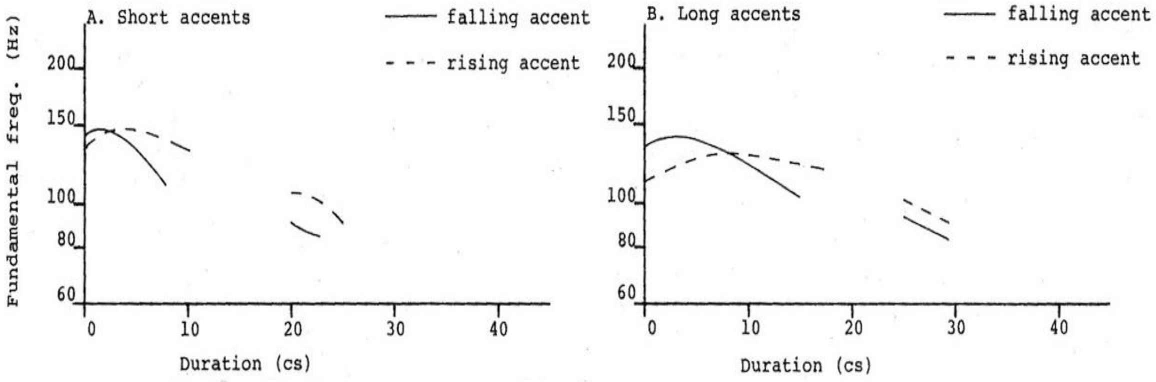


Figure 2.26. F_0 tracks of bisyllabic words in declarative-final condition (Purcell, 1973, p. 70)

2.4.3.3 Elenmari Pletikos (2008) – Akustički opis hrvatske prozodije riječi 'An acoustic description of Croatian word prosody'

In her doctoral dissertation Pletikos investigates the acoustic characteristics of the tonal system of the so-called „Croatian Supradialectal Speech" (henceforth CSS). Using various definitions found in works of other Croatian linguists such as „verified norm", „accepted pronunciation" or even „common all-Croatian accepted idiom", Pletikos (2008, p. 28) defines CSS as the language speakers, regardless of origin or native dialect, use when trying to communicate in standard Croatian. In other words, if one were to take standard literary Croatian as an ideal or target, CSS would be what a dialect-speaker would produce when trying to speak it. This makes CSS highly individual and probably more of an idiolect than a dialect or language. It is important to note that such a construct as CSS is inorganic and exists only on paper. An analogy would be to record English speakers from all over the world and call it „English Supradialectal Speech". In order to investigate this speech, a very heterogeneous group of 89 speakers from all regions of Croatia (including several from Bosnia and Herzegovina) were recruited. 14 speakers were males and 75 females, with a mean age of 21.9 years. The majority of the speakers recorded were students in Zagreb, who at the time of recording had already spent several years in that city. Before the recordings were made, each speaker was asked to assess the influence of the three dialect groups on his/her pronunciation. 6.8% reported Čakavian as their main influence, 31.1% Kajkavian and 62.1% Štokavian. However, according to the speakers' place of birth and where they spent most of their lives, 6.8% come from Čakavian-speaking areas, 44.9% Kajkavian-speaking and 48.3% Štokavian-speaking. Pletikos explains the difference between the speakers' own assessment and their origin by stating that living in Zagreb heightens the influence of Štokavian. The material recorded in the dissertation was an unevenly distributed set of 41 bisyllabic words carrying one of the four standard Croatian accents on the first syllable. Each of the four accents had between nine (LF) and thirteen (SF) target words, with two to four words having a long posttonic syllable. All target words were underscored and embedded into the carrier phrase *Reci ... sada* 'Say … now', which, according to the author, requires narrow focus. Acoustic measurements included mean F_0 and intensity every 10% of both vowels' duration and pitch range and intensity range of both vowels. Additionally, the relationship of F_0, intensity and duration between the accented and posttonic syllable (value of the accented syllable divided by the value of the posttonic syllable) were measured.

The results of all 89 speakers (based on 3266 bisyllabic words) show that duration could significantly differentiate between LF, LR and the short accents in the accented vowel. The difference between SF and SR was not significant. Posttonic syllables of rising accents were on average 5-6 ms longer than the falling accents, as seen in Figure 2.27.

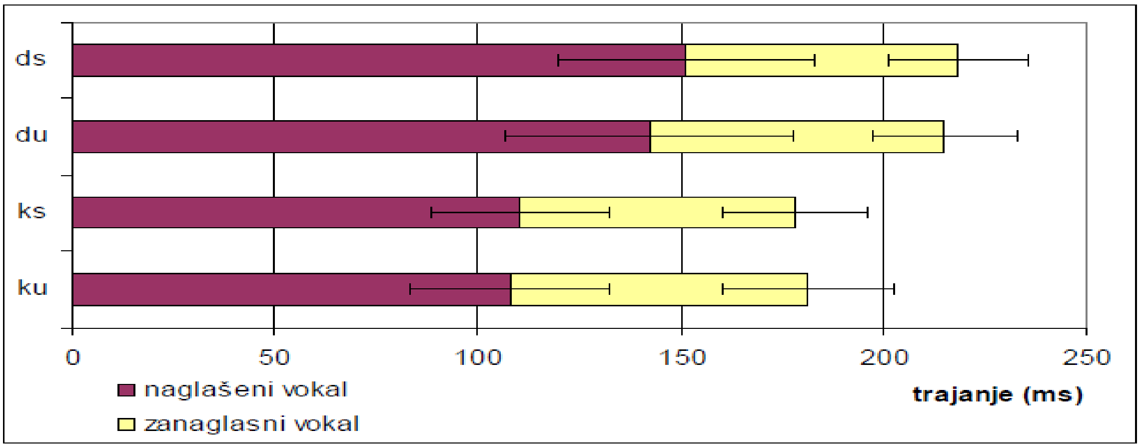


Figure 2.27. Mean duration in ms of accented (purple) and posttonic (yellow) vowels carrying four accents. ds – long falling, du – long rising, ks – short falling, ku – short rising (Pletikos, 2008, p. 94)

As can be seen in Figure 2.28 on the next page, the pitch contours of the accented and posttonic vowels can differentiate only between three accents: long falling, short falling and rising. In the accented and posttonic vowels, all accents exhibit a falling contour, which is however much steeper in the falling accents. LR and SR are practically identical in the accented syllable, with LR having slightly higher values in the posttonic. Contrary to previous investigations, the pitch peak of rising accents in the accented vowel is found, just like in the falling accents, at the beginning of the vowel. Furthermore, the posttonic of rising accents is not higher than the tonic. LF has the steepest fall and thus, the greatest pitch range (2.8 semitones). The pitch range of the accented vowel was significantly higher for falling accents, but was unable to contrast between LR and SR. Generally speaking, the pitch range of posttonic vowels was slightly higher for rising accents. However, only LF was significantly different from all other accents and LR contrasted only with LF. It is important to note, however, that the values presented in Figure 2.28 and in Pletikos' dissertation included words with and without PTL, which could have had an effect on the results.

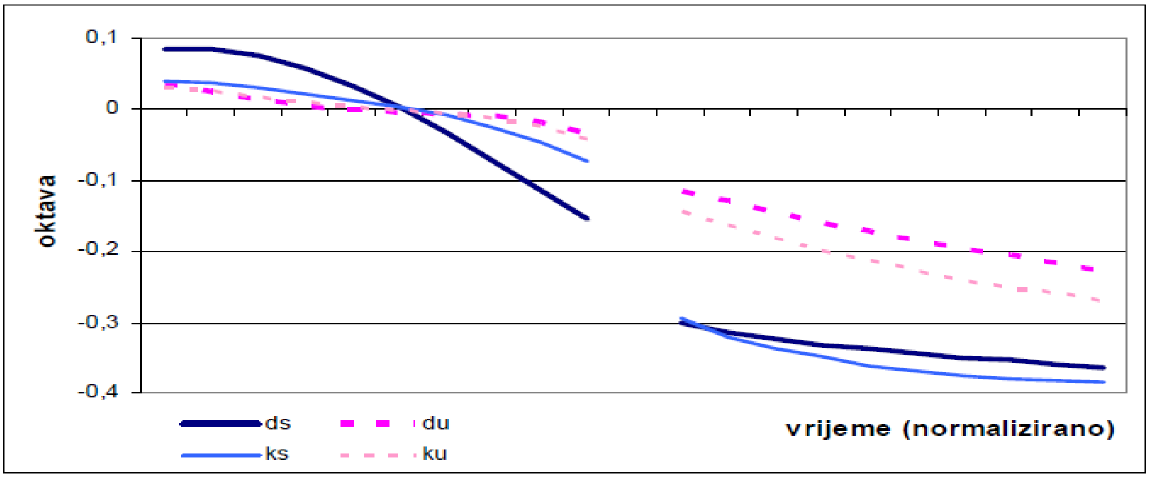


Figure 2.28. F_0 tracks of bisyllabic words carrying four accents produced by 89 speakers. The vertical axis represents frequency in octaves and the horizontal axis is is a normalized time scale. ds – long falling, du – long rising, ks – short falling, ku – short rising (Pletikos, 2008, p. 97)

Having concluded that pooling all 89 speakers together into one group, namely Croatian Supradialectal Speech, results in a rather ambiguous picture, it was decided to divide the speakers into groups according to their native accentual system, which could be either tonal (four accents), dynamic (one to two accents) and mixed (two to three accents). In order to achieve this division, four experts in tone perception (including the author) from the University of Zagreb listened to the entire recorded corpus to qualitatively and quantitavely judge the speakers' pronunciation. If more than 50% of the words pronounced by a given speaker were deemed to be pronounced „correctly" (i.e. as it should be pronounced according to the prescriptive literature) by three out of four experts, that speaker was designated as having a tonal accentual system. In total, 36 out of 89 speakers (40.4%) were assigned to the tonal group. Additionally, the tonal group was further divided according to geographical origin: Slavonia (twenty speakers), Dalmatia (seven speakers) and others (nine speakers).
In the tonal group, the duration of the accented vowel was highest for LF (161 ms), then LR (150 ms), SF (111 ms) and finally, SR (109 ms). Statistical analyis significantly distinguished between LF, LR and the short accents. Even though the duration of the posttonic was not very instrumental in differentiating the accents, the relationship between the accented and

posttonic vowels was highly significant and distinguished all four accents from each other. F_0 and intensity tracks of the tonal group are presented in Figure 2.29.

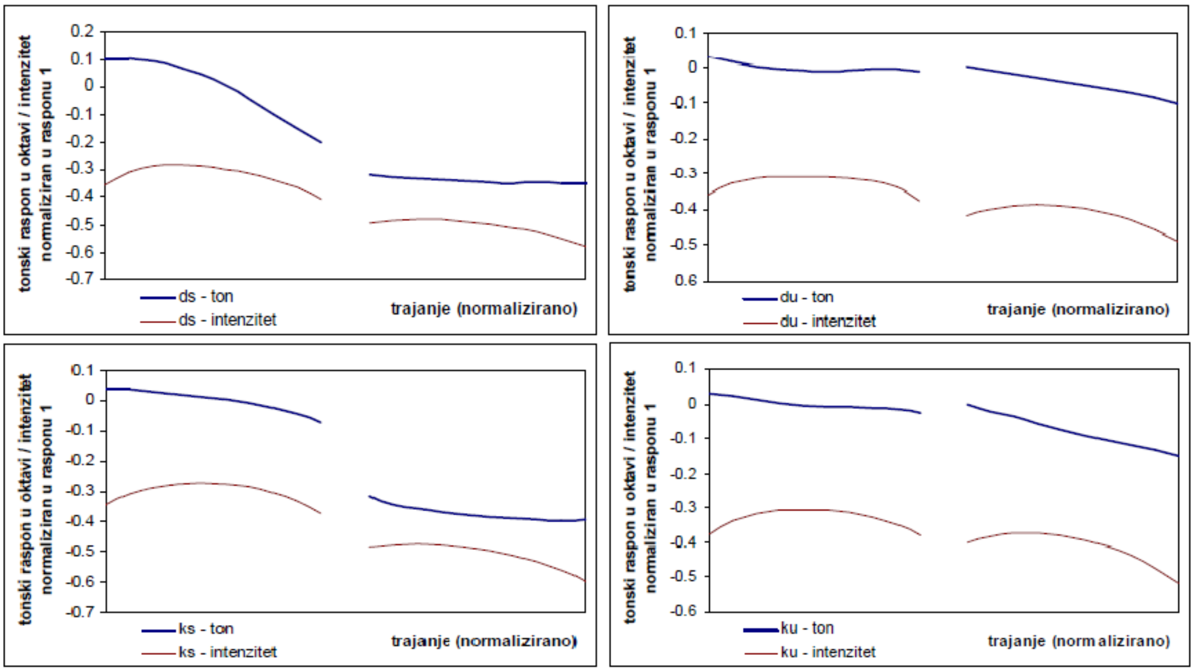


Figure 2.29. The correlation between F_0 and intensity of bisyllabic words carrying four accents produced by 36 speakers with a tonal system. Blue lines represent F_0 and brown lines intensity. The correlation values and the time scale are normalized. Top left panel – long falling, top right – long rising, bottom left – short falling, bottom right – short rising (Pletikos, 2008, p. 136)

The most striking difference between the entire group of 89 speakers as seen in Figure 2.28 and the 36 speakers who have a native tonal system in Figure 2.29 can be seen in the realization of rising accents. The tonal group pronounces rising accents with a much flatter contour and, most importantly, the posttonic vowels start with a higher F_0 than the accented vowels, much like in previous investigations. Falling accents have a notably higher pitch range (especially LF) than rising accents. Furthermore, the relationship between the mean pitch range in the accented vowel and the posttonic is significantly higher for falling accents (LF 3.5 semitones, SF 3.9 semitones) than for rising accents (LR 0.5 semitones, SR 0.9 semitones). The correlation between pitch contours and intensity contours (calculated by dividing the average F_0 in octaves throughout the vowel by the average normalized intensity in dB throughtout the same vowel) significantly distinguished between all four accents. This correlation value, calculated over both vowels of a word together, showed that rising accents (LR 0.35 and SR .048) have smaller intensity falls in their posttonics than the falling accents (LF 0.84 and SF 0.90). As can be seen in Figure 2.29 above, the intensity differences between accent types are rather small.

2.4.3.4 Jevgenij Zintchenko Jurlina (2013) – Wortakzent im Kroatischen 'Word accent in Croatian'

In his unpublished Master's thesis Zintchenko Jurlina investigated the production of lexical tone in standard Croatian based on the East Herzegovinian dialect as spoken in central Slavonia. A homogeneous dialectal background of the informants was very crucial, and for this purpose six native speakers were recruited. Five speakers originated from the city of Slatina and one was from the village of Čačinci (see Figure 1.5). In order to qualify as an informant in this investigation, a speaker had to be born, raised and schooled (at least nine years) in or around the above-mentioned settlements. Furthermore, each speaker's parents had to fulfill the same requirements. The necessary information was obtained from forms filled out by each speaker before recording. The speakers' mean age was 26.5 years. The recorded material consisted of a set of evenly distributed 96 bisyllabic nouns with one of the four Croatian accents on the initial vowel which were each embedded into the beginning of a declarative sentence, written by the author and checked for correctness by a native speaker. Declarative-initial position was selected in order to have a neutral intonation without the risk of tonal neutralization which is prevalent in final position. All posttonic vowels were phonologically short. Each sentence was unique and the target words were always under broad focus, as in *Bȍca vina je bila prazna* 'The bottle of wine was empty' or *Kàva se pije ujutro* 'Coffee is drunk in the morning' (target words were not marked in any way in the experiment). Each of the four accents had 24 target words and the sentence list was randomized and read three times by six speakers, which resulted in a maximum of 1728 words. 31 words were pronounced with either laryngealization or reduced vowels, so that the final number of vowels analyzed was 3394 (1697 bisyllabic words). In total, SF and LR had 428 target words each, LF 422 and SR had 419. The three sentence lists were presented to the speakers on paper and had a dummy sentence at the beginning and end of every page in order to exclude noise made by rustling when the page was turned. For each of the two vowels of a target word, duration was measured in ms from beginning to end using Praat version 5.3.49 (Boersma & Weenink, 2013). F_0 was measured in five points every 25% of a vowel's duration. Pitch peaks and valleys (maximum and minimum values) were measured in every vowel and given additionally as a percental value of the corresponding vowel's duration, referred to as "Max%" and "Min%" respectively. Two additional values were calculated to quantify the relationship between the accented and posttonic vowels: F_0 at the beginning of the posttonic vowel was subtracted from the F_0 value at the end of the accented vowel, referred to as "Delta-Start", and F_0 at the end of the posttonic vowel was subtracted from the

F_0 value at the end of the accented vowel, called "Delta-End". The results of the durational measurements are presented in Table 2.12. "Proportion" is used to show the relationship between the accented and posttonic vowels and is calculated by dividing the value in the posttonic by the one in the accented vowel, given in %.

Table 2.12. Mean duration in ms of accented and posttonic vowels and their proportion (adapted from Zintchenko Jurlina, 2013, p. 25)

Accent	Accented vowel	Posttonic vowel	Proportion
Short falling	92.5	60.2	65%
Short rising	93.9	57.3	60%
Long falling	116.6	54.8	47%
Long rising	119.6	54.2	45%

In the accented vowel two distinct groups can be observed with regards to the duration: short and long accents. Long accents had a mean duration of 118 ms and short accents 93 ms, which was approximately 22% shorter. A one-way ANOVA (*accent* as a fixed factor) and subsequent post hoc tests showed that duration could differentiate only between short and long accents in the accented vowel. The posttonic vowels were of roughly equal duration, with the short falling accent being the only one to have statistically significant differences from all other accents. Similar grouping can also be observed in the proportion between the accented and posttonic syllables. However, a two-way ANOVA (with *accent* and *syllable* – accented vs. posttonic as fixed factors) which included both vowels had a highly significant correlation between *accent* and *syllable*. Post hoc tests showed that all possible accent and syllable combinations were significantly different from each other. This implies that in sentence-initial bisyllabic words each accent has its own unique durational pattern.

The results of the F_0 measurements, demonstrated in Figure 2.30, show several similarities as well as differences to previous investigations. All accents have a distinctly rising contour in the accented vowel, as opposed to a rising-falling contour for falling accents in other investigations. Moreover, the shape of the contour in the accented vowel is almost identical in all accents, with the only tangible difference being the higher values of the falling accents. The posttonic vowels of all accents exhibit a falling contour, albeit not as steep as the rise in the accented vowels. As in the accented vowels, the difference between the rising and falling accents is realized as a difference in the global F_0 values, with rising accents being higher. As can be seen in the figure 2.30, F_0 contrasts only between accent type (falling vs. rising) in initial position, but not between accent length (short vs. long). These results partially confirm the statement made in Godjevac (2005) that phonologically, there are only two categories of accent: rising or falling.

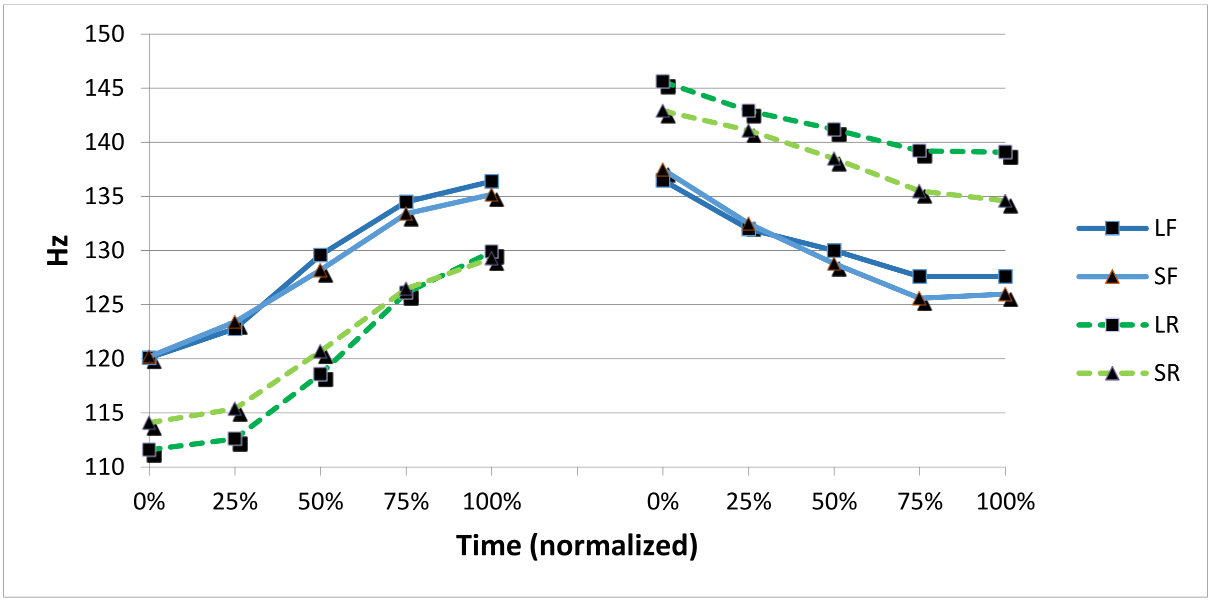


Figure 2.30. F_0 tracks of bisyllabic words carrying four accents in Zintchenko Jurlina's investigation (adapted from Zintchenko Jurlina, 2013, p. 28)

The difference between the start of the posttonic and the end of the accented vowels is still rather similar to results seen in previous investigations. Rising posttonics are higher (approximately 15 Hz) than their tonics, but for falling accents there is almost no difference (+/- 1 Hz) between the two syllables, which is seen in Table 2.13.

Table 2.13. Delta-Start and Delta-End values in Zintchenko Jurlina's investigation. Values are given in Hz (Zintchenko Jurlina, 2013, p. 31)

	Delta-Start	Delta-End
SF	1.79	-9.56
LF	-1.42	-10.46
SR	14.81	6.35
LR	16.06	8.36

Additionally, Delta-End values show that the end of the posttonic is consistently lower (-10 Hz on average) than the end of the accented vowel for falling accents and higher (7.3 Hz on average) for rising accents. Subsequent ANOVAs and post hoc tests showed that Delta-Start and Delta-End significantly differentiated only between rising and falling accents. The values and positions of the pitch peaks and values, although less robust in differentiating between the accents, did show a contrastive pattern within the accented vowels, as illustrated in Table 2.14.

Table 2.14. Minimum and maximum values (in Hz) and their position in the accented vowel (in % of the vowel's duration) (adapted from Zintchenko Jurlina, 2013, p. 32)

	Minimum	min%	Maximum	max%
SF	116.8	14%	139	76%
LF	116.8	12%	140.9	78%
SR	108.9	12%	131.9	84%
LR	106.4	11%	132.1	88%

Quite clearly, all values in Table 2.14 group according to accent type. For all accents, the pitch valley usually occurs at the beginning of the vowel and the pitch peak is located in the third quarter thereof. Corresponding to the values seen in Figure 2.30, falling accents' peaks and valleys are significantly higher than the ones in rising accents. Partially confirming results from previous investigations, pitch peaks of rising accents occur significantly later in the accented syllable, with a mean difference of 9%. There was no main effect for min%, suggesting the location of the pitch valley in the accented vowel plays no significant role in contrasting accents. Results for the posttonic vowels show a much compacter distribution, with hardly any differences between the four categories, as shown in Table 2.15.

Table 2.15. Minimum and maximum values (in Hz) and their position in the posttonic vowel (in % of the vowel's duration) (adapted from Zintchenko Jurlina, 2013, p. 34)

	Minimum	min%	Maximum	max%
SF	117.5	81%	142.9	14%
LF	120.8	81%	145.2	14%
SR	128.5	83%	148.3	17%
LR	131.3	82%	151.1	16%

In conclusion, Zintchenko Jurlina (2013) showed that a combination of durational and F_0 measurements is required to acoustically distinguish the four accents of Croatian from each other. Duration is responsible for contrasting between long and short accents, whereas global and inter-syllabic F_0 parameters differentiate between the falling and rising categories. In other words, at least for declarative-initial bisyllabic words with an initial accent, accent quality and accent quantity are independent of each other.

2.4.3.5 Snežana Gudurić & Dragoljub Petrović (2006) – O prirodi glasa [r] u srpskom jeziku 'Concerning the nature of the [r]-sound in the Serbian language

The vocalic characteristics of /r/ in Serbo-Croatian, which can also be syllabic, have attracted very little attention in phonetic investigations. The only work to specifically examine syllabic /r̥/ in Serbo-Croatian is the largely descriptive account published by Gudurić and Petrović in 2006, which will be discussed in this subsection, since in my experience, the phonetic and phonological characteristics of /r̥/ in Serbian and Croatian are identical.

Besides having a consonantal function, /r/ can also behave as a vowel. Vocalic or syllabic /r̥/ can appear in three different contexts: a) between two consonants – *vŕba* 'willow' or *kȓv* 'blood', b) at the beginning of a word before a consonant - *ȑzati* 'to whinny, inf. imperfective' or *ȑt* 'cape (geographical', c) between a prefixed vowel and a consonant like in b) – *zàrzati* 'to whinny, inf. perfective' or *pòrvati se* 'to wrestle, inf.' (note that *porvati se* is considered Serbian, while in Croatian it is written as *pohrvati se*). As shown in the examples above, /r̥/ can also carry an accent and even be contrastive in near-minimal pairs, as in *hr̀pa* 'pile, nom. sg.' - *hŕpā* 'pile, gen. pl.' or *br̀katī* 'mustached, m.' – *bŕkati* 'to mix up, inf.'. Acoustically, /r̥/ is characterized by three elements: preconsonantal vocoid, consonantal /r/ and postconsonantal vocoid. Both vocoids basically have the same vowel quality and can be described as [ə], which is confirmed by the findings of Lehiste and Ivić, who also measured the first two formants of each vowel in their investigations. Averaged across all four accents, accented /r̥/ had a mean F1 value of 491.25 Hz and an F2 of 1436.3 Hz (Lehiste & Ivić, 1996, p. 76), which are typical values for [ə] (Reetz & Jongman, 2009).

Gudurić and Petrović report that the preconsonantal vocoid's amplitude is slightly higher than the postconsonantal's. However, target words in this investigation show equal or sometimes even higher amplitude on the postconsonantal vocoid, which is illustrated in Figure 2.31. In any case, a higher level of contact between the alveolar ridge and the tongue (i.e. number of taps) leads to a shorter duration and lower amplitude in the vocoids. According to Barić et al. (1997), a short /r̥/ in Croatian has up to three taps and a long one up to five.

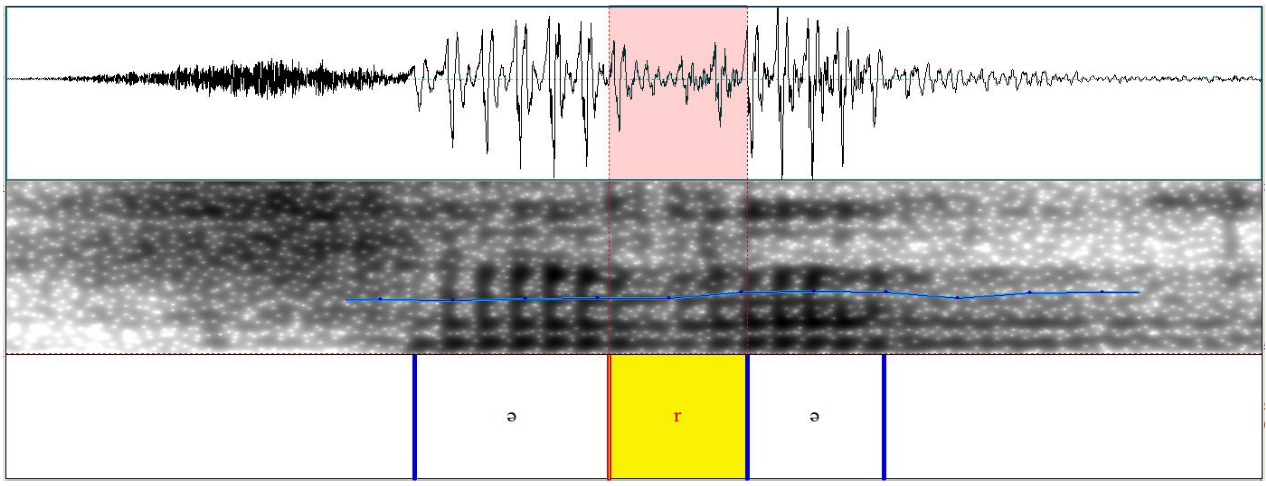


Figure 2.31. Vocalic /r̥/ (highlighted) with pre- and postconsonantal ə-vocoids in the word *cȓkva* 'church' as produced by speaker ŠM

Since pitch movements can still be detected in the consonantal part of the syllabic /r̥/, all three elements were segmented and analyzed in this dissertation as one unit.

2.4.3.6 Summary and Critique of Phonetic Investigations of Pitch Accent in Serbo-Croatian and Croatian

In order to make the acoustic and methodoligal similarities and differences between the various phonetic investigations of tone in Serbo-Croatian and Croatian clearer, nine different paramaters were used to summarize the results, as presented in Table 2.16. Note that the data seen in the table refers only to the most common and neutral condition used to investigate word prosody (described under Method of elicitation): declarative-initial in Zintchenko

Jurlina (2013) and declarative-medial in Lehiste and Ivić (1996), Purcell (1973) and Pletikos (2008). When only a single entity is written in Origin of informants, it indicates a single region in that country. Since the results of all 89 speakers in Pletikos (2008) were quite ambigious, the entries in that column refer only to the tonal group. Homogeneity is an abstract parameter which is lower the more informants differ from each other with regards to dialectal background, gender, profession and age. Contour in accented syllable and Global F_0 refer only to the shape and general values seen in F_0 tracks extracted during the investigation. Since all posttonic syllables had a falling contour in all investigations, they were left out of the summary. Difference between syllables highlights the variation in F_0 observed between the accented and posttonic vowels, i.e. which one was higher or lower for which accent type. Sifnigicant measures sums up the acoustic parameters which proved to be the most salient in differentiating between the four accents in each investigation. Note that while „inter-syllabic diff.“ refers to more general differences between the two syllables, „Delta-Start“ is a specific paramater used by Zintchenko Jurlina (2013) and denotes the relationship between the start of the posttonic and the end of the tonic. „Pitch peak“ applies only to the accented vowel.

Table 2.16. Summary of acoustic and methodological parameters used in four investigations of lexical tone in Serbo-Croatian and Croatian

	Lehiste & Ivić (1996)	Purcell (1973)	Pletikos (2008)	Zintchenko Jurlina (2013)
Origin of informants	Serbia (3 from Bosnia and Herzegovina and Croatia)	Bosnia and Herzegovina	Slavonia, Dalmatia & others (Croatia)	Slavonia (Croatia)
Number of informants	13 (primarily 1)	5	89 (36 in tonal group)	6
Homogeneity of informants	low (mixed gender, origin & profession)	medium (mixed origin & age)	low (mixed gender & origin)	high (same origin, gender & age)
Method of elicitation	medially in carrier phrase	medially in carrier dialogue	medially in carrier phrase	initially in natural sentence
Contour in accented syllable	Falling acc.: rising-falling Rising acc.: rising	Falling acc.: rising-falling Rising acc.: rising	Falling acc.: falling Rising acc.: level	Falling acc.: rising Rising acc.: rising
Pitch peak in accented syllable	Falling acc.: early Rising acc.: late	Falling acc.: early Rising acc.: late	Falling acc.: early Rising acc.: early (not measured)	Falling acc.: late (77%) Rising acc.: late (86%)
Difference between syllables	Falling acc.: posttonic is lower Rising acc.: posttonic is higher	Falling acc.: posttonic is lower Rising acc.: posttonic is higher	Falling acc.: posttonic is lower Rising acc.: posttonic is equal	Falling acc.: posttonic is equal Rising acc.: posttonic is higher
Global F_0	Accented vowel: falling is higher Posttonic vowel: rising is higher	Accented vowel: falling is higher Posttonic vowel: rising is higher	Accented vowel: falling is higher Posttonic vowel: rising is higher	Accented vowel: falling is higher Posttonic vowel: rising is higher
Significant measures	Pitch peak, inter-syllabic diff., duration	Pitch peak, inter-syllabic diff., duration	Pitch range, pitch-intensity correlation	Delta-Start, global F_0, duration

As shown throughout this entire section and stated in the Introduction, numerous methodological gaps and inconsistencies can be observed in the previous investigations. These gaps can be roughly divided into four aspects: a) Speakers (gender, age, profession), b) Linguistic background (native dialect, exposure to other idioms), c) Materials recorded (size, diversity, distribution, elicitation method) and d) Measurements (location of measurements, number of measurements).

Speakers of both genders were recorded in Lehiste & Ivić (1996) and Pletikos (2008). While the problem of comparing male and female voices was solved by Pletikos by measuring F_0 in octaves, it was measured in Hz by Lehiste & Ivić, who „normalized“ their data by grouping speakers according to their relative F_0. Age was a factor controlled for in most investigations, except for Purcell (1973), whose speakers' age ranged from 29 to 66 years, which could have influenced his results due to a generation gap. Although speakers' professions were not a distinct factor in any of the investigations and were usually uniform, most authors recorded only phonetically naive informants. Lehiste & Ivić, however, not only chose to record professional radio speakers and group them together with naive speakers with no previous training in pronunciation, but also to record one of the authors and present his results instead since they were deemed representative. It is therefore quite safe to assume that the results presented in Lehiste & Ivić have been influenced by the speakers' professional background and previous knowledge of the experiment.

The informants' linguistic background was the most varied aspect of all investigations presented so far. Lehiste & Ivić recorded thirteen speakers in total, ten of which came from Vojvodina and central Serbia, where the Šumadija-Vojvodina dialect is spoken. The other three informants were originally from ijekavian-speaking zones in Bosnia and Herzegovina and Croatia, where the predominant dialect is Eastern Herzegovinian. The most extreme variation in dialectal background is observed in Pletikos, where 89 speakers of all dialect groups from all over Croatia were recorded. It is important to note that Pletikos investigated CSS, for which such a variety of speakers is needed. Due to their dialectal heterogeneity, however, the two above-mentioned investigations do not present a clear picture of a single entity, be it a standardized regional variety or a dialect. Purcell and Zintchenko Jurlina (2013), on the other hand, concentrated on finding speakers with a uniform dialectal background. Purcell's speakers all originated from the same region in southern Bosnia and Herzegovina and spoke the "Western literary standard of contemporary Serbo-Croatian as spoken by people (with some education) in Bosnia-Hercegovina." (p. 48). Purcell did not specifically name the dialect spoken, but it can be safely assumed that it was Eastern Herzegovinian. Zintchenko Jurlina went even further and made sure all speakers' backgrounds were as similar as possible by recording only speakers born, raised and schooled (with the same conditions applying to their parents) in Slavonia, where the standard Eastern Herzegovinian dialect is spoken. These strict conditions were also used indirectly to control for exposure to other idioms, which was minimal in this case, compared to the other investigations. Lehiste & Ivić and Pletikos recorded informants who had been exposed to other Serbo-Croatian dialects (Novi Sad and Zagreb, respectively), although only Pletikos specifically adressed this issue in her dissertation. In Purcell, the informants grew up and lived in different parts of Yugoslavia and had been living in the USA for several years at the time of the recordings, although the author reports that their contact with English was minimal since they also preferred to socialize mainly with other Serbo-Croatian-speaking people.

The size, composition and distribution of the corpus recorded was also quite varied. Pletikos had the smallest set of target words (only 41), but due to the unusually large number of speakers, a sizable corpus was recorded. Purcell and Zintchenko Jurlina compiled larger sets of target words (50 and 96, respectively), and an adequate amount of samples was reached by repetition and a relatively small number of informants (5-6). Lehiste & Ivić recorded fairly large sets for one of the authors and for the rest of the speakers. With regard to composition and distribution, the only common feature that all investigations had was that all word lists contained bisyllabic words with an accented initial syllable. Purcell and Zintchenko Jurlina were the only ones to have evenly distributed sets, with the former investigating mono-, bi- and trisyllabic words, and the latter only bisyllabic (all without PTL in both cases). Pletikos' wordlist was not only unevenly distributed, but had words with and without PTL grouped together. Even though Lehiste & Ivić recorded a small amount of mono- and quadrisyllabic words, they were never presented or discussed, so it can be said that they only investigated bi- and trisyllabic words. In any case, their word lists were highly unevenly distributed, as illustrated in Table 2.9. As mentioned above, all investigations presented only words with an initial accent (other positions were recorded by Lehiste & Ivić but never presented). This is quite logical, since tonal contrast is only possible in that context, but on the other hand, the subject of tone in non-initial syllables hasn't been specifically addressed so far. Lehiste & Ivić also included words with a syllabic /r̥/, but as in many cases described here, they were not discussed in the text. The only phonetic investigation of syllabic /r̥/ in Serbo-Croatian I know of (Gudurić & Petrović, 2006) has already been presented in §2.4.3.5, but it did not contain a production experiment or any information on lexical tone. The elicitation methods used in the previous investigations can be divided into two groups. Purcell and Zintchenko Jurlina elicited more natural speech by embedding target words either in natural sentences or a short story, while Pletikos embedded hers in a short carrier phrase, which potentially induced a so-called „list intonation". Lehiste & Ivić recorded target words in both a short carrier phrase and in various natural sentences. However, since all words in sentence contexts had the same accent, certain interferences cannot be ruled out and the „naturalness" of the speech elicited is also disputable. It is also important to note that Pletikos' and Lehiste & Ivić's carrier phrases place the target word under narrow focus, as opposed to Zintchenko Jurlina, who only had broad focus in his work. Purcell recorded both types of focus. Finally, the domain investigated must also be considered. Lehiste & Ivić and Purcell examined in their works the interaction between intonation and tone by embedding words in three different sentence positions (initial, medial and final) with two intonational contours (declarative and interrogative). The other two investigations focused only on declarative sentences with words embedded initially (Zintchenko Jurlina) or medially (Pletikos). Lehiste & Ivić's and Purcell's investigations included a small number of measurement points in set positions of every syllable nucleus: beginning, middle, end and peak. Although not explained in either of the texts, it can be assumed that the authors drew F_0 and intensity tracks by hand and according to their general appearance. Additionally, having only 3 or 4 measurement points does not provide much information about the contour, which is therefore an approximation at best. However, due to the technical limitations at the time of writing, this is quite understandable. Pletikos and Zintchenko Jurlina, on the other hand, measured the acoustic parameters in set steps of the nucleus' duration, an approach which provides a much more accurate and robust representation of F_0 and intensity contours. While Zintchenko Jurlina only had five measurement points (every 25% of the nucleus duration), Pletikos' tracks had a higher „resolution" with measurements made every 10%.

2.4.3.7 Research Questions and Hypotheses

As mentioned in Chapter 1, the intent of this dissertation is to bridge the methodological and thematical gaps and inconsistencies of previous investigations in order to draw a clear and comprehensive picture of the production of lexical tone in standard Croatian. As can be seen in the previous subsection, two methodological factors are of utmost importance to this dissertation: a) a homogeneous group of speakers of the standard dialect with the same linguistic background, age and level of exposure to other idioms, and b) a large, well-balanced and evenly distributed corpus with a natural elicitation method. In addition to a general analysis of pitch production in three sentence environments, this dissertation will include the following subjects, which have so far been examined only superficially or not at all: a) tone in words with more than two syllables (tri- and quadrisyllabic), b) tone in non-initial syllables (penultimate and antepenultimate), c) pretonal syllables (first and second pretonals), d) tone in syllabic /r̥/ and e) the influence of PTL on tone. For more details about the speakers and materials recorded in this dissertation, see §3.1 and §3.2.

In accordance with the the measurements extracted in previous investigations, it was decided to measure F_0 every 10% of a nucleus' duration in order to gather as much information as possible about the pitch contour, whilst having a high resolution, like in Pletikos (2008). Pletikos also showed that pitch range was instrumental in differentiating between accent types, with falling accents having a significantly wider range than rising ones, for which reason this parameter was included in this investigation. Since mean F_0 tracks of falling accents in Zintchenko Jurlina (2013) showed consistently different contour levels than rising accents with no overlapping (higher in the accented and lower in the posttonal syllable, see Figure 2.30), a single measurement was selected to represent the global pitch – Overall Mean. Pitch Peak Alignment (PPA), measured in Smiljanić & Hualde (2000) and Smiljanić (2003, 2006) was very salient in contrasting not only between accent types, but also between tonal and non-tonal variants of Serbo-Croatian. PPA% was deemed to be a more efficient inter-syllabic measurement than Delta-Start (Zintchenko Jurlina, 2013) for two main reasons: a) it encompasses the relation between pitch peaks in the two most important syllables (accented and first posttonal) in a word, contrasting between falling and rising accents, and b) it clearly shows the temporal position of the pitch peak in the accented syllable, which varied considerably across different sentence positions, as seen in Lehiste & Ivić (1996) and Purcell (1973). Originally, maximum pitch values in each nucleus were also measured, but they proved to be quite redundant, since the information presented therein was already covered by OvMean and PPA%. For instance, if a certain syllable in a certain context had high overall pitch, its pitch maximum value was also high, and vice versa. For these reasons, pitch maximum was excluded from the analysis. As shown in §2.4.3.1 and §2.4.3.3, the role of intensity in the production of tone proved to be somewhat inconclusive, being either mostly insignificant (as suggested by Lehiste & Ivić, 1996) or significant only in combination with F_0 and only in posttonal syllables (Pletikos, 2008). Consequently, intensity measurements were not included in this dissertation. For more details on the acoustic parameters measured in this work, see §3.3.

Based on the results of the previous investigations, the following working hypotheses are proposed for this dissertation:

a) **Hypothesis 1**: Phonologically, there are only two categories of accent in Croatian – falling and rising. The contrast between short and long accents is independent of the tonal distinction. Therefore, F_0 measurements will serve primarily to distinguish between falling and rising accents, while duration will differentiate between the short and long categories, as in Zintchenko Jurlina (2013).

b) **Hypothesis 2**: Since the dialect investigated here is the same as in Zintchenko Jurlina (2013), it is expected that the production of tone will follow the same pattern: rising F_0 contours in accented syllables (higher for falling accents) and falling contours in all following syllables (lower for falling accents) for both accent types. Additionally, the same model is expected for accents with a syllabic /r̥/ and for non-initial rising accents.

c) **Hypothesis 3**: Accents in sentence-initial and sentence-medial positions are produced in the same manner (like in the previous hypothesis) and represent the basic pattern of tone in Croatian, similar to Lehiste & Ivić (1996) and Purcell (1973). Based on these investigations, it is anticipated that the tonal contrast in sentence-final position will be at least partially neutralized.

d) **Hypothesis 4**: In accordance with Lehiste & Ivić's (1996) tentative description, the global pitch in pretonal syllables is expected to be lower than accented, but higher than posttonal syllables.

e) **Hypothesis 5**: Aside from duration, no major differences are expected between tonal patterns with and without PTL. Since long vowels are more robust and dynamic (Reetz & Jongman, 2009), it is possible that syllables with PTL will have a wider pitch range and higher overall pitch.

3

METHODOLOGY

This chapter details the various methodologies used in the production experiment which was designed to investigate the acoustic properties of pitch accent in Croatian. As already explained at the beginning of Chapter 1 and §2.4.3, great pains were taken to maintain speaker homogeneity, while recording a relatively large and balanced corpus with diverse tonal patterns. §3.1 describes the participants of the production experiment and how they were selected, followed by an in-depth discussion of the materials used and recording procedures in §3.2. Finally, §3.3 is devoted to the various acoustic measurements used to analyze the recordings made.

3.1 Participants

As explained earlier in Chapters 1 and 2, the Eastern Herzegovinian dialect is the closest to the standard language, with an ijekavian pronunciation (as opposed to Younger Ikavian) and also the highest number of speakers in Croatia. For this reason, it was decided to record native speakers of Croatian from Slavonia, where Eastern Herzegovinian is the dominant dialect. In order to maximize speaker homogeneity and reduce various linguistic and sociological factors to a minimum, a relatively strict selection process was implemented. Speakers had to be born, raised and schooled in Slavonia, specifically in the Virovitica-Podravina County. Moreover, to ensure that no influences from other dialects or languages from home could affect the speakers' pronunciation, their parents also had to be from the same region. Additionally, it was determined that in order to avoid effects due to a generation gap, all speakers had to be between 20 and 35 years of age. With these conditions in mind, a participant questionnaire (see Appendix A for the original Croatian version and its English translation) was written, where all the above information was prompted in the form of questions such as „In which city were you born?“ or „Are your parents from the same city?“. A short interview with the same questions was conducted with each potential speaker, and if all requirements were met, the questionnaire was filled out and the recording could begin. Altogether, ten male native speakers of Croatian were recorded for the production experiment. For a summary of the speakers' personal information, see Table 3.1. At the time of the recordings, the speakers' age ranged from 24 to 35 years (mean: 27.5, SD: 3.5). Seven out of ten speakers were born in Virovitica (ca. 27 km west of Slatina, see Figure 1.5 for more details), two in Našice (ca. 20 km south-east of Čačinci) and one, speaker IP, was born in Knin (ca. 215 km south-west of Slatina in the Šibenik-Knin County). IP's father, who was an officer in the military, was stationed in Knin at the time, but since the family soon returned to Slatina, he still qualified for the recordings. Six speakers grew up in Slatina, three in Čačinci and one in Našice. All but two speakers were schooled in Slatina since most children in the area are assigned to the high school there. Most participants' parents (or at least one parent) were either from Slatina or Čačinci. One speaker's mother was from Voćin and another's father from Ćeralije, which are both villages in the vicinity of Slatina. One speaker's mother was from Sopje, a municipality ca. 11 km north-east of Slatina on the border with Hungary. Even though speaker ZK's father was originally from Bosnia, there was never any contact between them, so he was still recorded. None of the participants had any history of hearing or speaking conditions and none of them were paid for the recordings.

Table 3.1. Data of speakers recorded in the production experiment

Number	**Initials**	**Age**	**City of birth**	**Grew up in**	**School**	**Parents**	**Profession**
1	ZK	31	Virovitica	Slatina	Slatina	Mother - Voćin, father - Bosnia	Agricultural technician
2	TR	24	Virovitica	Čačinci	Orahovica	Čačinci	Commercialist
3	MP	25	Virovitica	Slatina	Slatina	Slatina	Student
4	MI	31	Našice	Našice	Našice	Našice	Teacher
5	IP	24	Knin	Slatina	Slatina	Slatina	Student
6	ŠM	35	Našice	Čačinci	Slatina	Čačinci	Electrician
7	MR	24	Virovitica	Slatina	Slatina	Mother - Slatina, father - Ćeralije	Mason
8	VB	26	Virovitica	Slatina	Slatina	Slatina	Policeman
9	BM	28	Virovitica	Čačinci	Slatina	Čačinci	Economist
10	MT	27	Virovitica	Slatina	Slatina	Mother - Sopje, father - Slatina	Student

3.2 Materials and Recording Procedures

As seen in §2.4.3 and Chapter 1, most phonetic investigations of tone in Serbo-Croatian and Croatian recorded either quite unevenly distributed sets of words (such as 102 words with V̏ V̌ and 71 words with V̀ V̌ in Lehiste & Ivić (1996), see Table 2.9 for more examples) and/or a rather limited selection of tonal patterns with respect to number of syllables or place of accent. Almost all investigations only had bi- and trisyllabic words with an accented initial syllable. Only Lehiste & Ivić (1996) recorded tri- and quadrisyllabic words with non-initial accentuation, but they were not analyzed in much detail. Even though words with syllabic /r̩/

were also recorded, they were mainly used to investigate vowel quality and not tone. Moreover, no investigation I know of has ever specifically analyzed the production of tone in pretonic syllables, a subject which has been neglected so far. For these reasons, it was decided to investigate a large and diverse set of accentual patterns which will also be evenly distributed to facilitate a more exact statistical analysis. This way, a broader spectrum of tone production in Croatian will be covered, with the additional benefit of addressing the above-mentioned methodological gaps, namely the realization of non-initial accent in words with more than two syllables, pitch in pretonic syllables, pitch in words with a syllabic /r̩/ and the influence of PTL. Furthermore, post-lexical effects associated with sentence position will also be investigated by placing target words at the beginning, middle and end of sentences. The sentences recorded will be discussed after the target words.
Altogether, 120 real Croatian words distributed across 46 distinct accentual patterns were selected. 116 words were nouns (usually in the nominative singular), while two were city names (Dubrovnik and Đurđevac), one adjective (*majčinski* 'motherly, adj. m. sg.') and one verb (*raditi* 'to work, inf.'). Words were selected according to their accentuation, as determined by Vukušić et al. (2007). Only words with a single possible accentuation (as opposed to doublets such as *glâvi/glávi* 'head, dat. sg') were picked. These target words had either one, two, three or four syllables. Since monosyllabic words can only have falling accents, only two patterns are possible: V̏ and V̂. For bisyllabic words, three patterns were recorded for each accent (for a total of 12), which was always initial: one with a short postaccentual syllable, one with a long postaccentual syllable and another with an accented syllabic /r̩/ with a short postaccentual syllable (no pattern with PTL was recorded for words with syllabic /r̩/). For example, LR had the following patterns: V́ V̌, V́ V̄ and Ŕ V̌. Bisyllabic words with no PTL are referred to as "2s" (= short), ones with PTL as "2l" (= long) and the third pattern as "2R". Trisyllabic words were divided according to their place of accent: ones with an accented initial syllable are referred to as "3a" and ones with an accented second syllable as "3b". In 3a, each accent had four patterns (for a total of 16), which were all the possible combinations of the presence or absence of PTL, for example: V̂ V̌ V̌, V̂ V̄ V̌, V̂ V̌ V̄ and V̂ V̄ V̄. Since only rising accents can appear on non-initial syllables, 3b had only two possible patterns for each of the two accents (4 altogether), for instance: V̌ V̀ V̌ and V̌ V̀ V̄. Quadrisyllabic words were divided similarly to trisyllabic words: "4a" denotes words with an accented second syllable and "4b" an accented third syllable. Initial accentuation in quadrisyllabic words was not investigated since it would require 32 (eight for every accent) additional patterns to cover all the possible combinations with and without PTL, which would

make the corpus too large. There were four patterns for each of the two rising accents in 4a (8 total), as illustrated by LR: V̆ V́ V̆ V̆, V̆ V́ V̄ V̆, V̆ V́ V̆ V̄ and V̆ V́ V̄ V̄. Much like 3b, 4b had only two patterns (4 altogether), for example: V̆ V̆ V̀ V̆ and V̆ V̆ V̀ V̄. It should be noted that for some tri- and quadrisyllabic patterns, no "organic" (i.e. purely typological, as opposed to paradigmatic) words could be found, which is why a rather large quantity of nouns with the phonologically long *-ōst* suffix (akin to English *-ness*, as in 'happiness') was selected. For a summary of all tonal patterns recorded for the production experiment, see Table 3.2 below. The complete list of target words and their English translation is found in Appendices B1 and B2, respectively. More information on how each segment was labeled will be given later in this section.

Table 3.2. Summary of tonal patterns recorded (patterns with short accented syllables are colored gray)

Syllables	Pattern	Items	Example	Syllables	Pattern	Items	Example
1	V̏	4	pȁs	3a	V̀ V̄ V̆	2	kòšārka
	V̂	4	sîn		V̀ V̆ V̄	2	kònobār
2s	V̏ V̆	2	čȁša		V̀ V̄ V̄	2	Dùbrōvnīk
	V̂ V̆	2	mêso		V́ V̆ V̆	2	nádimak
	V̀ V̆	2	kùpus		V́ V̄ V̆	2	pítānje
	V́ V̆	2	prózor		V́ V̆ V̄	2	národnōst
2l	V̏ V̄	2	pȁmēt		V́ V̄ V̄	2	nástāvnīk
	V̂ V̄	2	dnêvnīk	3b	V̆ V̀ V̆	4	kukùruz
	V̀ V̄	2	dùhān		V̆ V̀ V̄	4	tambùrāš
	V́ V̄	2	rúkōm		V̆ V́ V̆	4	komárac
2R	Ȑ V̆	4	dȑvo		V̆ V́ V̄	4	mogúćnōst
	R̂ V̆	4	cȓkva	4a	V̆ V̀ V̆ V̆	2	kobàsica
	R̀ V̆	4	hr̀đa		V̆ V̀ V̄ V̆	2	kolèbānje
	Ŕ V̆	4	sŕna		V̆ V̀ V̆ V̄	2	fonètičār
3a	V̏ V̆ V̆	2	pȍbjeda		V̆ V̀ V̄ V̄	2	nedòrāslōst
	V̏ V̄ V̆	2	srȅdīšte		V̆ V́ V̆ V̆	2	boróvnica
	V̏ V̆ V̄	2	kȉšobrān		V̆ V́ V̄ V̆	2	zanímānje
	V̏ V̄ V̄	2	knjȉžēvnīk		V̆ V́ V̆ V̄	2	sunárodnjāk
	V̂ V̆ V̆	2	dnêvnica		V̆ V́ V̄ V̄	2	besprijékōrnōst
	V̂ V̄ V̆	2	sûnčānje	4b	V̆ V̆ V̀ V̆	4	tjestenìna
	V̂ V̆ V̄	2	smîrenōst		V̆ V̆ V̀ V̄	4	toleràntnōst
	V̂ V̄ V̄	2	vêzānōst		V̆ V̆ V́ V̆	4	Dalmatínac
	V̀ V̆ V̆	2	grànica		V̆ V̆ V́ V̄	4	genijálnōst

In monosyllabic words, each of the two falling accents has four items. Combined with the 2R words, bisyllabic words have eight items for each of the four accents. 3a words have the same distribution and quantity of items as bisyllabic words. Since 3b contains only words with rising accents, there is a total of 16 items - eight for each accent. 4a and 4b each have eight items per accent, just like 3b. A list of the patterns grouped by number of syllables and accent with quantity of items is presented below in Table 3.3. In summary, multisyllabic words with initial accentuation (2s/l + 2R and 3a) have eight items for each group with all four accents, words with non-initial accentuation (3b, 4a and 4b) have eight items per group with both rising accents and monosyllabic words only have four items with both falling accents.

Table 3.3. Accentual patterns grouped by number of syllables and accent with quantity of items

Syllables	Pattern	Items
1	V̏	4
	V̂	4
2	V̏ V̆, V̏ V̄, Ȑ V̆	4 + 4
	V̂ V̆, V̂ V̄, R̂ V̆	4 + 4
	V̀ V̆, V̀ V̄, R̀ V̆	4 + 4
	V́ V̆, V́ V̄, Ŕ V̆	4 + 4
3a	V̏ V̆ V̆, V̏ V̄ V̆, V̏ V̆ V̄, V̏ V̄ V̄	8
	V̂ V̆ V̆, V̂ V̄ V̆, V̂ V̆ V̄, V̂ V̄ V̄	8
	V̀ V̆ V̆, V̀ V̄ V̆, V̀ V̆ V̄, V̀ V̄ V̄	8
	V́ V̆ V̆, V́ V̄ V̆, V́ V̆ V̄, V́ V̄ V̄	8
3b	V̆ V̀ V̆, V̆ V̀ V̄	8
	V̆ V́ V̆, V̆ V́ V̄	8
4a	V̆ V̀ V̆ V̆, V̆ V̀ V̄ V̆, V̆ V̀ V̆ V̄, V̆ V̀ V̄ V̄	8
	V̆ V́ V̆ V̆, V̆ V́ V̄ V̆, V̆ V́ V̆ V̄, V̆ V́ V̄ V̄	8
4b	V̆ V̆ V̀ V̆, V̆ V̆ V̀ V̄	8
	V̆ V̆ V́ V̆, V̆ V̆ V́ V̄	8

As mentioned at the beginning of this section, each target word was placed in three different simple Croatian declarative and pragmatically neutral sentences to test the effects of position on the production of tone. Most of the target words selected for this experiment were nouns since they have a wider and more diverse range of tonal patterns than other parts of speech and it was deemed easier to combine them with sentences. For a list of all the sentences and their English translation, see Appendix B3. All sentences were written by the author of this dissertation and were later given to three native speakers of Croatian, who were not recorded in the production experiment, for quality control. The sentences had at most one clause consisting of one intonation phrase to avoid post-lexical boundary tones in medial position. The sentences' length ranged from three words, such as "*Budućnost je nepredvidljiva.*" ('The future is unforeseen.') to eight words, like "*Vojna parada će se održati u četiri sata*." ('The military parade will be held at four o'clock'). The mean number of words per sentence was 5.2, with a standard deviation of 1.02. No particular theme was selected for the sentences in general, and each one usually had a rather neutral and mundane context revolving around the target word so as not to influence the pronuniation. Target words in initial and final position were placed at the absolute beginning and end of sentences, respectively. In the case of medial position, target words were usually at least 1-2 phonological words away from the end

or beginning of the sentence. Although the overall length of the sentences and the medial words' distance from the beginning or the end were not wholly uniform, it was still viewed as acceptable due to the size of the recorded corpus in general and the number of speakers.
The production materials were presented separately to each speaker printed on 16 A4 sheets of paper. Since speakers tend to turn to the next page while still reading the last sentence, it was decided to place filler sentences at the top and bottom of each page to avoid recording rustling. The fillers had the same basic form as the sentences with the target words. This way, 120 target words each placed in three different positions resulted in a total of 360 items, and together with 32 fillers, each speaker read 392 sentences.
The recordings were made in small and quiet rooms, usually in speakers' homes in Slatina, Čačinci and Našice (speaker MI). All major electric appliances in the rooms were turned off to avoid generating background noise. The recordings were made using the built-in microphone of an Olympus LS10 recording device at a sampling frequency of 44.1 kHz and 16 bits. The recording device was placed on a tripod in a 45-degree angle and approximately 40-50 cm away from the speaker's mouth.
Speakers were told about the purpose of the recordings only after they were done. Each speaker was instructed to read the materials in a normal tempo with normal loudness and to try to maintain the same distance from the microphone. Taking a short break during the recording to relax and drink some water was strongly recommended, since most recordings took between 15 and 20 minutes to complete. All participants took the offered break, with several even taking two. The speakers were instructed to repeat a sentence if they felt they had mispronounced it. The author of this dissertation was also present at all the recordings to correct speakers and request to repeat a sentence they had pronounced incorrectly. During this process, two words were consistently mispronounced by almost all speakers. *Peràdārnīk* 'chicken coop', being a rather rare word, was pronounced most often as *peradárnīk* and *gotovìna* 'cash' was usually substituted for the surname of a famous Croatian general, (Ante) Gotòvina. However, sentences with such mispronunciations were always repeated until produced correctly.

3.3 Acoustic Measurements

All the recordings made were converted to mono with Praat, version 6.0.37 (Boersma & Weenink, 2018). Using the same program, all syllable nuclei in each target word were labeled and extracted for later use. Although the TBU in Croatian is the mora, it was decided that finding so many target words with a sonorant coda would be too time-consuming, which is why only syllable nuclei were analyzed. I use the term *syllable nuclei* here since not only vowels were extracted, but also syllabic /r̩/. However, in this and the following chapter, whenever extraction or analysis of vowels or syllables is mentioned, syllabic /r̩/ is also included.

Vowels were demarcated in Praat based on observance of the spectrogram and oscillogram. In general, the onset and offset of quasi-periodic vibrations in the oscillogram combined with the onset and offset of vowel formants (as opposed to nasal formants) served as the basis for determining vowel boundaries. In words with a syllabic /r̩/, the nucleus was defined as the first vocoid, the /r/ itself and the second vocoid, as described in §2.4.3.5 and illustrated in Figure 2.31. In some cases, especially in sentence-final position or between two voiceless fricatives/affricates, no pitch could be measured. The solution, which was to change one of Praat's so-called advanced pitch settings, will be described in the next paragraph. In any case, words which had one or more deleted vowels (such as [grant͜sa] instead of [granit͜sa] 'border') were not analyzed at all. Out of a possible 3600 words (360 items x 10 speakers), 3473 words were included in the analysis, which comprised 9905 vowels. An example of the demarcation and labeling of the word *rješénje* 'decision, solution' is shown in Figure 3.1. The labels in the second tier give all the necessary information about that specific vowel. For instance, "3b" means that the word has three syllables with a second accented syllable, as seen in Tables 3.2 and 3.3. The next section, LR, shows the accent of the word. The third section gives the prosodic status of each syllable. In this word, "1p" is an initial pretonal syllable, "2a" is a second accented syllable and "3s" stands for a third phonologically short syllable. The final segment, which has three possible values, shows the word's position in the sentence, in this case initial (S = start).

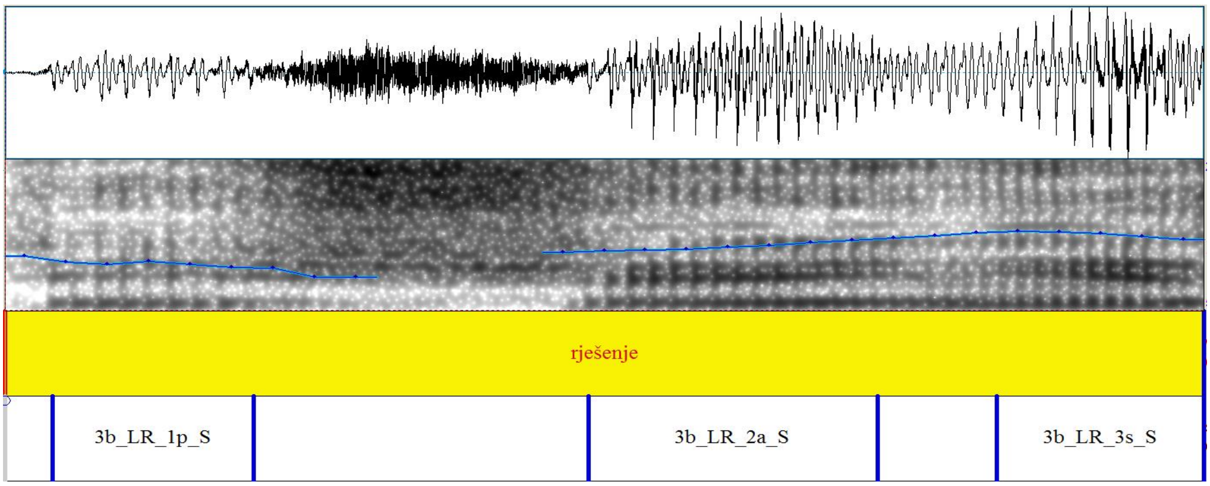


Figure 3.1. Exemplary demarcation of vowel boundaries in a target word. The blue line represents the fundamental frequency

In order to extract acoustic data from the demarcated vowels, a Praat script was written. Using Praat's autocorrelation algorithm, four parameters were different than the default setting: Pitch floor, Pitch ceiling, Very accurate and Voicing threshold. Since all speakers recorded were male, the pitch floor was set to 50 Hz and the pitch ceiling to 250 Hz (i.e. the effective range analyzed by the script), to avoid extracting overly high F_0 values. The Very accurate setting was turned on, which created a Gaussian analysis window with a physical length of 0.12 seconds. During the demarcation in Praat it was noticed that for some vowels (see previous paragraph), pitch could not be detected. For this reason, Voicing threshold was lowered from the default setting of 0.45 to 0.1, thus making Praat more likely to find voiced segments and calculate F_0. The complete script is found in Appendix C.

F_0 was originally measured in Hz and semitones over the baseline (s/b), in a way similar to Pierrehumbert (1980) and Frazier (2009b). Each speaker's lowest pitch value was taken as that speaker's individual baseline, after which Hz values were converted to s/b using the formula presented in §2.1. As clearly illustrated by Figure 3.2 below, differences between Hz and s/b measurements were minimal in all conditions. This is not surprising, since all recorded speakers were males with quite similar vocal patterns. For this reason, it was decided to measure and present F_0 only in Hz.

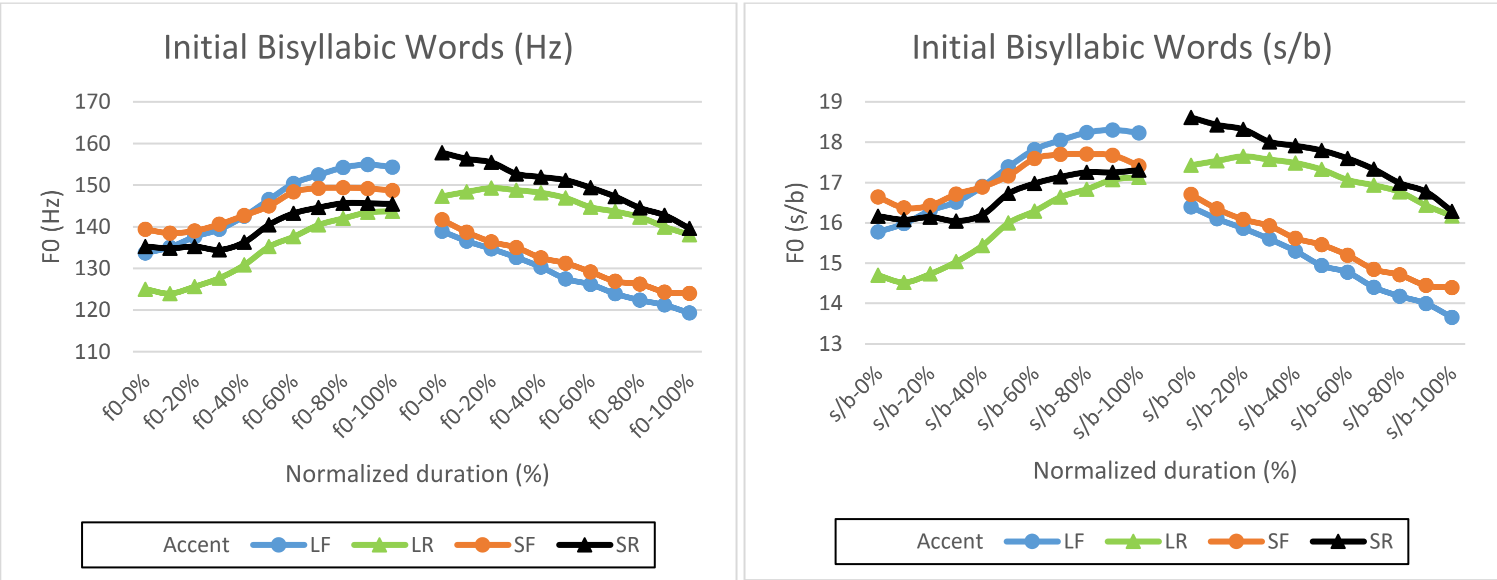


Figure 3.2. Mean F_0 tracks of initial bisyllabic words measured in Hz (left) and s/b (right)

For each nucleus included in the analysis, the following acoustic measurements were extracted:

a) Duration: the duration of the entire vowel, from its beginning to end, measured in ms.

b) f0-0% - f0-100%: F_0 was measured in Hz every 10% of a vowel's duration. Each measuring point is referred to by its percentage, for example f0-0% was measured at the beginning of the vowel and f0-100% at the end.
c) Overall F_0 Mean: the mean F_0 of each nucleus was measured across all ten measurement points in Hz in order to compare the overall pitch of various accent/syllable combinations. This measurement will be referred to throughout the rest of this dissertation as "OvMean".
d) Pitch Range: the pitch range of each vowel was calculated by subtracting the lowest Hz value from the highest. For the sake of brevity, this measurement will be referred to as "Range".
In addition to the above intra-syllabic measurements, one inter-syllabic was calculated:
e) Pitch Peak Alignment (PPA%): based on the methods used by Smiljanić and Hualde (2000) and Smiljanić (2003, 2006), as described in §2.4.2.3, PPA% was measured in each word with more than one syllable. Pitch peaks in the accented and the first posttonal syllable were compared to each other and their temporal relation to the end of the accented syllable was calculated. In keeping with the percental measurements of F_0 and other parameters, PPA% was also measured in percent. If the peak in the accented syllable was higher than the posttonal, the PPA% value of the word was that syllable's Max% (the pitch peak's location given in percent of the vowel duration) value minus 100, to show that it was produced *before* the end of the accented syllable. If the posttonal peak was higher, the posttonal syllable's positive Max% value was taken. For instance, a PPA% of -13.5% indicates that the pitch peak in that word was produced at the 86.5% point of the accented syllable's duration. In the measurement of PPA% in the above-mentioned investigations, the peaks in all syllables of the word were compared, but since only bisyllabic words were recorded, the method used in this dissertation is basically the same.

4

RESULTS OF PRODUCTION EXPERIMENT

This chapter presents and analyzes the results of the production experiment described in the previous chapter. The results will be presented according to the target words' number of syllables and their sentential position. Starting with monosyllabic words, the acoustic characteristics of tone in sentence-initial position will be viewed first, then the medial position and finishing with the final. An additional overview will be presented at the end of each subsection, in which differences and similarities between the various positions will be discussed. The analysis of bisyllabic words begins with the production of tone in words with an accented syllabic /r̥/ and will continue with accented vowels. Since tri- and quadrisyllabic words have two distinct tonal configurations, 3a (first syllable accented) or 3b (second syllable accented) and 4a (second syllable accented) or 4b (third syllable accented), they will be discussed separately from each other. Each subsection is divided into four subject areas: a) Contour shape and overall pitch (OvMean), b) Pitch range and PPA%, c) Duration and d) Summary.

Statistical analysis was conducted using the software JMP 14.1 (SAS Institute, 2018). Most graphs were drawn with Microsoft Excel (Microsoft Office 365 ProPlus, Version 16.0.8431.2110). Before performing any statistical tests, the distribution of data in each word category (e.g. initial 3b or medial 4a words) was thoroughly examined. In cases where the distribution of a certain dependent variable was skewed, its data set was normalized with a log-transformation (base 10), as seen in Figure 4.1. If the log-transformation was successful and the distribution became or already was unimodal, one-way ANOVAs for the dependent variables OvMean, Duration and Pitch range (see below for more information on Pitch range and PPA%) in a Standard Least Square design using the REML (Restricted Maximum Likelihood) estimation were performed throughout this chapter, with Tukey HSD (Tukey, 1949) post hoc tests. In the event of a multimodal distribution after the log-transformation, the nonparametric Mann-Whitney *U* test (1947) with Steel-Dwass (Crichtlow & Fligner, 1991) post hoc tests were applied to the transformed data set. Unless specifically mentioned, results presented in this chapter for OvMean and Duration are based on the untransformed sets. For all distribution histograms, refer to Appendix D.

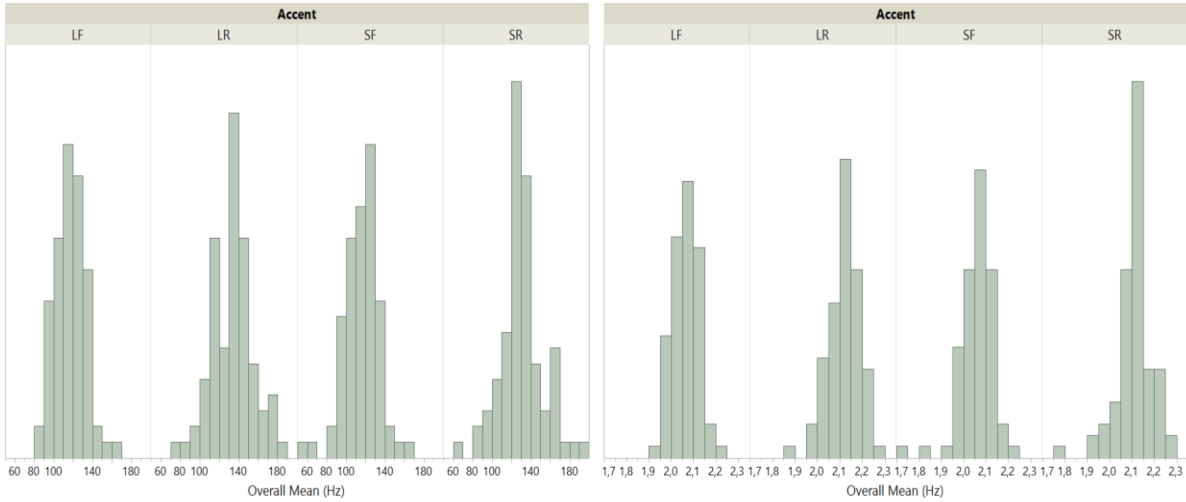


Figure 4.1. Distribution histograms of OvMean in posttonal syllables of medial bisyllabic words across the four accents. The untransformed data is on the left side and the log-transformed on the right

Additionally, the standard deviation (SD) of F_0 was inspected. Figure 4.2 below shows representative quantile boxplots of all F_0 measurement points in initial bisyllabic words across the four accents. In each boxplot, the topmost and lowest horizontal ticks represent the maximum and minimum values, respectively. The smaller ticks just below and above them show the 97.5th and 2.5th quantiles, which correspond to two SD's from the mean. Outliers outside of this range are represented by black circles.

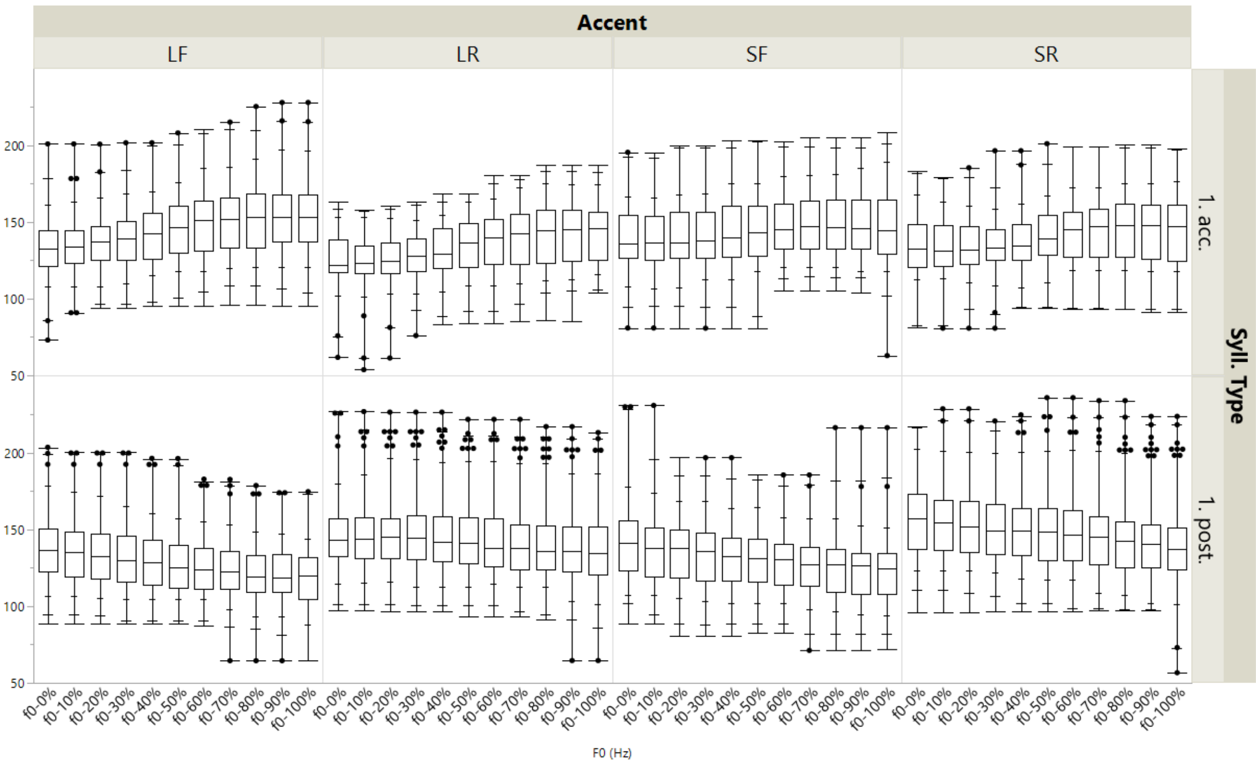


Figure 4.2. Boxplots showing means and quantiles of all F_0 measurement points in initial bisyllabic words across the four accents. Accented syllables are shown above and posttonals below

As can be seen in the above figure, SD is quite uniform throughout the individual accents and amounts to ca. 15-30 Hz in most cases. Differences between accent types are minimal, with rising accents occasionally being 2-3 Hz higher than falling ones. A slightly larger variation can be observed when comparing accented and posttonal syllables: posttonals of falling accents have at times mildly lower SD values (ca. 5 Hz) than their accented syllables, while the opposite can be said of rising accents. Additionally, measurement points with higher means, i.e. the end of an accented or the beginning of a posttonal syllable, tend to have higher SD (approximately 5 Hz at most), but such an occurrence is to be expected. For all quantile boxplots, refer to Appendix D.

For the dependent variables OvMean, Duration and Range, one-way ANOVAs performed throughout this chapter have the following possible independent variables: *accent* (SF, LF, SR, LR), *accent type* (rising, falling), *sentence* (initial, medial, final), *word type* (1, 2, 2R, 3a, 3b, 4a, 4b) and *speaker* (ZK, TR, MP, MI, IP, ŠM, MR, VB, BM, MT – random factor). Note that monosyllabic words only had SF and LF in *accent* (and falling in *accent type*), whereas 3b, 4a and 4b words only SR and LR (rising *accent type*). The full four *accents* and two *accent types* were found only in bisyllabic and 3a words. For all words with more than one syllable, the factor *pattern* was also examined. Bisyllabic words (without syllabic /r̩/) had two levels: 2s (phonologically short posttonal syllable) and 2l (phonologically long posttonal syllable). Converting patterns like V̌ V̀ V̌ (as seen in Table 3.3) into sequences which can be correctly shown by JMP resulted in the following levels for 3a words: ASS, ASL, ALS and ALL, where “A” stands for “accented”, “S” for “short” and “L” for “long”. 3b words contrasted between PAS and PAL, where “P” marks a pretonal syllable. Like 3a, 4a words had the patterns PASS, PASL, PALS and PALL. 4b words differentiated between PPAS and PPAL. In addition, *syllable type*, which shows the position and accentuation of a syllable, was inspected. Accented syllables were coded as either “1. acc.”, “2. acc.” or “3. acc.”, where the number gives the position of the syllable within the word and “acc.” means “accented”. Pretonal syllables could be either “1. pre.”, which is the first pretonal syllable *to the left* of the accented one (such as the first syllable in *Bosánci* or the second in *tjestenìna*), or “2. pre.”, which marked the second pretonal syllable, like the first one in *genijálnōst*. Likewise, posttonal syllables were defined as “1. post.” or “2. post.”, like in the third and fourth syllables in *kobàsica*, respectively. An overview of all independent variables can be seen in Table 4.1 below.

Table 4.1. Independent variables examined and their corresponding levels

	Variable	Levels
1	*Accent*	SF, LF, SR, LR
2	*Accent type*	rising, falling
3	*Sentence*	initial, medial, final
4	*Word type*	1, 2, 2R, 3a, 3b, 4a, 4b
5	*Pattern*	2s, 2l, ASS, ASL, ALS, ALL, PAS, PAL PASS, PASL, PALS, PALL, PPAS, PPAL
6	*Syllable type*	2. pre., 1. pre., 1. str., 2. str. 3. str., 1. post., 2. post.
7	*Speaker* (random factor)	ZK, TR, MP, MI, IP ŠM, MR, VB, BM, MT

Due to its nature, a different method of statistical analysis was required for the dependent variable PPA% in bisyllabic and 3a words. This variable has numerous positive and negative values (ranging from -100 to 100), which makes it very sensitive to values far from the mean. For this reason, it was decided to compare median values instead of means, since this method is much more stable and resistant to outliers. A simple comparison between the mean, its standard deviation and the median illustrates this vital difference, seen in Table 4.2.

Table 4.2. Mean, SD and median values of PPA% in initial syllabic /r̩/ words

Accent	Mean	SD	Median
LF	-25.25	30.88	-10
LR	-16.25	40.1	0
SF	-29.5	37.95	-25
SR	-9.75	40.6	0

Calculating the mean results in a rather ambiguous picture, since all accents have negative values. The extremely high SD further indicates that the mean is in fact skewed due to high negative and positive values. The median, on the other hand, shows much clearer and more realistic values, especially in conjunction with the distribution of PPA% across the four accents, as shown in Figure 4.3.

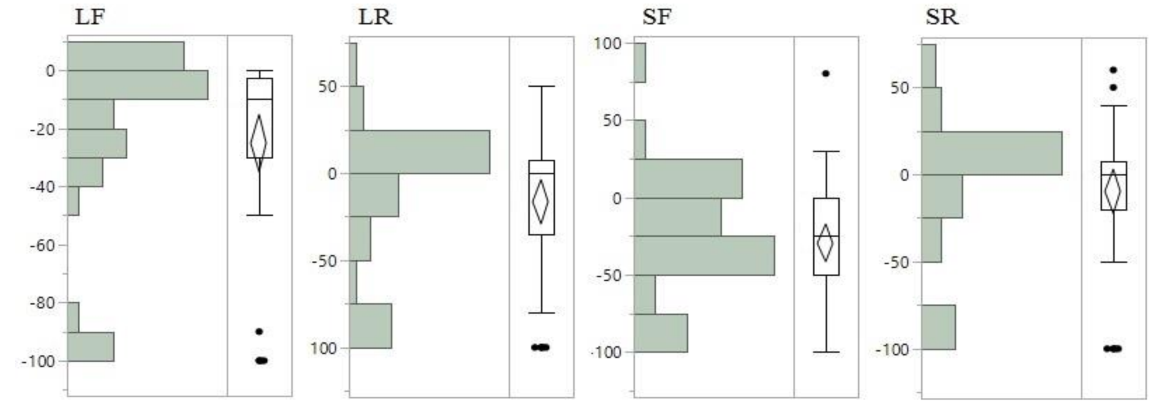


Figure 4.3. Distribution of PPA% values across the four accents in initial syllabic /r̥/ words

In the above boxplot, the horizontal bar inside the box represents the median, while the center of the diamond shows the mean. Most pitch peaks in rising accents, as seen from the distribution, were realized during the first 10% of the posttonal syllable, whereas falling accents had predominantly negative values, meaning their pitch peaks were realized in the accented syllable. Returning to Table 4.2, it can be clearly seen that the median values are more in line with this distribution. Accordingly, statistical analysis of PPA% in bisyllabic and 3a words was done using the non-parametric Van der Waerden test (1953) and Steel-Dwass post hoc tests (Chrichtlow & Fligner, 1991).

Measurements of Pitch range showed a distinct positively skewed distribution, with values falling predominantly in the 0-30 Hz range, as shown in Figure 4.4. Such a distribution is only natural, since pitch range tends to revolve around the standard deviation of a speaker's overall F_0 (Traunmüller & Eriksson, 1995), which was between 15 and 30 Hz in most cases. Additionally, it has been shown that male speakers have lower pitch range than females when measured in Hz (Andreeva et al., 2014), which would also explain the relatively low values found in this investigation. For these reasons, all Range data sets were log-transformed (base 10) to normalize their distribution.

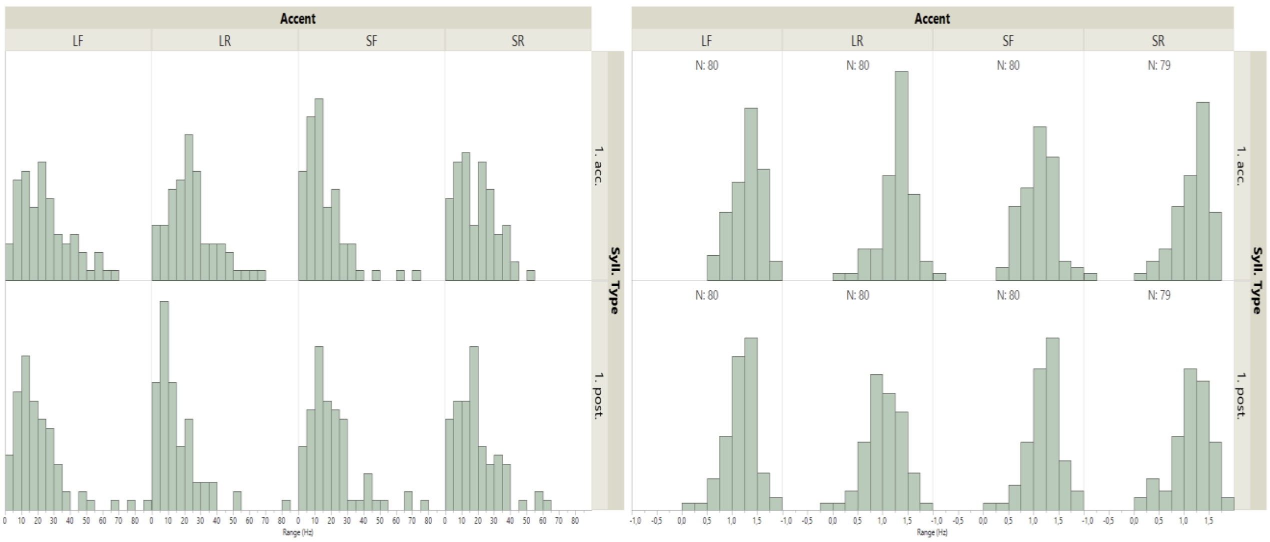


Figure 4.4. Distribution histograms of Range in initial bisyllabic words across the four accents. Accented syllables are above and posttonals below. The untransformed data is on the left and the transformed on the right

4.1 Monosyllabic Words

4.1.1 Initial Monosyllabic Words

a) Contour shape and overall pitch

Mean F_0 tracks extracted from all measurement points are shown in Figure 4.5[11]. All measurement points in both accents had a sample size of 40, except for LF's f0-0% and f0-100% with 39. It can be clearly seen that both SF and LF basically have the same pitch contour, which can be described as rising-falling or mostly rising. Both accents' contours gradually rise and reach their pitch peak at about the third quarter of the vowel, after which a slight downward movement towards the end of the syllable can be observed. The most striking difference between the two accents is in the consistently higher F_0 values of LF throughout the vowel. A one-way ANOVA with *OvMean* as a dependent variable showed a significant main effect for *accent*, $F(1, 69) = 5.66$, $p = .0201$, confirming the above observation: LF's 149 Hz were significantly higher than SF's 142.24.

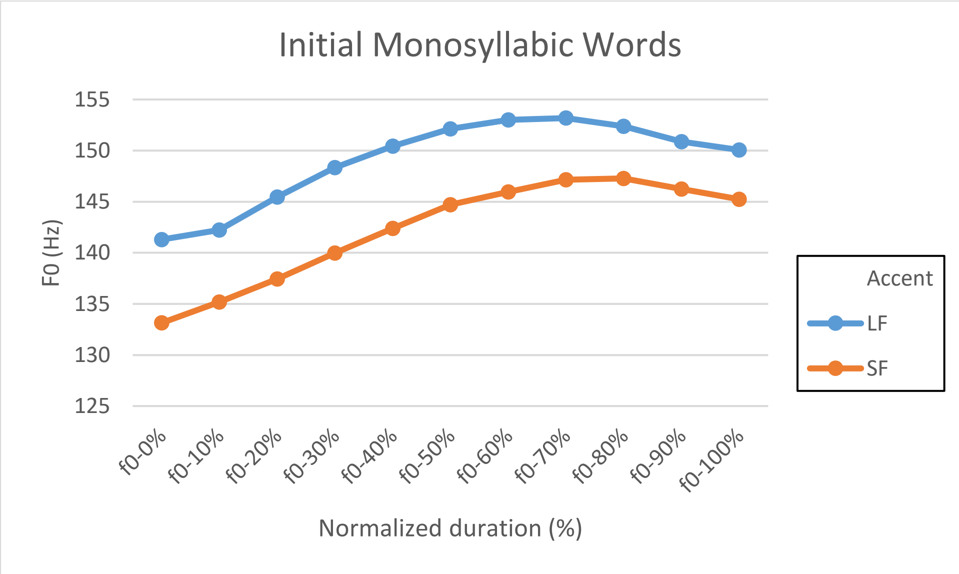


Figure 4.5. Mean F_0 tracks of initial monosyllabic words

b) Pitch range

LF had an average pitch range of 17.59 Hz, which was only slightly greater than SF's 16.1. A one-way ANOVA was conducted with *accent* as an independent variable, but no significant differences were found. This, together with the contours in Figure 4.2, indicates that both accents' rising movement was equally steep.

[11] The mean values of all measurement points for all subsections in Hz are found in Appendix D.

c) Duration

Durational measurements present a rather unexpected situation: LF had a mean duration of 102.44 ms (SD 23.88), which was almost the same as SF with 98.97 ms (SD 23.56). A one-way ANOVA confirmed the lack of significance between the two accents' average duration: $F(1, 69) = 0.48$, $p = .49$. This suggests that the difference between SF and LF in initial condition is purely tonal.

d) Summary

Both SF and LF have the same duration (100.71 ms on average) and a mostly rising contour, which is slightly higher (6.75 Hz) for LF. The pitch range is almost identical in both accents and has an average value of 16.85 Hz.

4.1.2 Medial Monosyllabic Words

a) Contour shape and overall pitch

Mean F_0 tracks extracted from all measurement points are shown in Figure 4.6 and the measurement points' sample size in Table 4.3. Both accents' contours are relatively level, even though a slight rising at the beginning and a somewhat larger falling movement at the end of the vowel can be detected. As in initial words, LF also has higher overall Hz values than SF throughout the syllable, with 135.84 Hz and 130.76 Hz, respectively. However, a Mann-Whitney *U* test with OvMean as a dependent variable showed no significant main effect for *accent*, SF vs. LF Z = -1.17 $p = .238$.

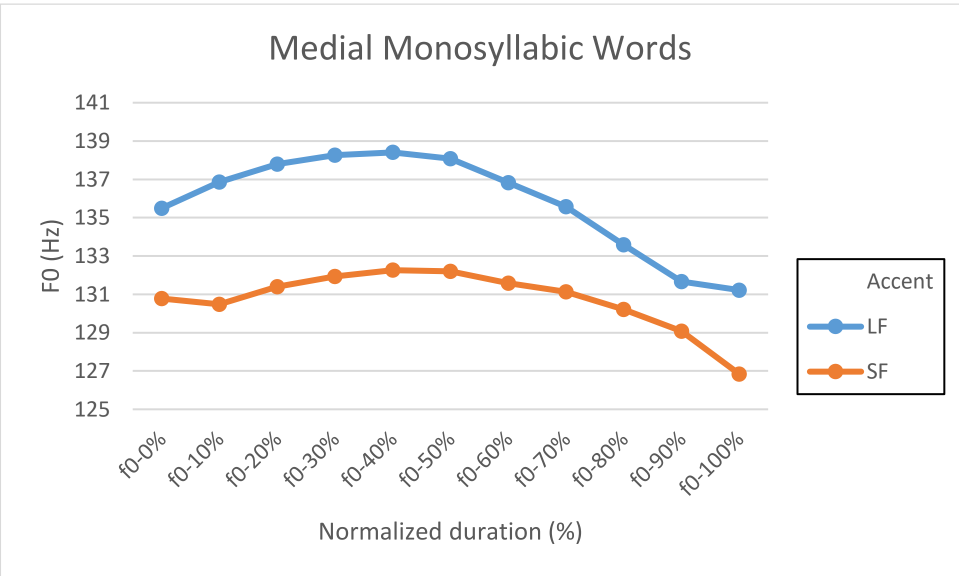


Figure 4.6. Mean F_0 tracks of medial monosyllabic words

Table 4.3. Number of samples in measurement points in medial monosyllabic words

Accent	f0-0%	f0-10%	f0-20%	f0-30%	f0-40%	f0-50%	f0-60%	f0-70%	f0-80%	f0-90%	f0-100%
LF	38	40	40	40	40	40	40	39	39	39	38
SF	40	40	40	40	40	40	40	40	40	40	39

b) Pitch range

Range was practically identical in both accents: 10.93 Hz in LF and 10.72 Hz in SF. A one-way ANOVA showed no statistical main effect for *accent*, $F(1, 69) = 0.315$, $p = .576$.

c) Duration

Much like in initial words, duration varied very little between the accents and did not significantly differentiate between them. A Mann-Whitney *U* test with Duration as a dependent variable showed no main effect for *accent*, SF vs. LF Z = -1.01 $p = .31$. With a mean duration of 98.77 ms (SD 24.76), LF was only slightly longer than SF's 92.85 ms (SD 21.24).

d) Summary

Medial monosyllabic words exhibit a flat contour with a minor fall at the end for both accents. The contour produced in LF is slightly steeper and higher (5.08 Hz). Pitch range is identical for both accents (mean 10.82 Hz), while LF has a slightly higher duration, which averages at 95.81 ms for SF and LF together. The results suggest that there are no acoustic differences between the accents in medial position.

4.1.3 Final Monosyllabic Words

a) Contour shape and overall pitch

Mean F_0 tracks extracted from all measurement points are shown in Figure 4.7, with sample size in Table 4.4. Both contours have almost the exact same values in the first third of the vowel, after which a distinct separation can be observed. While both falling, SF's contour levels out in the last third, whereas LF has a noticeable dip with a minor rise towards the end of the syllable. As opposed to the two previous positions, it is SF that has higher overall Hz (92.9 Hz vs. 90.07 Hz, respectively) values. Being almost non-existent up until the 30%-point, the differences between the two accents gradually grow towards the end. The biggest contrast is observed in the 70%-point, which has a mean value of 7.86 Hz. However, differences between the accents with respect to OvMean were not statistically significant.

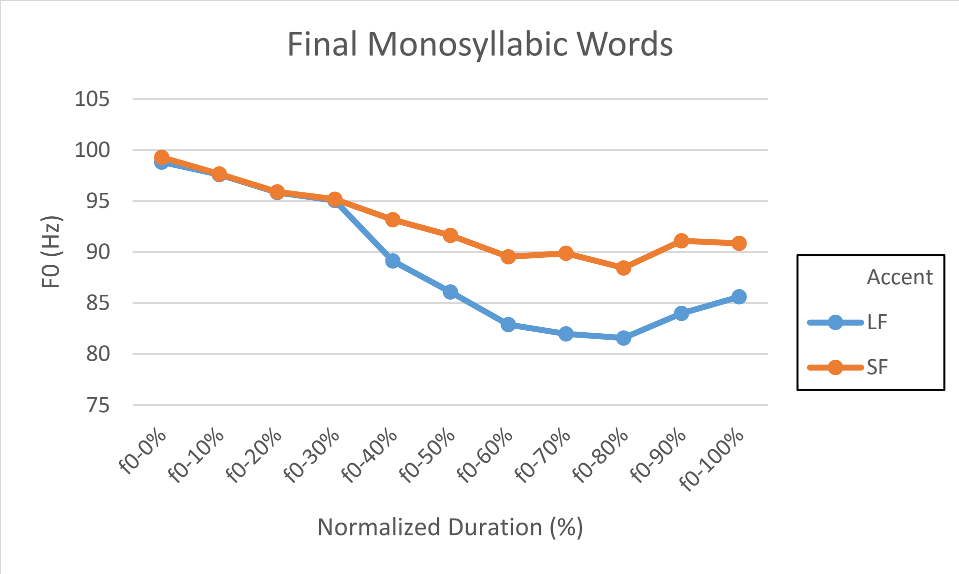


Figure 4.7. Mean F_0 tracks of final monosyllabic words

Table 4.4. Number of samples in measurement points in final monosyllabic words

Accent	f0-0%	f0-10%	f0-20%	f0-30%	f0-40%	f0-50%	f0-60%	f0-70%	f0-80%	f0-90%	f0-100%
LF	33	38	38	38	38	36	35	30	27	21	14
SF	37	40	40	39	39	39	38	34	34	28	25

b) Pitch range

Pitch range in LF was 25.48 Hz on average, which was only 2.65 Hz greater than SF. There was no main effect found for *accent* in a one-way ANOVA, $F(1, 68) = 0.29$, $p = .588$.

c) Duration

Unlike the tonal variables, duration in the final condition clearly contrasts between the accents. LF's mean duration of 139.57 ms (SD 32.72) was 26.29 ms longer than SF's 113.27 ms (SD 33.41). A one-way ANOVA showed that the difference between SF and LF was statistically significant, $F(1, 69) = 14.34$, $p = .0003$. This suggests that the tonal contrast seen in the initial position is neutralized at the end of a sentence in favor of a durational one.

d) Summary

Both accents' contours are falling and identical in the first third of the vowel, with SF flattening out shortly thereafter, while LF exhibits a falling-rising movement. The mean pitch range for both accents was 23.83 Hz. LF was significantly longer than SF, with a mean duration of 126.42 ms for both accents.

4.1.4 Overview and Comparison of Monosyllabic Words

a) Contour shape and overall pitch

Comparing the contours of long and short falling accents across the three sentential positions shows a distinct pattern for each condition. Throughout most of the vowel's duration, accents are clearly rising when realized in a sentence-initial condition, level in medial and falling in final. Mean F_0 tracks of SF and LF pooled together across positions are displayed in Figure 4.8. Note that even though there are several acoustic differences between the accents within the sentential positions, this Figure's purpose is to show patterns *between* them, which will facilitate a more meaningful comparison. Upon closer inspection, it becomes evident that the initial and medial conditions share more characteristics with each other than they do with the final condition. Starting with roughly the same pitch, initials and medials are quite close to each other with respect to their overall F_0 values (145.62 Hz and 133.3 Hz, respectively), whereas finals are much lower than that, having a mean value of 91.51 Hz. Additionally, in both initials and medials, LF has higher overall pitch, which is reversed in the final position. Conducting a one-way ANOVA with OvMean and *accent*, *sentence* and their interaction *accent* x *sentence* showed a significant effect for *sentence*, $F(2, 224) = 420.13$, $p < .0001$ and *accent* x *sentence*, $F(2, 224) = 3.74$, $p = .025$. A Tukey's HSD post hoc test showed that the differences in OvMean between sentence positions were highly significant ($p < .0001$). Furthermore, the interaction between *accent* and *sentence* could not distinguish between SF and LF when they were in the same position or between initial SF and medial LF, but all other comparisons were statistically significant, with a *p*-value of $< .0001$, except for initial SF vs. medial SF ($p = .0007$).

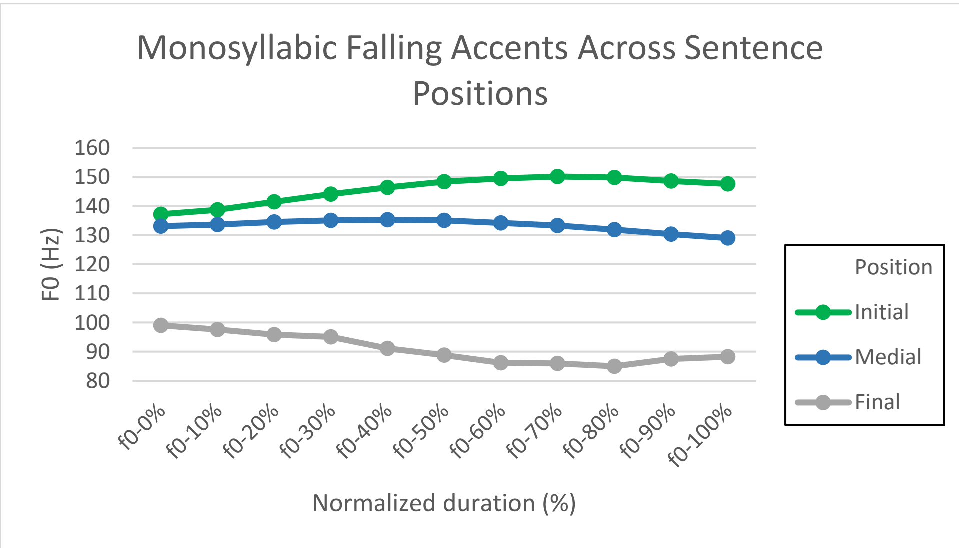


Figure 4.8. Mean F_0 tracks of monosyllabic falling accents pooled together across three sentence positions

b) Pitch range

Mean values of combined and accent-specific pitch range are shown in Table 4.5. To further investigate the relation between sentence conditions and accents, a one-way ANOVA was conducted with the following independent variables: *accent*, *sentence* and their interaction *accent* x *sentence*. There was a significant effect on Range only for *sentence*, $F(2, 224) = 21.74$, $p < .0001$. A post hoc test revealed that pitch range significantly contrasted between all sentence positions: final vs. medial $p < .0001$, final vs. initial $p = .0013$ and initial vs. medial $p = .0073$. Together with this significane, the Range column in Table 4.5 shows a definite pattern: in monosyllabic words, pitch range is largest in the final condition, followed by the initial and smallest in the medial.

Table 4.5. Mean pitch range values of monosyllabic words across sentence positions and accents

Sentence	Accent	Range
Initial	Combined	16.84
	LF	17.59
	SF	16.1
Medial	Combined	10.82
	LF	10.93
	SF	10.72
Final	Combined	23.83
	LF	25.48
	SF	22.83

c) Duration

To analyze the effects on Duration, a one-way ANOVA was conducted with the same three independent variables as above. There was a significant main effect for *accent*, $F(1, 225) = 12.9$, $p = .0004$, *sentence*, $F(2, 225) = 32.9$, $p < .0001$ and *accent* x *sentence*, $F(2, 225) = 4.77$, $p = .0093$. The mean duration of all segments is shown below in Table 4.6. Post hoc tests show that across all sentence positions, LF was significantly longer than SF by 11.8 ms. Confirming the findings of the previous subsections, duration could significantly differentiate between the longer final condition on the one hand, and the medial and initial on the other. Furthermore, in the context of the *accent* x *sentence* interaction, only the comparisons between final LF and all the other segments ($p < .0001$) and between final SF and medial SF ($p = .0059$) were significant.

Table 4.6. Mean duration values in ms of monosyllabic words across sentence positions and accents (standard deviation shown in parentheses)

Sentence	Accent	Duration (ms)
Initial	Combined	100.71 (23.64)
	LF	102.44 (23.89)
	SF	98.97 (23.57)
Medial	Combined	95.81 (23.11)
	LF	98.77 (24.76)
	SF	92.85 (21.24)
Final	Combined	126.42 (35.43)
	LF	139.57 (32.73)
	SF	113.27 (33.42)

d) Summary

To conclude this entire section, Table 4.7 was drawn, illustrating the similarities and differences between and within the parameters of accent and sentence position. The column Contour describes the general shape of the pitch movements within the accented vowel. OvMean refers to the accent which had generally higher pitch throughout most of the vowel. The rest of the columns describe the values of the acoustic measurement made, where “inter.” stands for “intermediate”. Entries are marked with an asterisk if the corresponding measurement had significantly distinguished between the short falling and long falling accents.

Table 4.7. Summary of the acoustic characteristics of falling accents in monosyllabic words

	Contour	OvMean	Range	Duration
Initial	rising	LF*	inter.	inter.
Medial	level	LF	small	inter.
Final	falling	SF	large	long*

4.2 Bisyllabic Words

4.2.1 Syllabic /r̩/ Words

The purpose of this section is to analyze the production of tone in words with an accented syllabic /r̩/, a subject which has so far been neglected in previous investigations. The analysis will be performed according to the usual format: production in the initial sentence position will be discussed first, followed by the medial and then the final position. An overview and comparison between the various conditions will be made at the end of this section. Afterwards, as will be shown by the results, all bisyllabic words will be analyzed together.

Before starting with the initial condition, several non-tonal acoustic characteristics of syllabic /r̩/ should be inspected, as illustrated by the initial word *cȓkva* ‘church’ in Figure 4.9, which was deemed representative.

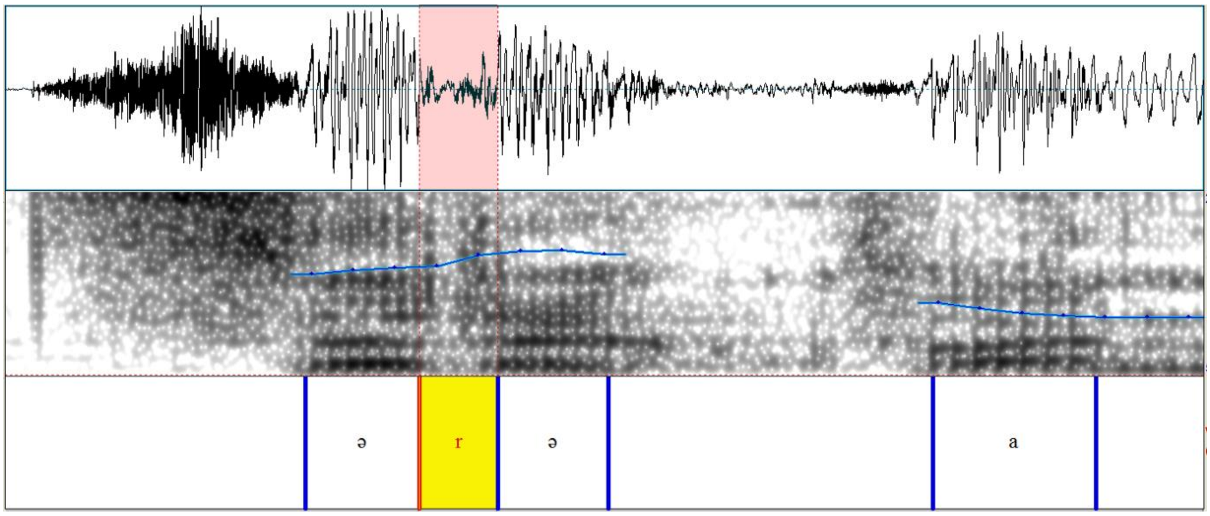


Figure 4.9. Representative demarcation of *cȓkva* ‘church’, produced sentence-initially by speaker ZK (pitch is shown as a blue line)

As shown above and described in §2.4.3.5, /r̩/ is made up of three distinct parts. Two equally long (40 ms each) vocoids surround a shorter period (28 ms in this case) of the /r/ sound itself. In most cases, /r/ was produced with one or two taps, and was characterized by a low intensity and lack of a clear formant structure. Both vocoids have the same vowel quality, with F1 and F2 values of ca. 500 Hz and 1500 Hz, respectively, which is highly characteristic of [ə] (Reetz & Jongman, 2009). The vocoids’ intensity varied somewhat between speakers and sentence conditions, but for the most part, it was very similar in both segments. In the illustration above, the first vocoid has an intensity peak of 62 dB, which is only three dB higher than the peak in the second vocoid. The vocoids’ duration was also usually sufficiently long for pitch to be successfully measured. However, some nuclei (especially SR) exhibit a slight dip in pitch between the first vocoid and the /r/, which produces a distinct falling-rising contour. This can be explained by the fact that approximants generally have a more irregular articulation and spectral characteristics (Reetz & Jongman, 2009). Such a case is illustrated below in Figure 4.10.

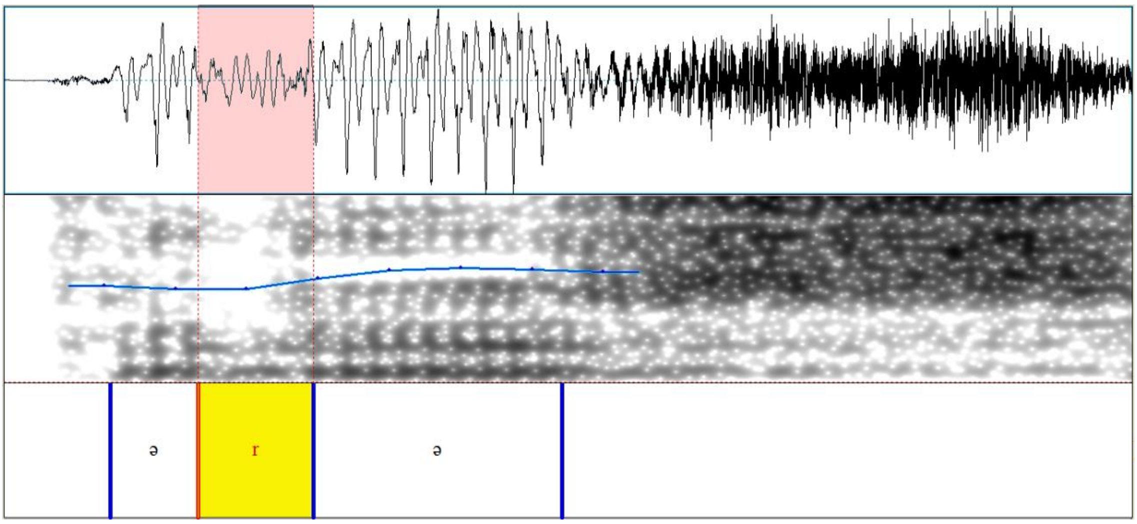


Figure 4.10. Pitch dip in the center of a syllabic /ṛ/ in *pr̀sa* ‘breast, chest’ as produced by speaker MT

4.2.1.1 Initial Syllabic /ṛ/ Words

a) Contour shape and overall pitch

Mean F_0 tracks are displayed in Figure 4.11 and their sample size in Table 4.8 („Acc.“ stands for „accented syllable“ and „Post.“ for „posttonal syllable“). In the accented syllable, falling accents have a very similar rising contour and global F_0 values, except for the last 40% of SF, which are quite level in comparison with LF. LR has noticeably lower pitch throughout the syllable and a slightly more pronounced fall at the beginning, but otherwise the contour is almost the same as SF and LF. SR has the most unusual characteristics in this position, starting with higher pitch than all other accents and a recognizable pitch dip after the first 20%, the contour then rises, while having very similar values to SF. Explained by the irregular articulation and weaker spectral structure in the previous subsection, this dip will be disregarded for purposes of describing the contour shape. A one-way ANOVA showed a significant main effect of OvMean (log-transformed) for *accent*, $F(3, 147) = 8.6$, $p < .0001$. A post hoc test revealed that LR’s overall mean of 133 Hz was significantly lower than all other accents’ (LF vs. LR $p < .0001$, SR vs. LR $p = .0007$, SF vs. LR $p = .026$), which ranged from 141 Hz to 145 Hz. All other comparisons were not significant.

All vowels in the posttonal syllable are clearly falling. LR, however, continues rising from the accented syllable, which is why the fall begins slightly later. Otherwise, it can be seen that posttonals tend to group according to their accent type and length, with rising accents having noticeably higher overall pitch values and long accents being lower within each type (SR > LR > SF > LF). This hierarchy was partially confirmed in a one-way ANOVA, which had a significant effect of OvMean (log-transformed) for *accent*, $F(3, 147) = 31.35$, $p < .0001$. A post hoc test differentiated between all accents (SR vs. LF, SR vs. SF and LR vs. LF *p*

<.0001, LR vs. SF *p* =.0056, SR vs. LR *p* =.0093), except for SF and LF, whose overall means were not significantly different.

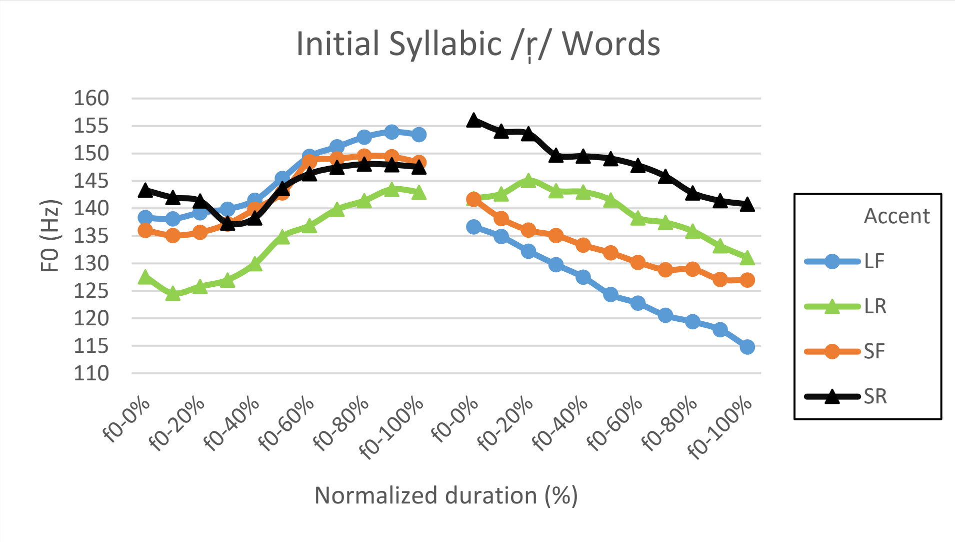


Figure 4.11. Mean F_0 tracks of initial syllabic /ɽ̩/ words

Table 4.8. Number of samples in measurement points in initial syllabic /ɽ̩/ words across the four accents

Accent	Syllable	f0-0%	f0-10%	f0-20%	f0-30%	f0-40%	f0-50%	f0-60%	f0-70%	f0-80%	f0-90%	f0-100%
LF	Acc.	40	40	40	40	40	40	40	40	40	40	40
	Post.	40	40	40	40	40	40	40	40	40	40	40
LR	Acc.	37	39	40	40	40	40	40	40	40	38	38
	Post.	34	37	39	39	40	40	39	39	39	39	39
SF	Acc.	38	40	40	39	40	40	38	38	38	38	38
	Post.	40	40	40	40	40	39	39	38	37	37	36
SR	Acc.	36	37	37	37	38	39	40	40	40	40	40
	Post.	40	39	39	38	39	40	40	40	38	38	37

b) Pitch range and PPA%

Mean values of pitch range and PPA% are shown in Table 4.9 (note that values under PPA% are the median). In the accented syllable, a one-way ANOVA revealed a main effect for *accent* on *Range*, $F(3, 147) = 2.89$, *p* =.0374, but was significantly different only between LR and SF (*p* =.0285). In the posttonal syllable, pitch range values of falling accents were higher than the ones in the accented syllable. LF had slightly greater pitch range than the rest, but the differences were not statistically significant.

The most striking difference between falling and rising accents can be seen in their pitch peak alignment. As shown in Figure 4.11 and Table 4.9, peaks in falling accents are realized in the accented syllable, whereas rising accents peak at the beginning of the posttonal. In other words, both accent types have a rising contour in the accented syllable, but the falling accents reach their peak earlier and start falling rapidly, which is seen by the considerably lower values at the beginning and throughout the posttonal syllable. Rising accents usually have a rising contour all through the accented syllable and the peak is reached relatively early in the posttonal, after which there is a steep fall quite like in the falling accents. PPA% is much better at differentiating between accent types (rising vs. falling) than between two accents of the same type (short vs. long). This is confirmed by a Van der Warden test (*p* =.0022), which significantly differentiated between all accents of a different type, but not between short or long: SR vs. LF Z = 3.12 *p* =.0095, SR vs. SF Z = 3.09 *p* =.0106, LR vs. LF Z = 2.6 *p* =.0451 and LR vs. SF Z = -2.68 *p* =.0361.

Table 4.9. Mean pitch range and PPA% values in initial syllabic /r̩/ words

Accent	Syllable	Range	PPA%
LF	Acc.	20.47	-10
	Post.	22.6	
LR	Acc.	24.47	0
	Post.	17.65	
SF	Acc.	15.35	-25
	Post.	19.29	
SR	Acc.	19.59	0
	Post.	18.93	

c) Duration

Mean and SD values of every accent and syllable are shown in Table 4.10. In the accented syllable there was a significant main effect on Duration for *accent*, $F(3, 147) = 10.41$, $p < .0001$. A post hoc test revealed that duration was significantly longer only between short and long accents, with no significant differences in the same durational category (LF vs. SR $p < .0001$, LR vs. SR *p* =.0003, LF vs. SF *p* =.0024, LR vs. SF *p* =.0067). The ratio between long and short accented syllables was 1.18. There was also a main effect for *accent* in the posttonal syllable, $F(3, 147) = 3.49$, *p* =.0173. However, only the difference between LF and SF was significant (*p* =.0113).

Table 4.10. Mean and SD values of duration in initial syllabic /r̩/ words

Accent	Acc.	Post.
LF	92.71 (19.35)	62.5 (11.83)
LR	91.55 (18.78)	55.11 (13.58)
SF	79.12 (19.44)	52.3 (20.81)
SR	75.76 (14.74)	57.11 (13.53)

d) Summary

In conclusion, all accents in the accented syllable have a rising contour, with LR having distinctly lower overall pitch. Long accents have a longer duration than short accents. All the posttonal syllables have a falling contour, which is slightly delayed for LR. Overall mean pitch values are highest for SR, followed by LR and lowest for both falling accents. No major durational differences were observed in the posttonal. Rising accents begin with a higher pitch in the posttonal than the end of the accented syllable, and falling accents show a reversed pattern. Pitch peaks were consistently produced in the last quarter of the accented syllable for falling accents and at the beginning of the posttonal for the rising accents, with little or no difference within each accent type.

4.2.1.2 Medial Syllabic /r̩/ Words

a) Contour shape and overall pitch

Mean F_0 tracks are displayed in Figure 4.12, with the sample size in Table 4.11. In the accented syllable, all four accents have roughly the same contour, which can be described as rising. Compared with the initial condition, the rise in the medial position is much milder. While SR has a slight fall at the beginning, the rising movement in other accents is quite straightforward. SR and LF have practically the same overall pitch, whereas LR is noticeably lower and SF higher. A one-way ANOVA showed a significant main effect on OvMean (log-transformed) for *accent*, $F(3, 144) = 9.28$, $p < .0001$. Post hoc tests differentiated only between SF and LR ($p < .0001$), LF and LR ($p = .0148$) and SF and SR ($p = .0270$).

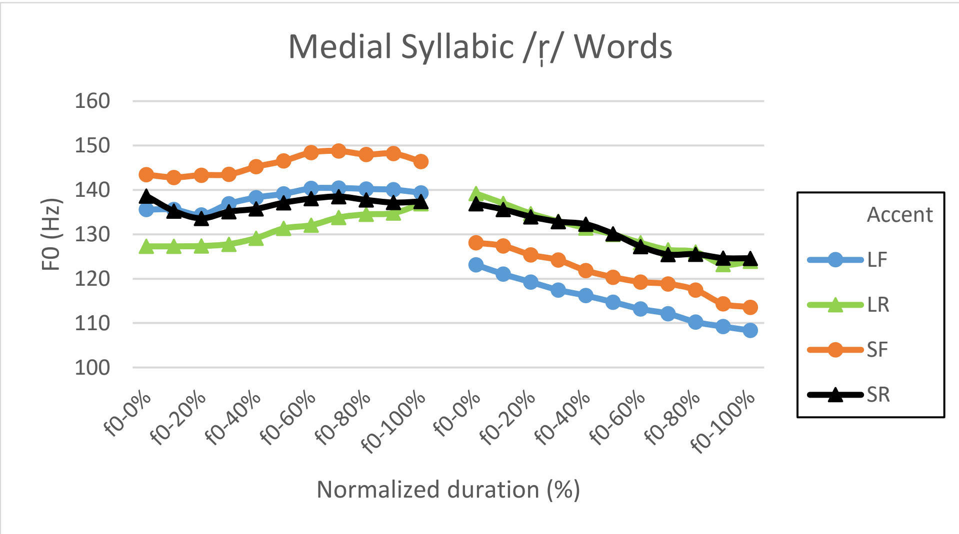


Figure 4.12. Mean F_0 tracks of medial syllabic /r̩/ words

Posttonal syllables exhibit the same falling contour shape as the previous condition, mainly grouped according to accent type, with rising accents being higher than falling ones. It can be seen that SR and LR have almost identical pitch values, while SF's are slightly higher than LF's. An ANOVA showed a main significant effect for *accent*, $F(3, 144) = 22.12$, $p < .0001$. A post hoc test revealed that OvMean (log-transformed) differentiated only between accents of a different type: SR vs. LF, LR vs. LF, SR vs. SF and LR vs. SF ($p < .0001$).

Table 4.11. Number of samples in measurement points in medial syllabic /ɽ̩/ words across the four accents

Accent	Syllable	f0-0%	f0-10%	f0-20%	f0-30%	f0-40%	f0-50%	f0-60%	f0-70%	f0-80%	f0-90%	f0-100%
LF	Acc.	40	40	40	39	39	39	39	40	40	37	37
	Post.	39	40	40	40	40	40	40	40	40	40	39
LR	Acc.	38	38	38	38	38	38	40	40	39	38	36
	Post.	39	40	40	40	40	40	40	40	40	39	39
SF	Acc.	35	37	37	37	37	36	36	36	36	35	35
	Post.	35	35	35	35	36	35	35	34	33	33	33
SR	Acc.	37	38	39	39	39	39	39	39	40	40	38
	Post.	40	40	40	40	40	40	39	39	40	39	37

b) Pitch range and PPA%

Mean values of pitch range and PPA% are shown in Table 4.12. In the accented syllable, pitch range values were very much alike, with only SF being slightly lower. However, there was no main effect for *accent*.

Table 4.12. Mean pitch range and PPA% values in medial syllabic /ɽ̩/ words

Accent	Syllable	Range	PPA%
LF	Acc.	14.38	-35
	Post.	15.5	
LR	Acc.	13.58	0
	Post.	16.87	
SF	Acc.	11.02	-40
	Post.	12.42	
SR	Acc.	14.43	-40
	Post.	15.09	

Pitch range in the posttonal syllable varied slightly between accents, being greatest for LR and smallest for SF. Additionally, range was greater than in the accented syllable for all accents. However, no main effect for *accent* was found.

Comparing both syllables of the medial condition shows a slightly different picture than in the previous subsection. The difference between the syllables in the falling accents is quite the same, with posttonals starting distinctively lower than the end of the accented syllables.

However, rising accents show no such difference. Moreover, the slight fall at the beginning of the accented syllable of SR, which in many cases had the highest pitch values in the word, shifted the median values of PPA% to -40%. A Van der Waerden test (*p* <.0001) showed very similar results to the one conducted in the previous subsection, except that the difference between SR and SF was not significant: LR vs. LF Z = 5.13 *p* <.0001, SR vs. LR Z = -3.1 *p* =.0104, SF vs. LR Z = -5.57 *p* <.0001. It is quite safe to assume that were it not for the fall at the beginning of SR, its PPA% values would have been significantly different than SF's.

c) Duration

Mean and SD values of every accent and syllable are shown in Table 4.13. There was a statistical main effect for *accent* on Duration in the accented syllable, *F*(3, 144) = 14.39, *p* <.0001. A post hoc test showed that durational differences were only significant between long and short accents, with LF being slightly longer than LR, but not significantly so: LF vs. SR, LF vs. SF (*p* <.0001), LR vs. SR (*p* =.0031) and LR vs. SF (*p* =.0298). The ratio between long and short accented syllables was 1.18. The posttonal syllable exhibited a larger variation with the following hierarchy: LF > SR > LR > SF. As could be expected, there was a significant main effect for *accent*, *F*(3, 144) = 16.01, *p* <.0001. The significance of this hierarchy was partially confirmed by post hoc tests, which showed that only the difference between SR and LR was not significant: LF vs. SF (*p* <.0001), SR vs. SF (*p* =.0002), LF vs. LR (*p* =.0027), LR vs. SF (*p* =.0053) and LF vs. SR (*p* =.0423). Since the duration of the posttonal syllable varied so much between accents, it was decided to conduct a one-way ANOVA with the interaction *accent* x *syllable type* to investigate the relationship between both parameters, which had a statistical main effect, *F*(3, 297) = 4.4, *p* =.0047. Besides showing that each accent's accented syllable was significantly longer than its posttonal (all four comparisons had a *p*-value of <.0001), a post hoc test also revealed that in general, there were no significant differences between each pair with adjacent values (i.e. LF acc. with 101.68 ms and LR acc. with 93.49 ms or SR acc. with 81.01 ms and LF post. with 70.01 ms). Out of 28 possible comparisons, 16 were statistically significant, with *p*-values being <.0001 for most of them.

Table 4.13. Mean and SD values of duration in medial syllabic /r̩/ words

Accent	Acc.	Post.
LF	101.68 (18.7)	70.01 (15.35)
LR	93.49 (22.44)	56.96 (16.42)
SF	83.09 (13.35)	44.45 (15.51)
SR	81.01 (15)	60.26 (19.06)

d) Summary

All accents in the accented syllable have a moderately rising contour, except for SR, which also has a fall at the beginning. SF had the highest overall pitch values, LR the lowest, and LF and SR were in between. LR's peaks were realized consistently later than all other accents'. All posttonal syllables have a falling contour, and rising accents had higher overall pitch. Rising accents' posttonals start at around the same pitch as the end of their accented syllable, and falling posttonals start considerably lower. Throughout both syllables, pitch peaks were realized around the 60%-point of the accented syllable for falling accents and SR, whereas LR mostly had peaks located at the beginning of the posttonal. Duration in the accented syllable was consistently longer for long accents, while the posttonal exhibited greater variation.

4.2.1.3 Final Syllabic /r̥/ Words

a) Contour shape and overall pitch

Mean F_0 tracks are displayed in Figure 4.13. Note that in some cases, as seen in Table 4.14, certain measurement points are not shown (marked bold in the Table), since less than four values could be extracted due to laryngealization or voicelessness. However, this problem only occurs in the final condition. All accents in the accented syllable are distinctly falling. The steepest falls can be observed in LF and LR, whereas SF and SR have a more level contour. Due to the very similar pitch values, contrasting between the accents visually is not so simple, which was also confirmed statistically by the lack of a main effect for *accent* on OvMean (log-transformed).

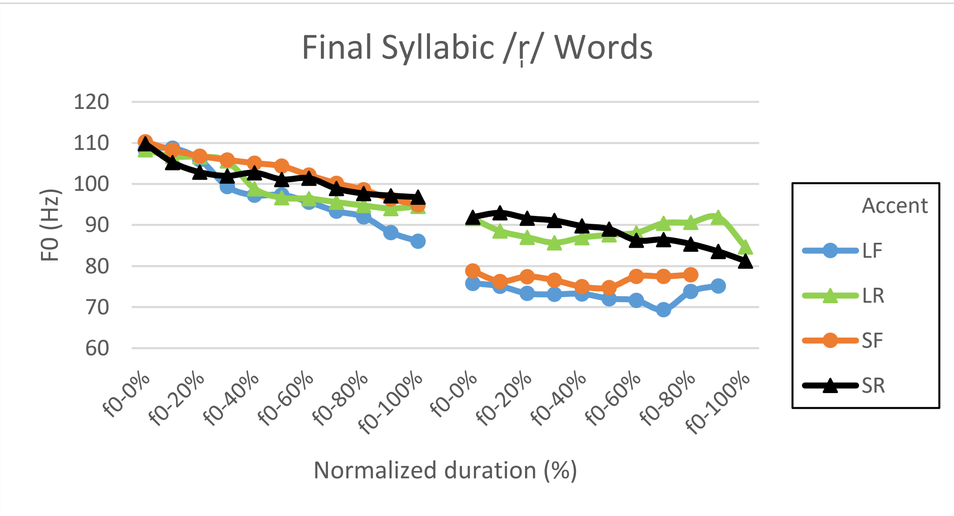


Figure 4.13. Mean F_0 tracks of final syllabic /r̥/ words

Posttonals are either level (SF and LF), falling (SR) or falling-rising-falling (LR). Like in other conditions, the distinction between falling and rising accents can be clearly seen by comparing their overall pitch values. An ANOVA showed a statistical main effect on OvMean (log-transformed) for *accent*, $F(3, 89) = 5.82$, p =.0011. However, a post hoc test only distinguished SR from LF (p =.0038) and from SF (p =.0106).

Table 4.14. Number of samples in measurement points in final syllabic /r̩/ words across the four accents

Accent	Syllable	f0-0%	f0-10%	f0-20%	f0-30%	f0-40%	f0-50%	f0-60%	f0-70%	f0-80%	f0-90%	f0-100%
LF	Acc.	37	39	39	36	36	36	38	38	37	36	26
	Post.	19	20	19	17	15	13	12	11	8	6	**3**
LR	Acc.	33	35	32	31	31	36	35	35	35	32	22
	Post.	26	28	28	28	25	22	19	15	11	9	5
SF	Acc.	34	34	34	31	30	30	30	31	30	28	26
	Post.	15	17	15	14	14	14	10	8	5	**3**	**1**
SR	Acc.	34	36	36	36	37	38	38	38	38	38	31
	Post.	25	30	33	32	32	30	19	15	13	9	6

b) Pitch range and PPA%

Mean values of pitch range and PPA% are shown in Table 4.15. In the accented syllable, there was no statistical main effect on Range, which suggests that tonal contrasts are neutralized in the accented syllable. In the posttonal syllable, pitch range values were almost identical, except for LF, which was noticeably smaller. A one-way ANOVA showed no main effect for *accent*.

Since the contour in the final condition is universally falling, pitch peaks were realized very early at the beginning of the accented syllable. The only exception here is LR, with peaks produced at the 20%-point. A Van der Waerden test distinguished between LR and both falling accents (p =.0165): LR vs. LF Z = 2.65 p =.0395 and LR vs. SF Z = -2.58 p =.0481.

Table 4.15. Mean pitch range and PPA% values in final syllabic /r̩/ words

Accent	Syllable	Range	PPA%
LF	Acc.	25.11	-100
	Post.	4.87	
LR	Acc.	15.38	-80
	Post.	7.77	
SF	Acc.	18.51	-100
	Post.	7.28	
SR	Acc.	19.68	-100
	Post.	8.61	

c) Duration

Mean and SD values of every accent and syllable are shown in Table 4.16. In the accented syllable, there was a significant main effect on Duration (log-transformed) for *accent*, $F(3, 136) = 21.82$, $p < .0001$. As in the previous conditions, duration was significantly different only between short and long accents: LF vs. SR, LR vs. SR, LF vs. SF ($p < .0001$) and LR vs. SF ($p = .0005$). The ratio between long and short accented syllables was 1.27 on average. Even though the posttonal syllable of LF was somewhat longer than the rest, who were grouped tightly around each other, there were no significant differences found between the accents.

Table 4.16. Mean and SD values of duration in final syllabic /r̩/ words

Accent	Acc.	Post.
LF	121.32 (26.56)	80.49 (26.17)
LR	118.33 (25.02)	71.13 (22.48)
SF	98.81 (20.18)	72.95 (25.55)
SR	88.89 (15.8)	72.61 (27.05)

d) Summary

In conclusion, all accents have a rather straightforward falling contour and very similar overall pitch values in the accented syllable, which suggests a loss of tonal contrast. Posttonal syllables preserved this contrast, which can be seen by the higher overall pitch of rising accents. All accents realized the pitch peak right at the beginning of the first syllable, and the only difference observed was in LR, which had slightly later peaks. Duration in the accented syllable differed only between long and short accents, with very little variation in the posttonal.

4.2.1.4 Overview and Comparison of Syllabic /r̩/ Words

a) Contour shape and overall pitch

Comparing the contour shapes of all accents across the different sentence conditions shows a similar picture to the one seen in monosyllabic words. Initials and medials can be loosely grouped together, seeing that all accents have a rising contour (steeper in initial condition) in the accented syllable and their overall and pitch range values are relatively close to each other. The falling contours in the posttonal and the consistently higher pitch values of rising accents make this grouping more meaningful. On the other hand, accents in the final condition are falling both in the accented and the posttonal syllable. Furthermore, overall and pitch range values are much lower than in the other two conditions. Tonal contrast is almost nonexistent in the accented syllable, but is still present in the posttonal, with rising accents having generally higher values. Since differences between individual accents have already been reviewed in the previous subsections, a one-way ANOVA with OvMean as a dependent variable and *accent type*, *syllable type*, *sentence* and their respective two-way interactions as independent variables was conducted. Note that only results of the interactions will be discussed. A main effect was found on *sentence* x *syllable type*, $F(2, 865) = 24.17$, p <.0001. A post hoc test revealed that initial and medial accented syllables and initial posttonal syllables behave as a group against the other constituents, which differed significantly between each other (all comparisons had a *p*-value of <.0001). In general, initial and medial syllables were significantly higher than final ones. A main effect was also found for *accent type* x *syllable type*, $F(1, 865) = 103.29$, p <.0001. A post hoc test showed that rising accented and posttonal syllables behave as a group against the falling syllables, which had the highest and lowest values. There was no significant interaction between *accent type* and *sentence*.

b) Pitch range and PPA%

Table 4.17 displays pitch range and PPA% values for accent types across all conditions. Using the same statistical model as above, a one one-way ANOVA was conducted. For Range, only the interaction between *sentence* and *syllable type* was significant, $F(2, 858) = 45.74$, p <.0001. A post hoc test revealed that pitch range values were roughly divided into three groups, which differed significantly from each other: the highest values were found in initial and final accented syllables, followed by the medials and lowest for final posttonals. Within the first two groups, posttonal syllables had a slightly smaller pitch range than accented ones, although the differences were not significant. These results clearly indicate that pitch range differentiates between sentence conditions much better than it does between accents or accent types.

Calculating PPA% across sentence conditions reveals a distinct pattern: pitch peaks in the entire word are produced the closest to the end of the accented syllable in initial condition (median -10) and closest to the beginning of the same syllable in the final condition (median -100). The medial condition had a median value of -30. This was confirmed by a Van der Waerden test (p <.0001): initial vs. final Z = 9.92 p <.0001, medial vs. final Z = 7.56 p <.0001 and initial vs. medial Z = 4.38 p <.0001. Comparing only accent types with a Van der Waerden test showed a significant difference between falling (-40) and rising (-20) accents: Z = -4.4 p <.0001.

Table 4.17. Mean pitch range and PPA% values of accent types in syllabic /r̩/ words across sentence conditions

Condition	Acc. Type	Syllable	Range	PPA%
Initial	Falling	Acc.	17.91	-20
		Post.	20.94	
	Rising	Acc.	21.85	0
		Post.	18.29	
Medial	Falling	Acc.	12.77	-40
		Post.	14.02	
	Rising	Acc.	14.01	-10
		Post.	15.95	
Final	Falling	Acc.	22.08	-100
		Post.	5.95	
	Rising	Acc.	17.56	-90
		Post.	8.22	

c) Duration

Mean and SD values of duration across accent types and sentence positions are shown in Table 4.18. When calculated together, falling and rising accents do not differ very much in their duration within each sentence position.

Table 4.18. Mean and SD values of duration across accent types and sentence condition in syllabic /r̩/ words

Condition	Acc. Type	Acc.	Post.
Initial	Falling	85.91 (20.45)	57.4 (17.58)
	Rising	83.66 (18.56)	56.11 (13.5)
Medial	Falling	92.75 (18.75)	57.73 (20.01)
	Rising	87.26 (19.99)	58.62 (17.76)
Final	Falling	110.68 (26.18)	76.97 (25.99)
	Rising	103.23 (25.43)	71.88 (24.75)

On the other hand, comparing only positions clearly shows a longer duration for both syllables in the final condition. However, it is safe to assume that this longer duration can be attributed to final lengthening, which is not directly connected to the nature of tone itself. A one-way ANOVA revealed a main statistical effect for *sentence*, $F(2, 917) = 85.03$, $p < .0001$, which showed that the final condition was significantly longer than the other conditions ($p < .0001$). However, none of the interactions were significant.

d) Summary

Table 4.19 below sums up the results of all measurements made in this section. It is quite similar to Table 4.7, but several differences must be noted. In each cell except Duration and

PPA%, the first entry refers to the accented and the second to the posttonal syllable. The entries under Contour are descriptions of the contour shape. OvMean denotes the accent type in each syllable which had overall higher pitch. The first entry under PPA% denotes falling accents and the second rising. Duration is given for the entire word since no major differences were observed between accent types and the ratio between accented and posttonal syllables was very similar across conditions - 1.49 on average.

Table 4.19. Summary of the acoustic characteristics of falling and rising accents in syllabic /r̥/ words

	Contour	OvMean	Range	PPA%	Duration
Initial	rise, fall	falling, rising	large, large	-20, 0	inter.
Medial	rise, fall	falling, rising	inter., inter.	-40, -10	inter.
Final	fall, fall	same, rising	large, small	-100, -90	long

4.2.2 Combined Bisyllabic Words

Having dealt with the production of tone in syllabic /r̥/ words, it is now time to turn to the rest of the bisyllabic words, of which there are two patterns: 2s (accented first syllable and short posttonal) and 2l (accented first syllable and long posttonal). As will be demonstrated, the production of tone in all bisyllabic patterns is fundamentally the same, which requires a combined analysis. Studying the F_0 tracks of the various patterns, several distinct common characteristics were found which were crucial in coming to this conclusion. Note that these are strong tendencies and there are exceptions to them, but they most definitely hold true for most cases. In essence, these tendencies are a reflection of what was already analyzed in §4.2.1: a) initially and medially, all accented syllables have a rising contour and all posttonals are falling, b) in the final condition, both syllables have falling contours, c) the overall pitch of falling accents is higher in the accented syllable and lower in the posttonal, and, perhaps most importantly, d) pitch peaks in words with falling accents are produced in the accented syllable and rising accents place them in the posttonal. A study of Figure 4.14 on the next page, which displays a side-by-side comparison of 2s and 2l F_0 tracks in all sentence positions, will make the similarities between them abundantly clear.

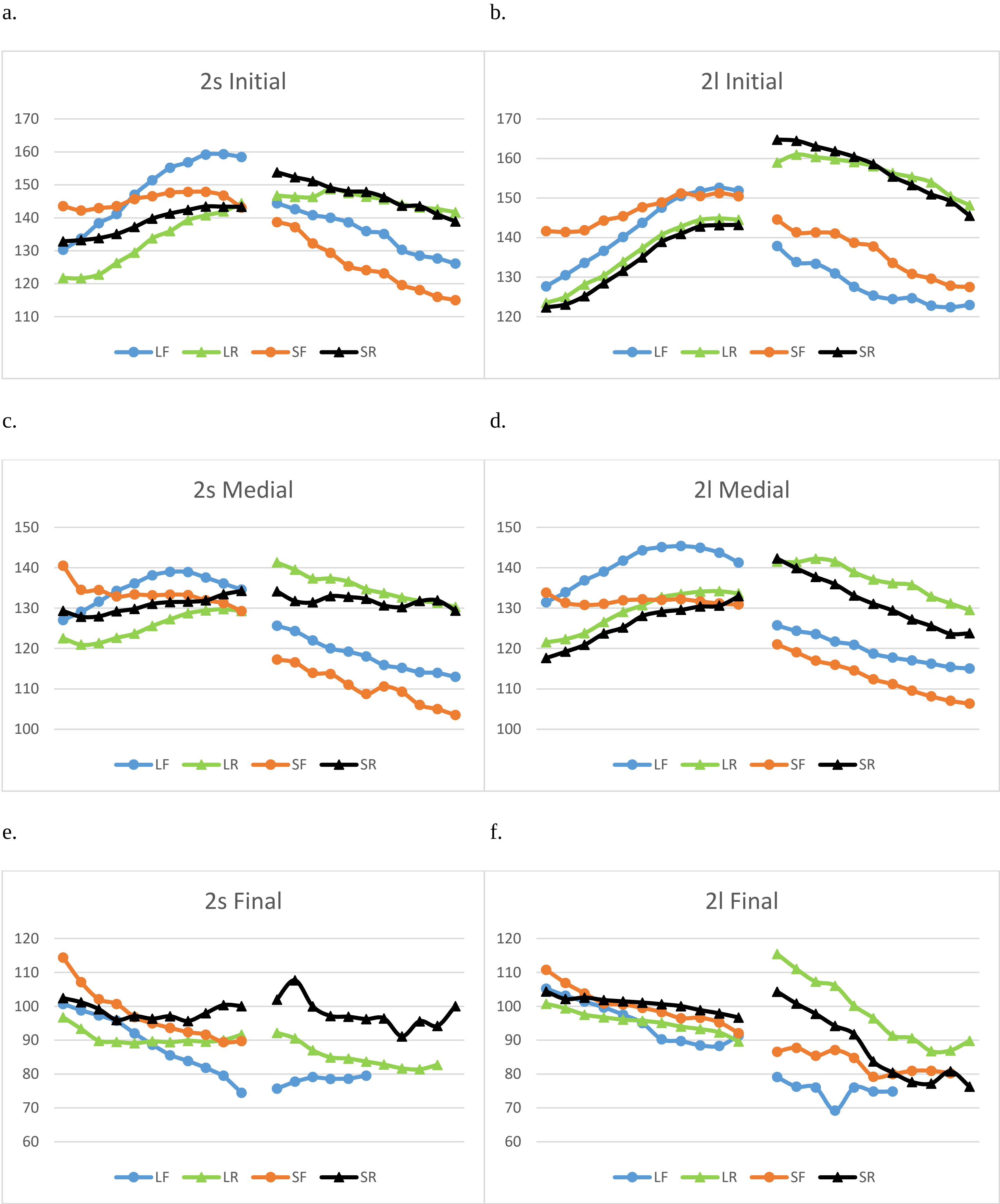


Figure 4.14. Mean F_0 tracks of accents in 2s and 2l words in all sentence positions

Note that to fit all the graphs on the page and to show as much of the contours as possible, the axes' labels were removed. The vertical axis shows F_0 in Hz and the horizontal is a normalized time scale in % of the vowel's duration. In 4.14e, no contour is shown for posttonal SF (as well as several measurement points in other accents), since all measurement points had less than four values. Comparing between patterns will show that although not identical, their contours are quite compatible with respect to the four factors mentioned above. The most notable exceptions can be found in medial SF, which is quite level in both patterns (except for the initial fall in 2s). More importantly, however, is the striking similarity between 2s, 2l and 2R. For this reason, all bisyllabic words will be analyzed together in the coming subsections. This will not only strengthen the statistical model, but also solve the problem of missing values in the final condition. Since the difference between patterns is more temporal, they will be briefly discussed in each subsection's Duration part.

4.2.2.1 Initial Bisyllabic Words

a) Contour shape and overall pitch

Mean F_0 tracks are displayed in Figure 4.15. In the accented syllable, all accents have a very similar rising contour, which starts out as a short plateau. This plateau is longest in SR and shortest in LF. As in previous conditions, accents tend to group according to their type with respect to overall pitch, with falling accents being generally higher. This was confirmed in a one-way ANOVA, which showed a statistical main effect for *accent*, $F(3, 306) = 20.29$, $p < .0001$. A post hoc test showed that falling accents had in general significantly higher overall pitch than rising accents: LF vs. LR, SF vs. LR ($p < .0001$), LF vs. SR ($p = .0022$). SR was also significantly higher than LR ($p = .0022$).

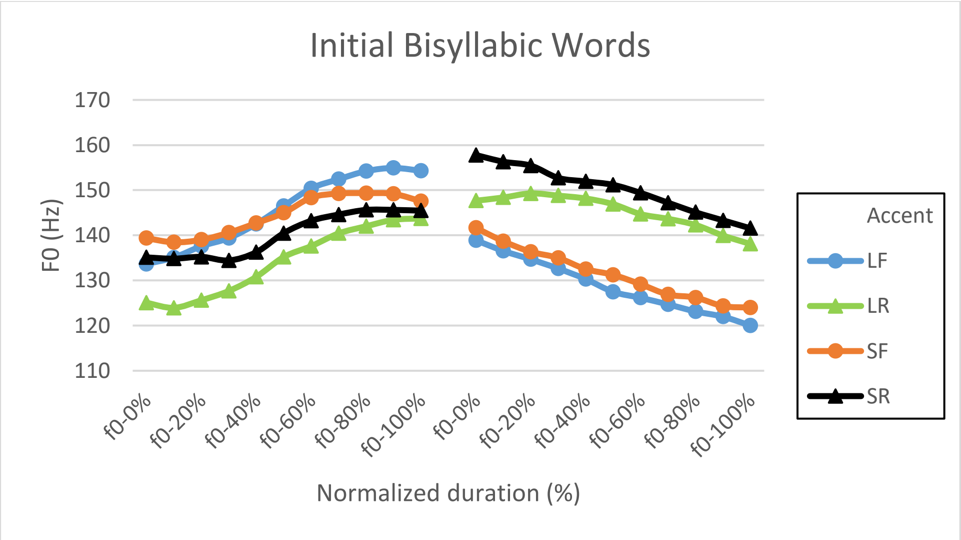


Figure 4.15. Mean F_0 tracks of initial bisyllabic words

In the posttonal syllable, all accents have a characteristic falling contour. The tendency to group according to accent types is even stronger in this syllable. The only exception is the rise at the beginning of LR, which turns into a fall after about 30%. The typically higher pitch in rising accents can also be observed. A one-way ANOVA showed a main effect for *accent*, $F(3, 306) = 44.48$, $p < .0001$. As expected, OvMean distinguished only between accent types, with rising accents having significantly higher pitch (all comparisons had a *p*-value of <.0001).

*Table 4.*20. Number of samples in measurement points in initial bisyllabic words across the four accents

Accent	Syllable	f0-0%	f0-10%	f0-20%	f0-30%	f0-40%	f0-50%	f0-60%	f0-70%	f0-80%	f0-90%	f0-100%
LF	Acc.	80	80	80	80	80	80	80	80	80	80	80
	Post.	80	80	80	80	80	80	79	76	74	73	73
LR	Acc.	77	79	80	80	80	80	80	80	80	78	77
	Post.	72	76	78	79	80	80	79	79	79	79	79
SF	Acc.	77	80	80	79	80	80	78	78	78	78	78
	Post.	80	79	79	78	78	77	77	76	75	75	73
SR	Acc.	74	76	76	76	77	78	79	79	79	79	78
	Post.	78	78	78	77	78	79	79	79	77	77	76

b) Pitch range and PPA%

Mean values of pitch range and PPA% are shown in Table 4.21. In the accented syllable, there was a main effect on Range for *accent*, $F(3, 306) = 8.8$, $p < .0001$. A post hoc test distinguished mostly between long and short accents: LF vs. SF ($p = .0001$), LR vs. SF ($p = .0003$) and LF vs. SR ($p = .0282$). In the posttonal syllable, a main effect was found on Range, $F(3, 305) = 5.78$, $p = .0007$, and a post hoc test contrasted only between LR and SF ($p = .0012$) and LR and LF ($p = .0038$). Short accents had a larger pitch range than in the accented syllable.

Table 4.21. Mean pitch range and PPA% values in initial bisyllabic words

Accent	Syllable	Range	PPA%
LF	Acc.	24.18	-10
	Post.	19.59	
LR	Acc.	23.49	0
	Post.	14.48	
SF	Acc.	15.44	-20
	Post.	20.34	
SR	Acc.	18.85	0
	Post.	18.7	

The PPA pattern found in other initial and medial contexts can be clearly seen. The only contour which is slightly exceptional is LR's, which continues to rise well into the first third of the posttonal. As before, a Van der Waerden test distinguished between all accents of a different type (p <.0001): SR vs. LF Z = 6.12 p <.0001, SR vs. SF Z = 5.79 p <.0001, LR vs. LF Z = 5.71 p <.0001, SF vs. LR Z = -5.59 p <.0001.

c) Duration

For the comparison between patterns, 2s and 2R were pooled together since they both have a phonologically short posttonal syllable. Mean and SD duration values of patterns are shown in Table 4.22. The duration of the accented syllable showed very little variation between patterns. A one-way ANOVA with *accent*, *pattern* and their crossing *accent* x *pattern* was conducted, and a main effect was found only for *accent*, $F(3, 300) = 15.14$, p <.0001. A post hoc test showed that, quite as expected, long accented syllables were significantly longer than short ones. This suggests that pattern has no effect on the duration of the accented syllable.

Table 4.22. Mean and SD values of duration across accents and patterns in initial bisyllabic words

Pattern	Accent	Acc.	Post.
2s+2R	LF	93.74 (20.63)	58.43 (13.49)
	LR	96.14 (21.17)	51.01 (13.3)
	SF	78.36 (19.7)	51.07 (17.88)
	SR	74.16 (15.64)	54.11 (13.5)
2l	LF	95.88 (22.81)	46.11 (8.38)
	LR	85.15 (18.01)	47.3 (12.37)
	SF	79.01 (14.59)	53 (9)
	SR	78.77 (16.14)	68.33 (16.15)

Posttonals of short accents in the 2l condition are indeed longer than in 2s (especially SR's), but this is reversed for the long accents, which have a shorter duration in 2l. Averaged across all accents, phonologically long posttonals are almost identical in duration to the short posttonals (53.68 ms vs. 53.65 ms, respectively). A main effect was found for *accent*, $F(3, 302) = 9.64$, p <.0001. The duration of SR was significantly higher than all other accents' (SR vs. LR p <.0001, SR vs. SF p =.0008, SR vs. LF p =.0012). The interaction between *accent* and *pattern* was also significant, $F(3, 302) = 10.84$, p <.0001, and a post hoc test confirmed the significantly longer duration of SR in the 2l pattern.
Returning to the combined bisyllabic words now, Table 4.23 shows mean and SD duration values of all accents and syllables. Much like in the comparison above, duration in the accented syllable is longer for long accents. A one-way ANOVA with a significant main

effect for *accent* confirmed this, $F(3, 304) = 24.42$, $p < .0001$. All comparisons between short and long accents had a *p*-value of <.0001. The average ratio between accented long and short syllables was 1.22. The posttonal syllable shows a much smaller variation, although SR's relatively high value still stands out. There was a main effect for *accent*, $F(3, 306) = 5.24$, $p = .0015$, which showed that SR's duration was significantly higher than LR's ($p = .0026$) and SF's ($p = .0232$).

*Table 4.*23. Mean and SD values of duration in initial bisyllabic words

Accent	Acc.	Post.
LF	94.24 (21.02)	55.35 (13.48)
LR	93.4 (20.87)	50.08 (13.1)
SF	78.52 (18.47)	51.55 (16.09)
SR	75.33 (15.79)	57.71 (15.42)

d) Summary

All accents in the accented syllable have a rising contour, with falling accents having higher overall pitch. Long accents had a greater pitch range than short accents. The posttonal syllable is characterized by a falling contour, where rising accents have higher overall pitch. Pitch peaks were produced in the last fifth of the accented syllable in falling accents and at the beginning of the posttonal for rising accents. Duration in the accented syllable was longer for long accents and mostly the same in the posttonal, except for SR, which was significantly longer than all others.

4.2.2.2 Medial Bisyllabic Words

a) Contour shape and overall pitch

Mean F_0 tracks are displayed in Figure 4.16 and the sample size of all measurement point in Table 4.24. The accented syllable exhibits very similar contours to the ones observed in the initial position. Short accents start with a slight fall, which is truncated into a plateau in the long accents. Falling accents have almost identical pitch values after the first third, which can be observed in the rising accents only in the last third. In the accented syllable, a one-way ANOVA showed a significant main effect on OvMean (log-transformed) for *accent*, $F(3, 304) = 13.83$, $p < .0001$. A post hoc test significantly distinguished only between falling and rising accents: LF vs. LR, SF vs. LR ($p < .0001$), LF vs. SR ($p = .0053$), SF vs. SR ($p = .006$).

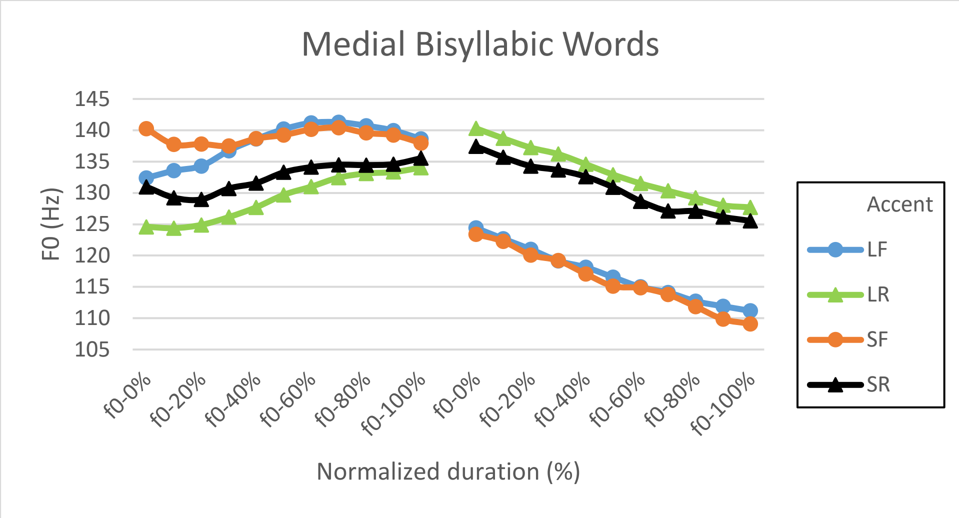


Figure 4.16. Mean F_0 tracks of medial bisyllabic words

The posttonal syllable shows a clear-cut distinction between rising and falling accents, which are grouped together. The contours are universally falling, with rising accents being noticeably higher, which was confirmed in a one-way ANOVA that had a significant main effect for *accent*, $F(3, 304) = 50.43$, $p < .0001$. Like in the accented syllable, OvMean (log-transformed) distinguished only between falling and rising, with all comparisons having a *p*-value of <.0001.

Table 4.24. Number of samples in measurement points in medial bisyllabic words across the four accents

Accent	Syllable	f0-0%	f0-10%	f0-20%	f0-30%	f0-40%	f0-50%	f0-60%	f0-70%	f0-80%	f0-90%	f0-100%
LF	Acc.	80	80	80	79	79	79	79	80	80	77	77
	Post.	79	80	80	80	80	80	80	80	80	79	78
LR	Acc.	78	78	78	78	78	78	80	80	79	78	76
	Post.	79	80	80	80	80	80	80	80	80	79	79
SF	Acc.	66	76	76	77	77	76	76	75	75	74	72
	Post.	74	75	75	75	76	75	74	73	72	72	69
SR	Acc.	74	78	79	79	79	79	79	79	80	79	74
	Post.	78	80	80	80	80	80	79	79	80	78	74

b) Pitch range and PPA%

Mean values of pitch range and PPA% are shown in Table 4.25. In the accented syllable, pitch range values were quite uniform across accents, except for SF, which was unusually small. There was a main effect for *accent*, $F(3, 303) = 8.12$, $p < .0001$. A post hoc test showed that SF's pitch range was significantly smaller than the long accents': LF vs. SF ($p < .0001$), LR vs. SF ($p = .0039$).

Table 4.25. Mean pitch range and PPA% in medial bisyllabic words

Accent	Syllable	Range	PPA%
LF	Acc.	14.87	-30
	Post.	13.82	
LR	Acc.	13.16	0
	Post.	15.05	
SF	Acc.	9.65	-50
	Post.	13.89	
SR	Acc.	13	0
	Post.	16.55	

In the posttonal syllable, rising accents had a slightly larger pitch range, but the differences were not significant. Additionally, all posttonals except LF had a greater range than in the corresponding accented syllable.

The usual PPA% pattern found in previous conditions can also be observed here. LF's peaks are realized at the 70%-point of the accented syllable, and SF's are found in the middle of the same segment. Rising accents reach their peak at the beginning of the posttonal. A Van der Waerden test distinguished only between falling and rising accents (p <.0001): LR vs. LF Z = 7.63 p <.0001, SR vs. SF Z = 4.7 p <.0001, SR vs. LF Z = 4.18 p =.0002 and SF vs. LR Z = -7.58 p <.0001.

c) Duration

Table 4.26 below shows mean and SD duration values for accents and syllables across patterns. Duration in the accented syllable in both patterns was longest for LF, followed by LR, SF and SR. Short accents were clustered around each other, whereas the difference between the long accents was somewhat greater. A one-way ANOVA with *accent*, *pattern* and *accent* x *pattern* was conducted. There was a main effect only for *accent*, $F(3, 300)$ = 31.78, p <.0001, and a post hoc test distinguished between LF, LR and the short accents, which behaved as a group. This indicates that patterns have no effect on the accented syllable's duration. Like in the the previous condition, short accents' posttonals were longer in 2l, whereas long accents displayed shorter duration in the same pattern. The phonologically short posttonals were slightly longer than the phonologically long syllables (55.17 ms and 52.02 ms on average, respectively), although this difference was not significant. SR in both patterns had an unusually long duration, which was confirmed in a one-way ANOVA that showed a main effect for *accent*, $F(3, 298)$ = 9.01, p <.0001. SR was significantly longer than all other accents: SR vs. SF, SR. vs LR (p <.0001), SR vs. LF (p

=.0053). The interaction between *accent* and *pattern* was also significant, $F(3, 298) = 15.36$, $p <.0001$. A post hoc test showed that, in general, 2l SR and 2s+2R LF were significantly longer than most other constituents.

Table 4.26. Mean and SD values of duration across accents and patterns in medial bisyllabic words

Pattern	Accent	Acc.	Post.
2s+2R	LF	108.47 (22.69)	63.8 (17.45)
	LR	97.77 (24.75)	54.76 (15.44)
	SF	83.86 (16.8)	45.27 (15.3)
	SR	77.52 (18.05)	56.86 (18.16)
2l	LF	108.23 (13.25)	42.07 (10.06)
	LR	97.55 (18.42)	44.84 (12.85)
	SF	82.54 (17.08)	53.67 (12.05)
	SR	81.7 (15.08)	67.52 (16.36)

Table 4.27 shows mean and SD duration values of accents and syllables. As expected, long accents have a longer duration in the accented syllable. However, within each long or short pair, the falling accent is longer than the rising. This pattern was partially confirmed by an ANOVA, which had a main effect for *accent*, $F(3, 304) = 44.61$, $p <.0001$. LF and LR were each significantly different than the rest, while the short accents behaved as a group (LF vs. SR, LF vs. SF, LR vs. SR and LR vs. SF $p <.00001$, LF vs. LR $p =.0013$). The ratio between long and short accented syllables was 1.27 on average. In the posttonal syllable, duration was more uniform than in the accented one, except for SR, which was noticeably longer. SF had a rather short duration, and a main effect was found for *accent*, $F(3, 302) = 9.12$, $p <.0001$. SF was significantly shorter than SR ($p <.0001$) and LF ($p =.0002$) and SR was longer than LR ($p =.0294$).

Table 4.27. Mean and SD values of duration in medial bisyllabic words

Accent	Acc.	Post.
LF	108.41 (20.6)	58.37 (18.48)
LR	97.71 (23.22)	52.28 (15.38)
SF	83.52 (16.77)	47.48 (14.91)
SR	78.57 (17.36)	59.42 (18.23)

d) Summary

All accents in the accented syllable have a rising contour, while SF and SR have an additional fall at the beginning. Overall means are grouped according to accent type, with falling accents having higher values. Posttonal syllables are falling and grouped much more tightly according to accent type, with rising accents having higher overall pitch. Peaks in falling accents are realized in the second quarter of the accented syllable and at the beginning of the posttonal for rising accents. Duration was significantly longer for long accents in the accented syllable and rather uniform in the posttonal, although SF was somewhat shorter and SR noticeably longer.

4.2.2.3 Final Bisyllabic Words

a) Contour shape and overall pitch

Mean F_0 tracks are displayed in Figure 4.17, with sample size in Table 4.28. In the accented syllable, all contours are clearly falling, with the only difference between falling and rising accents being a slightly more level pitch in the latter. There was a significant main effect on OvMean for *accent*, $F(3, 286) = 4.29$, $p = .0055$. A post hoc test showed that SF's overall pitch was only significantly higher than LF's ($p = .0144$) and LR's ($p = .0386$). The low significance rates indicate at least a partial tonal neutralization in the accented syllable in final position.

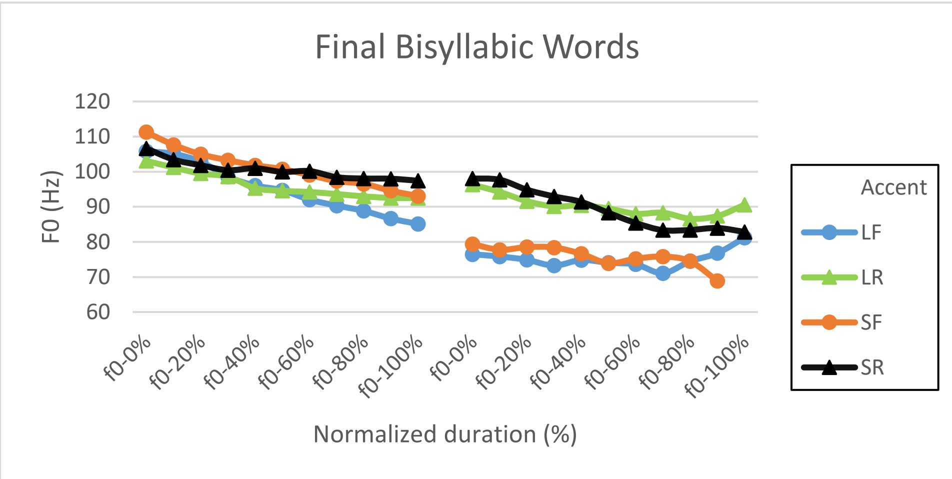


Figure 4.17. Mean F_0 tracks of final bisyllabic words

The posttonal syllable, despite the neutralization in the accented syllable, shows the usual pattern of overall pitch, with rising accents being grouped together and being higher. Since missing values were most common in the final position (compare Figures 4.14e and 4.14f), this has caused some values, especially at the end of the posttonal syllable, to be skewed. For this reason, I believe that the final rising movements in falling accents can be disregarded, since they also clearly contradict the general falling contour found elsewhere. There was a main effect for *accent*, $F(3, 175) = 9.14$, $p < .0001$, which distinguished only between rising and falling accents: SR vs. LF ($p = .0003$), SR vs. SF ($p = .0006$), LR vs. LF ($p = .0055$), LR vs. SF ($p = .0094$). Just like in final syllabic /r̥/ words, the tonal contrast between falling and rising accents is maintained in the posttonal.

Table 4.28. Number of samples in measurement points in final bisyllabic words across the four accents

Accent	Syllable	f0-0%	f0-10%	f0-20%	f0-30%	f0-40%	f0-50%	f0-60%	f0-70%	f0-80%	f0-90%	f0-100%
LF	Acc.	72	74	74	71	71	71	72	72	71	65	49
	Post.	30	33	31	28	24	21	19	15	12	9	5
LR	Acc.	73	75	71	70	70	75	74	74	72	65	47
	Post.	50	55	55	55	53	50	44	40	34	28	19
SF	Acc.	60	64	67	64	63	63	63	64	61	58	50
	Post.	26	29	29	25	25	24	19	16	11	7	**2**
SR	Acc.	68	73	74	75	76	77	76	76	73	71	59
	Post.	52	58	62	60	60	57	45	40	35	25	19

b) Pitch range and PPA%

Mean values of pitch range and PPA% are shown in Table 4.29. In the accented syllable, pitch range was noticeably greater in falling accents, with LF having the highest value. This was partially confirmed by an ANOVA, which had a statistical main effect, $F(3, 285) = 4.69$, $p < .0001$. A post hoc test differentiated between LF and LR ($p = .0034$) and SR ($p = .0196$). Accented syllables had a greater range than posttonals, as opposed to the other conditions. For the posttonal syllables, the above tendency is reversed - pitch range is higher in rising accents, especially in SR, where it was unusually large. There was a main effect on Range for *accent*, $F(3, 172) = 3.63$, $p = .0140$, which only distinguished SR from LF ($p = .0242$).

Table 4.29. Mean pitch range and PPA% values in final bisyllabic words

Accent	Syllable	Range	PPA%
LF	Acc.	22.89	-100
	Post.	5.96	
LR	Acc.	14.43	-90
	Post.	9.64	
SF	Acc.	19.84	-100
	Post.	6.2	
SR	Acc.	15.84	-90
	Post.	14.16	

PPA% values did not vary much between accents, since most peaks were produced right at the beginning of the accented syllable due to its falling contour. A Van der Waerden test revealed that PPA% distinguished only between LF and the rising accents ($p = .0003$): LR vs. LF $Z = 3.92$ $p = .0005$, SR vs. LF $Z = 3.75$ $p = .001$. This serves as a further confirmation of the presence of at least partial tonal contrast in the final condition.

c) Duration

Mean and SD values of duration across patterns, accents and syllables are shown in Table 4.30. Besides being substantially longer for long accents, the duration of SF in 2s+2R is longer than SR's, whereas this is reversed in the 2l pattern. Additionally, accented syllables in 2l had slightly higher duration. An ANOVA showed a significant effect for *accent*, $F(3, 283) = 76.58$, $p < .0001$. Duration was significantly different only between long and short accents ($p < .0001$). The same relation was found in the significant interaction between *accent* and *pattern*, $F(3, 283) = 3.83$, $p = .0103$. This indicates that patterns have no effect on the accented syllable's duration.

Table 4.30. Mean and SD values of duration across accents and patterns in final bisyllabic words

Pattern	Accent	Acc.	Post.
2s+2R	LF	129.05 (27.5)	75.12 (26.73)
	LR	128.06 (26.26)	64.07 (21.7)
	SF	95.99 (24.83)	71.92 (25.65)
	SR	86.78 (18.08)	68.06 (25.99)
2l	LF	139.31 (16.72)	61.84 (17.52)
	LR	138.65 (20.75)	62.11 (18.46)
	SF	82.17 (19.44)	63.09 (12.97)
	SR	93.13 (23.1)	82.96 (18.72)

In posttonal 2s+2R syllables, higher duration for falling accents can be observed. Values in 2l are rather similar to each, except for SR, which is noticeably longer. On average, posttonals in 2l were slightly shorter than in 2s+2R: 69.79 ms vs. 67.5 ms, respectively. A one-way ANOVA had a main effect for *accent*, $F(3, 285) = 3.59$, $p = .014$, but a post hoc test showed that only the longest and shortest segments, SR and LR, were statistically different ($p = .0075$). The interaction between *accent* and *pattern* also had a main effect, $F(3, 285) = 4.94$, $p = .0023$, but only a very small amount of comparisons was statistically significant.
Table 4.31 shows the mean and SD values of duration in accents and syllables. Duration in the accented syllable is much like in all the other conditions: long accents have a higher duration. A one-way ANOVA showed a statistical main effect for *accent*, $F(3, 287) = 84.31$, $p < .0001$, which distinguished only between short and long accents (all comparisons had a *p*-value of <.0001). The ratio between the accented and posttonal's durations was 1.44 on average. In the posttonal syllable, most accents except LR have a very similar duration. No significant effect was found for *accent*.

Table 4.31. Mean and SD values of duration in final bisyllabic words

Accent	Acc.	Post.
LF	131.54 (25.64)	71.93 (25.37)
LR	130.81 (25.25)	63.57 (20.82)
SF	92.24 (24.16)	69.52 (23.15)
SR	88.39 (19.51)	71.83 (25.1)

d) Summary

In conclusion, all contours in the accented syllable are falling with minimal differences in overall pitch and pitch range between the accents, indicating a loss of tonal contrast. In the posttonal, all contours are also falling, but a very clear distinction can be seen between rising and falling accents with respect to overall pitch, with rising accents having significantly higher values. Both accent types have a comparable pitch range in the posttonal. Although quite similar to each other due to the uniform falling contour in the accented syllable, PPA% was able to distinguish between LF and the rising accents, with the former having slightly earlier peaks in the accented syllable. Duration was mostly significant in differentiating between accented syllables of short and long accents.

4.2.2.4 Overview and Comparison of Bisyllabic Words

a) Contour shape and overall pitch

Contour shapes and overall pitch values in combined bisyllabic words are very much like the ones seen in syllabic /r̥/ words. Patterns in the initial and medial conditions can be loosely grouped together. Accented syllables are rising for all accents, and falling ones have higher overall pitch. Posttonals exhibit a falling contour and a clear grouping according to accent type, with rising accents having higher overall pitch. Two major differences between the two conditions, however, can be observed. The level pitch at the beginning of the accented syllable is noticeably longer in the initial condition, whereas in the medial, the contour's rising shape is more straightforward. Furthermore, the rising movement itself is steeper in the initial condition, which is also confirmed by the pitch range values discussed in the next part. In other words, the contour in the medial position is a somewhat truncated version of the initial condition, since it is located in a prosodically less prominent position. In the final condition, both syllables are falling with very little tonal contrast in the accented syllable. In the posttonal, however, falling and rising accents have significantly different overall pitch, quite like in the other conditions. A one-way ANOVA was conducted with the independent variables *accent type*, *sentence*, *syllable type* and their respective interactions. Note that only the interactions will be discussed. A main effect was found for *sentence* x *syllable type*, *F*(2,

1738) = 39.14, *p* <.0001. A post hoc test revealed that except initial accented and initial posttonal, all individual condition/syllable type combinations were statistically different from each other (all comparisons had a *p*-value of <.0001). Overall pitch was highest in the initial condition, followed by the medial and then lowest in the final. Additionally, in each condition, the accented syllable had higher pitch. The interaction between *syllable type* and *accent type* was significant, *F*(2, 1738) = 265.5, *p* <.0001 and a post hoc test showed that overall pitch was highest in accented falling syllables, followed closely by both rising syllables and substantially lower for falling posttonals. All comparisons except the two rising syllables were highly significant (*p* <.0001). The differences can be attributed to the much lower pitch of falling posttonals due to the peak being produced in the accented syllable.

b) Pitch range and PPA%

Table 4.32 displays mean pitch range and PPA% values for accent types across all conditions. Using the same statistical model as above, a one-way ANOVA was conducted. There was a statistical main effect on Range for the interaction *sentence* x *syllable type*, *F*(2, 1739) = 21.002, *p* <.0001, which showed the same distribution of significance as in syllabic /r̩/ words: both initials and accented final syllables formed one group with the largest pitch range, followed by the medials, and lowest for the final posttonals. The value for final posttonals is so low because of the mostly level contour found in falling posttonal syllables, which has by far the smallest pitch range.

Table 4.32. Mean pitch range and PPA% values of accent types across sentence conditions in bisyllabic words

Condition	Acc. Type	Syllable	Range	PPA%
Initial	Falling	Acc.	19.81	-10
		Post.	19.97	
	Rising	Acc.	21.19	0
		Post.	16.58	
Medial	Falling	Acc.	12.31	-40
		Post.	13.85	
	Rising	Acc.	13.08	0
		Post.	15.8	
Final	Falling	Acc.	21.44	-100
		Post.	6.08	
	Rising	Acc.	15.14	-90
		Post.	11.99	

PPA% values of falling accents shift toward the beginning of the accented syllable the closer they are to the beginning of the sentence. Pitch peaks were produced at the 90%-point of the accented syllable in initial condition, 60% in the medial and right at the beginning in the final. Rising accents in the initial and medial conditions, however, all had peaks at the start of the posttonal. In the final condition, rising peaks were shifted to the 10%-point of the accented syllable, which was slightly later than in falling accents. A Van der Waerden test revealed that PPA% was statistically different between all sentence positions: initial vs. final Z = 12.65 p <.0001, medial vs. final Z = 9.91 p <.0001, initial vs. medial Z = 5.82 p <.0001. Comparing accent types confirmed the difference between rising and falling: Z = 8.86 p <.0001.

c) Duration

Mean and SD values of duration across accent types and sentence positions are shown in Table 4.33. As in previous conditions, duration varied very little between accent types or between the initial and medial conditions. A one-way ANOVA with *sentence*, *accent type*, *syllable type* and their respective interactions was conducted. A significant main effect was found for *sentence* x *syllable type*, $F(2, 1851) = 8.39$, $p = .0002$. A post hoc test revealed that final accented syllables were the longest, followed by medial accented, initial accented and then the posttonal syllables in the same order. All comparisons except medial post. vs. initial post. were highly significant. This shows that accented syllables are indeed longer than posttonals, and that the duration is higher the closer the target word is to the end of the sentence.

Table 4.33. Mean and SD values of duration across accent types and sentence condition in bisyllabic words

Condition	Acc. Type	Acc.	Post.
Initial	Falling	86.28 (21.22)	53.45 (14.92)
	Rising	84.42 (20.57)	53.87 (14.76)
Medial	Falling	96.2 (22.54)	53.06 (17.65)
	Rising	88.14 (22.58)	55.83 (17.18)
Final	Falling	112.44 (31.71)	70.77 (24.27)
	Rising	109.33 (30.93)	67.73 (23.37)

The interaction between *syllable type* and *accent type* was also significant, $F(1, 1851) = 4.98$, $p = .0257$. A post hoc test showed that accented falling syllables had the longest duration, followed by accented rising and then both posttonals, which were not significantly different from each other (all significant comparisons had a p-value of <.0001, except for acc. falling vs. acc. rising $p = .0113$).

d) Summary

A summary of the acoustic characteristics of bisyllabic words is shown below in Table 4.34, which has the same properties as Table 4.19. It can be seen that the non-final conditions have roughly the same pattern of production, with the largest differences being a smaller range and earlier peaks in the medial. Contrast between falling and rising accents was maintained primarily through tonal acoustic parameters, while the short/long distinction was was upheld by durational measures. The final condition, on the other hand, follows an altogether different pattern: falling contours throughout the word with partial neutralization of the tonal contrast in the accented syllable. The distinction between accent types is sustained by higher pitch in the posttonal syllable together with slightly later pitch peaks in rising accents. Additionally, larger differences in pitch range between syllable types and generally a longer duration were observed.

Table 4.34. Summary of the acoustic characteristics of falling and rising accents in bisyllabic words

	Contour	OvMean	Range	PPA%	Duration
Initial	rise, fall	falling, rising	large, large	-10, 0	inter.
Medial	rise, fall	falling, rising	inter., inter.	-40, 0	inter.
Final	fall, fall	same, rising	large, small	-100, -90	long

4.3 Trisyllabic Words

4.3.1 3a Trisyllabic Words

Since 3a words have four possible accentual patterns (ASS, ASL, ALS, ALL), comparing all conditions in one place is not a viable option. For this reason, the contours of the various patterns will be presented and shortly discussed at the beginning of each condition's subsection. As in Figure 4.14, the axes' labels are removed to conserve space.

4.3.1.1 Initial 3a Trisyllabic Words

a) Contour shape and overall pitch

Figure 4.18 displays the pitch contours of all initial 3a patterns. When considering the prototypical parameters for rising and falling accents in the initial and medial positions named in §4.2.2, namely a) rising contour for all accents in the accented syllable and falling in the posttonal, b) higher overall pitch for falling accents in the accented syllable and the reverse in the posttonal and c) pitch peaks in the accented syllable for falling accents and in the posttonal for rising accents, several differences can be observed between the various patterns. The first two parameters can be confirmed to varying degrees in all four patterns. In

ASS and ALL, for instance, the accented syllable of SR is actually slightly higher than the falling accents, but only at the beginning of the vowel. There is also a certain tendency for the first posttonal syllable to exhibit more distance between the accents when the vowel is phonologically long, as can be seen by comparing panes a and b with c and d of Figure 4.18. Pitch in the second posttonal shows either no differences between accents (ASS and ALL), or slightly higher values for rising accents (ASL and ALS). The biggest discrepancy is, however, found in the third parameter, specifically, in the pitch peak alignment of SF in the ASS and ALL patterns. Panes a and d of Figure 4.18 show that peaks in SF were produced in the posttonal, suggesting a “switch” to the rising type. Since this only happened to one accent in two patterns, it was decided to exclude SF in ASS and ALL from all following analyses except for Duration.

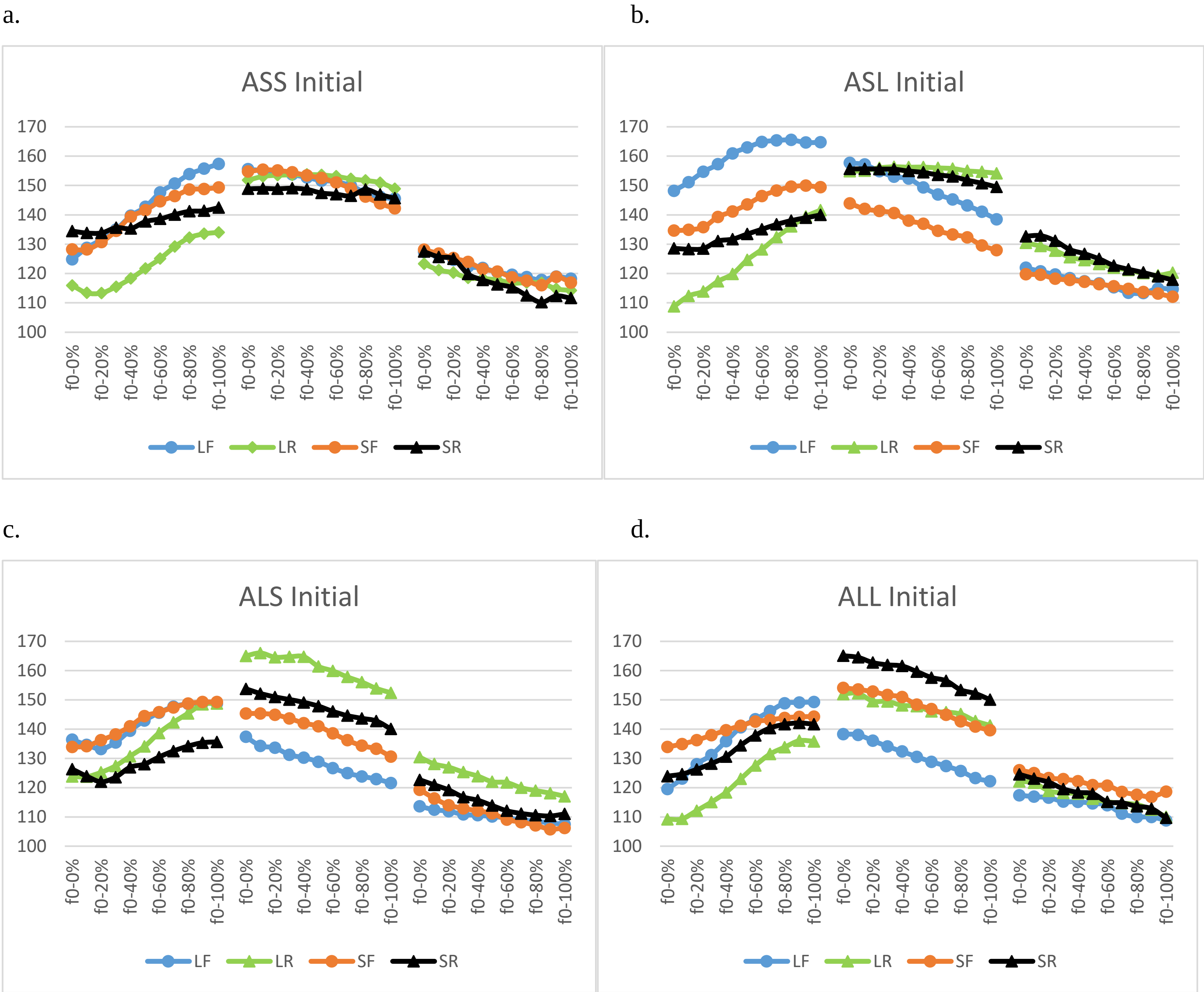


Figure 4.18. Mean F_0 tracks of initial 3a words in all four patterns

Mean F_0 tracks are displayed in Figure 4.19 with the sample size in Table 4.35. In the accented syllable, all accents have a rising contour. The falling accents have higher overall pitch and have an identical contour in the first half of the vowel, after which LF grows higher. Rising accents have a slight delay in their rising movement, which is seen as a short plateau at the beginning of the syllable. While RS has a contour quite similar to the falling accents, LR has a much steeper rise (reaching RS's pitch only at the end of the vowel), which sets it apart from the rest. A one-way ANOVA showed a statistical main effect for *accent*, $F(3, 260) = 36.94$, $p < .0001$. A post hoc test showed that while falling accents did not differ from each other, they were as a group statistically higher than the rising accents, of which LR was significantly lower: LF vs. LR, SF vs. LR, LF vs. SR ($p < .0001$), SF vs. SR ($p = .0005$), SR vs. LR ($p = .0051$).

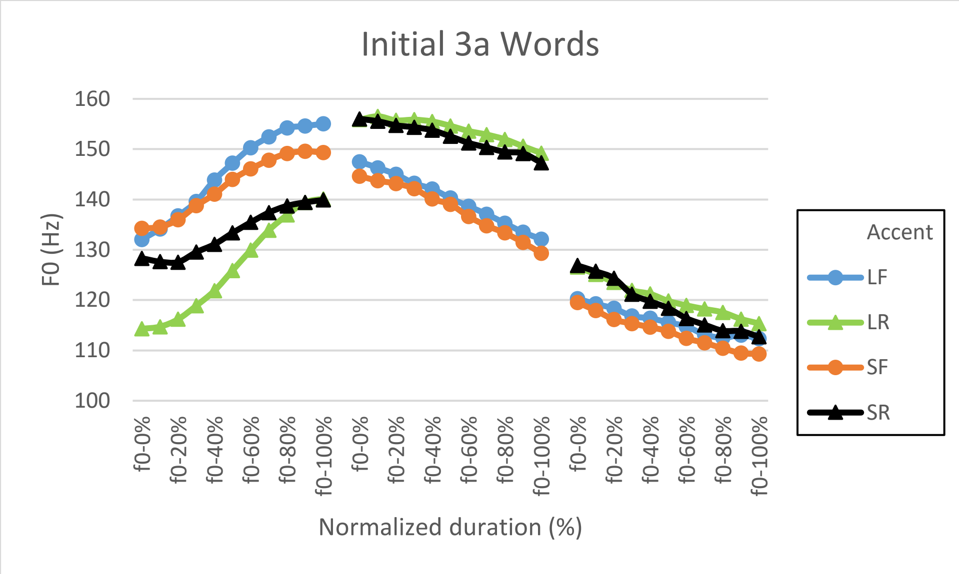


Figure 4.19. Mean F_0 track of initial 3a words

The first posttonal syllable exhibited falling contours for all accents, with a very clear distinction between falling and rising. Both the shape of the contour and its pitch hardly varied between accents of the same type. This was confirmed by an ANOVA, which had a main effect for *accent*, $F(3, 258) = 21.81$, $p < .0001$. As expected, OvMean distinguished only between rising and falling accents ($p < .0001$ for all comparisons).

Table 4.35. Number of samples in measurement points in initial 3a words across the four accents

Accent	Syllable	f0-0%	f0-10%	f0-20%	f0-30%	f0-40%	f0-50%	f0-60%	f0-70%	f0-80%	f0-90%	f0-100%
LF	Acc.	75	76	77	77	77	77	77	77	77	77	77
	Post. 1	76	77	77	77	77	77	77	77	77	77	77
	Post. 2	76	77	77	77	77	77	77	77	77	76	75
LR	Acc.	78	79	79	79	79	79	79	79	79	79	79
	Post. 1	78	78	77	77	77	77	77	76	76	76	76
	Post. 2	77	77	77	77	77	77	77	76	76	75	69
SF	Acc.	38	38	38	38	38	38	38	38	38	38	38
	Post. 1	37	37	37	37	37	37	37	37	37	37	37
	Post. 2	38	38	38	38	38	38	38	38	38	38	36
SR	Acc.	76	78	79	79	79	79	79	79	79	79	79
	Post. 1	77	77	77	77	77	77	77	77	78	78	78
	Post. 2	76	78	78	77	77	77	77	77	75	74	72

The second posttonal syllable (henceforth post. 2) continued the falling trend seen in the first posttonal (henceforth post. 1). As in post 1., accents were grouped according to accent type and rising accents had higher overall pitch, but the differences were not as obvious. Additionally, the pitch of rising post. 2 syllables was well within the range seen in rising accented syllables, whereas falling post. 2 were noticeably lower than their accented counterparts. A main effect was found for *accent*, $F(3, 257) = 7.23$, $p < .0001$, which only distinguished between SF and LR ($p = .0007$), SF and SR ($p = .0122$) and LR and LF ($p = .0041$).

b) Pitch range and PPA%

Mean values of pitch range and PPA% are shown in Table 4.36. In the accented syllable, pitch range was noticeably larger in the long accents, with rather small differences in each durational group. A main effect was found for *accent*, $F(3, 260) = 19.84$, $p < .0001$. A post hoc test distinguished only between long and short accents: LR vs. SR, LR vs. SF, LF vs. SR ($p < .0001$), LF vs. SF ($p = .0126$). This indicates that a longer duration in the accented syllable creates favourable conditions for a larger pitch range.

Table 4.36. Mean pitch range and PPA% values in initial 3a words

Accent	Syllable	Range	PPA%
LF	Acc.	26.03	-10
	Post. 1	15.68	
	Post. 2	11.21	
LR	Acc.	28.96	10
	Post. 1	10.3	
	Post. 2	13.43	
SF	Acc.	18.47	0
	Post. 1	15.86	
	Post. 2	12.07	
SR	Acc.	16.37	0
	Post. 1	11.85	
	Post. 2	15.41	

In post. 1, the distribution of pitch range is according to accent type and not quantity as in the accented syllable. Falling accents have a greater range than rising accents, of which SR is slightly larger. This was partially confirmed in an ANOVA, which had a main effect for *accent*, $F(3, 255) = 9.13$, $p < .0001$. A post hoc test showed that LR's pitch range was significantly lower than SF's ($p = .0009$) and LF's ($p < .0001$). In post. 2, pitch range shows no apparent pattern as before, with SR having the highest values, followed by LR, SF and finally with LF. A main effect was found for *accent*, $F(3, 257) = 6.22$, $p = .0004$. Only the difference between SR and LF was significant ($p = .0002$).

Median PPA% values show no difference between the short accents, with both realizing their pitch peaks at the beginning of post. 1. The biggest difference is seen between LF and LR, with the former producing peaks at the end of the accented syllable and the latter at the 10%

point of post. 1. These differences were statistically significant, as shown by a Van der Waerden test (*p* <.0001): LR vs. LF Z = 7.95 *p* <.0001, SR vs. LF Z = 6.21 *p* <.0001, SR vs. SF Z = 4.61 *p* <.0001, SF vs. LR Z = -6.13 *p* <.0001. This is compatible with the pattern seen in all conditions and word types already discussed.

c) Duration

Since 3a words have four patterns with four accents each, a table with their durational values would simply be too large to present in this subsection. Therefore, it has been moved to Appendix D under Table D.10. A review of the data presented there reveals no discernable pattern, with phonologically short syllables being often longer than phonologically long ones, and not only inside the same word, but also across different patterns. It appears that the only generalization possible is that long accents have a longer duration than short ones in the accented syllable. Furthermore, in the accented syllable, LR had the longest and SR the shortest duration (except for in ALL, where SF was the shortest). The distribution of duration in the posttonal syllables is even more chaotic, which strongly suggests that duration is only relevant in the accented syllable.

Table 4.37 shows mean and SD duration values of all accents and syllables. In the accented syllable, long accents had a longer duration, with LR being the longest and SR the shortest. A one-way ANOVA showed a main effect for *accent*, *F*(3, 299) = 46.79, *p* <.0001. A post hoc test distinguished between all accents except for SF vs. SR (LR vs. SR, LR vs. SF, LF vs. SR, LF vs. SF *p* <.0001, LR vs. LF *p* =.0141). Post. 1 shows similar values for most accents, with the exception of SR, which is somewhat shorter. A main effect was found for *accent*, *F*(3, 299) = 3.9, *p* =.0092, which only distinguished between SF and SR (*p* =.005). A very similar situation is seen in post. 2, where it is LR now that is noticeably shorter than the other accents. Post. 2 syllables were 6-10 ms longer than post. 1, with the exception of LR.There was a statistical main effect for *accent*, *F*(3, 298) = 12.63, *p* <.0001. As expected, LF, SF and SR behaved as a group against LR, which was significantly shorter (SF vs. LR, LF vs. LR *p* <.0001, SR vs. LR *p* =.0017). Even with the combined values of all patterns, duration is salient only in the accented syllable, and mostly in differentiating between long and short accents. The ratio between long and short accents in the accented syllable was 1.36 on average.

Table 4.37. Mean and SD values of duration in initial 3a words

Accent	Acc.	Post. 1	Post. 2
LF	97.81 (22.97)	52.89 (16.7)	62.45 (14.41)
LR	108.18 (22.03)	54.4 (16.99)	50.3 (13)
SF	77.22 (21.85)	57.25 (15.12)	63.85 (16.56)
SR	73.22 (21.61)	49.07 (15.24)	59.06 (17.79)

d) Summary

Initial 3a words show the same pattern found in other non-final contexts: in the accented syllable, all accents have a rising contour (especially steep in LR) and falling accents have higher overall pitch. Long accents also had a significantly larger pitch range. In post. 1, all contours are falling and grouped according to accent type, with rising accents having higher pitch values. Contours in post. 2 were also falling, and rising accents were only slightly higher than falling ones. Falling accents realized their peaks at the end of the accented syllable and rising accents at the beginning of the first posttonal. Duration was mostly relevant for the accented syllable, in which LR was the longest, followed by LF and then by SF and SR together.

4.3.1.2 Medial 3a Trisyllabic Words

a) Contour shape and overall pitch

Figure 4.20 displays the pitch contours of all medial 3a patterns. Of the four patterns, ALS is the most prototypical, since all the corresponding parameters discussed earlier are met. ASS and ASL are different in that falling accents do not have higher overall pitch in the accented syllable. Moreover, the contour of SF's accented syllable in ASL is actually falling. However, the most important parameter for distinguishing between falling and rising (as seen by the results of the phonetic investigations discussed in Chapter 2), PPA%, is highly compatible with other conditions and contexts in the ASS, ASL and ALS patterns. The situation in ALL is quite different. Although overall pitch in the accented syllable is higher for falling accents, the first posttonal syllable of SF is quite irregular. Post. 1 shows nearly identical pitch as the rising accents, and together with the lack of a noticeable fall between the first two syllables (as in LF), an incomplete change in accent type is assumed. For this reason, as in the previous section, SF in ALL will be excluded from F_0 analyses.

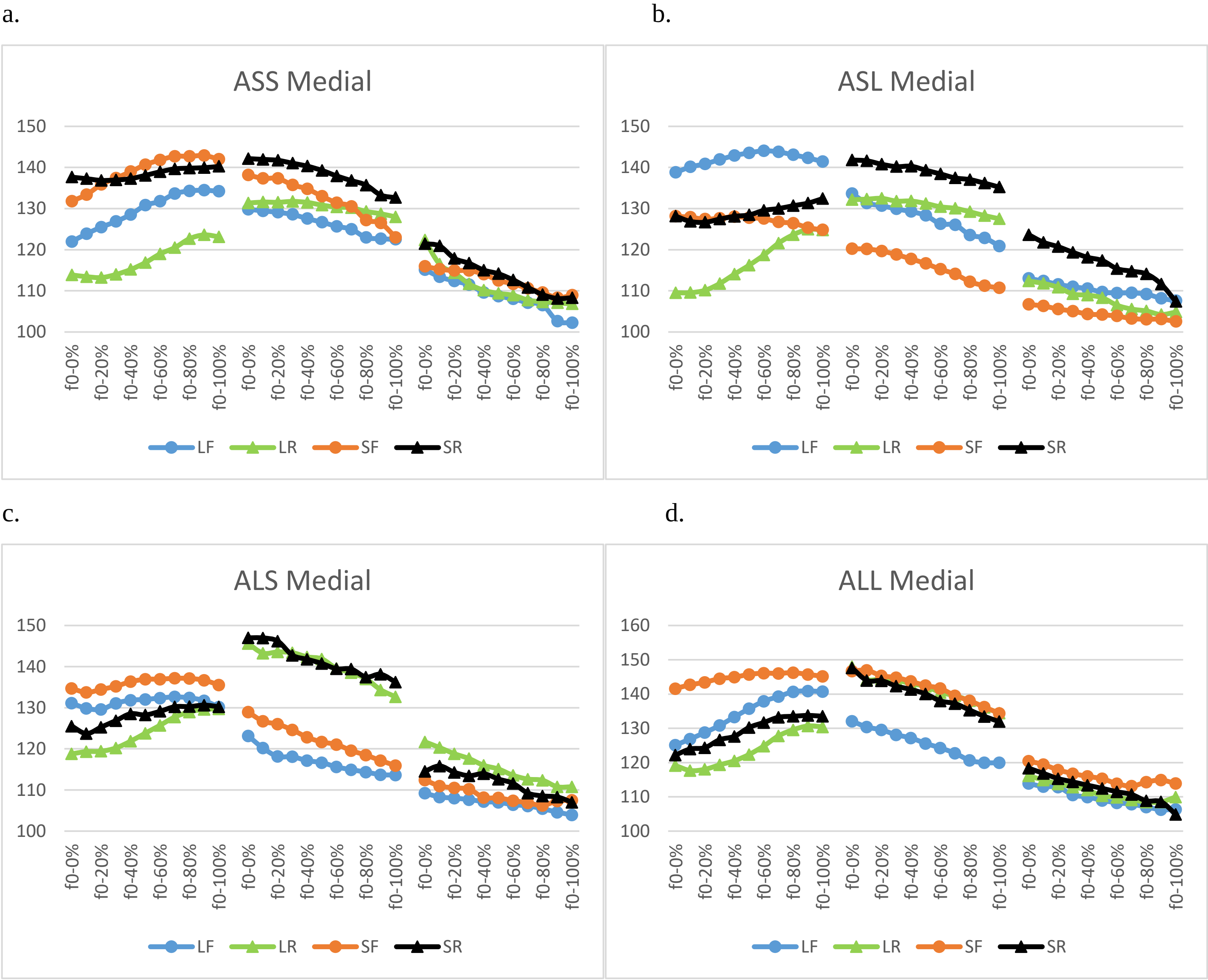


Figure 4.20. Mean F_0 tracks of medial 3a words in all four patterns

Mean F_0 tracks of combined medial 3a words are shown in Figure 4.21 and the sample size in Table 4.38. In the accented syllable, all accents have a rising contour. Rising accents have a short plateau at the beginning of the vowel, which is slightly longer than in initial condition. LR stands out due to its noticeably lower pitch and SR for its unusual proximity to the falling accents. Falling accents have higher pitch and the rising movement seen is less steep. In fact, the only two major differences (besides slightly lower overall pitch) between this condition and the initial is SR's higher pitch in the accented syllable and LR's lower pitch in the first posttonal. A one-way ANOVA showed a main effect on OvMean (log-transformed) for *accent*, $F(3, 279) = 27.87$, $p < .0001$. A post hoc test revealed that LR had significantly lower pitch than the rest of the accents, which behaved as a group ($p < .0001$ in all three comparisons). In post. 1, accents are grouped according to accent type, with rising accents being higher, much like in other conditions. SR has slightly higher pitch than LR, while both falling accents are almost identical. A main effect was found on OvMean (log-transformed) for *accent*, $F(3, 279) = 29.46$, $p < .0001$. Rising accents behaved as a group against falling accents, with a *p*-value of <.0001 in all comparisons. The falling contours continue into the second posttonal syllables. The distribution of accents is like the one found in the previous syllable, but with considerably lower values and a smaller difference between accent types. A main effect was found on OvMean (log-transformed) for *accent*, $F(3, 275) = 5.69$, $p = .0009$. A post hoc test revealed that SR had a significantly higher pitch than the falling accents, which behaved as a group (SR vs. SF $p = .0017$, SR vs. LF $p = .0040$).

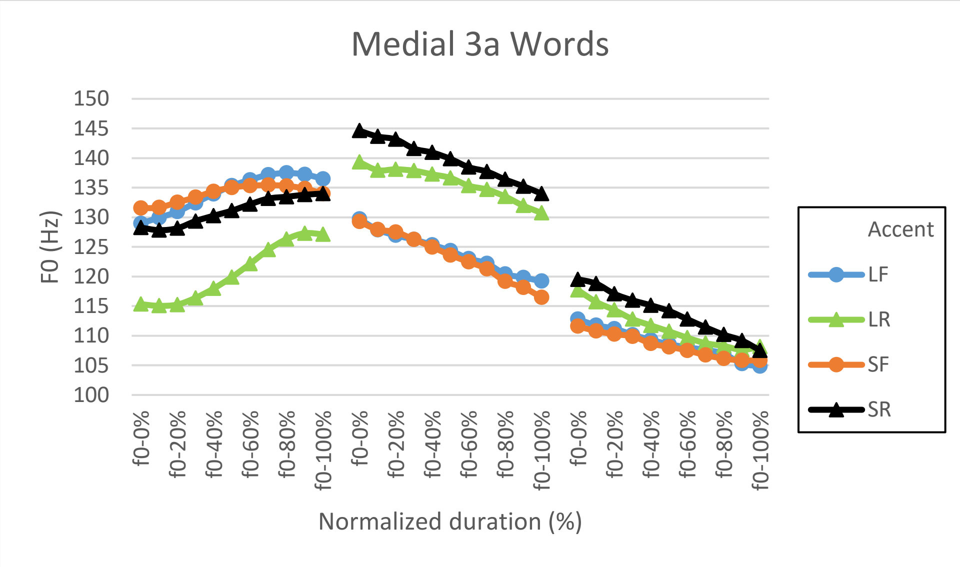


Figure 4.21. Mean F_0 tracks of medial 3a words

Table 4.38. Number of samples in measurement points in medial 3a words across the four accents

Accent	Syllable	f0-0%	f0-10%	f0-20%	f0-30%	f0-40%	f0-50%	f0-60%	f0-70%	f0-80%	f0-90%	f0-100%
LF	Acc.	77	78	78	78	78	78	78	78	78	78	78
	Post. 1	78	78	78	78	78	78	78	78	78	78	75
	Post. 2	77	79	79	79	79	79	79	78	77	76	72
LR	Acc.	77	78	78	78	78	78	78	78	78	78	78
	Post. 1	76	77	77	77	77	77	78	78	78	78	78
	Post. 2	72	73	74	74	74	74	73	73	72	68	61
SF	Acc.	59	59	59	59	59	59	59	59	59	59	59
	Post. 1	57	59	59	59	59	59	58	58	58	58	57
	Post. 2	58	59	59	58	57	57	57	56	56	53	51
SR	Acc.	73	76	76	76	76	77	77	77	77	77	77
	Post. 1	75	77	77	77	77	77	77	77	77	76	76
	Post. 2	75	76	75	75	74	74	74	74	74	74	69

b) Pitch range and PPA%

Mean values of pitch range and PPA% are shown in Table 4.39. Pitch range in the accented syllable was generally larger for long accents, although SR was quite close. SF's pitch range was the smallest, which is also seen in its relatively level contour. An ANOVA showed a main effect for *accent*, $F(3, 279) = 5.8$, $p = .0007$. However, only the differences between LR and SF ($p = .0004$) and SR ($p = .0253$) were significant.

Table 4.39. Mean pitch range and PPA% values in medial 3a words

Accent	Syllable	Range	PPA%
LF	Acc.	12.35	-20
	Post. 1	11.61	
	Post. 2	8.87	
LR	Acc.	14.44	0
	Post. 1	9.68	
	Post. 2	10.51	
SF	Acc.	8.92	-40
	Post. 1	12.85	
	Post. 2	7.1	
SR	Acc.	10.47	0
	Post. 1	11.21	
	Post. 2	13.13	

Pitch range in post. 1 varied little between the accents, except for SF, which had a relatively larger value. There was a main effect for *accent*, $F(3, 279) = 3.49$, $p = .016$, but only SF differed from LR ($p = .0089$). In post. 2, range was generally larger in rising accents than in falling ones, which is best seen in SR and SF. A main effect was found for *accent*, $F(3, 274) = 3.34$, $p = .0196$. A post hoc test showed that SR's pitch range was significantly higher than SF's ($p = .025$).

Median PPA% values show that, compared to the initial position, pitch peaks (especially in falling accents) are produced earlier. As in other conditions and word types, pitch peaks in falling accents appear roughly in the last third of the accented syllable, while they occur at the beginning of the posttonal in rising accents. This was confirmed in a Van der Waerden test ($p < .0001$): LR vs. LF Z = 7.18 $p < .0001$, SR vs. LF Z = 5.08 $p < .0001$, SR vs. SF Z = 6.21 $p < .0001$, SF vs. LR Z = -7.89 $p < .0001$.

c) Duration

Mean and SD duration values of all accents and patterns are displayed in Appendix D under Table D.13. Much like in the previous condition, duration was very inconsistently distributed across patterns and accents. In general, long accents had a longer duration than short accents, although in some cases, the difference between them was rather minimal (like LF and SF in ASL). The accent with the longest duration was by far LR, which was shorter than LF only in ALS. Likewise, SR had the shortest duration, which was longer than SF in ALS. Posttonal syllables showed a rather chaotic distribution that showed no clearly discernable pattern. For the most part, phonologically long syllables were only slightly longer than short ones, especially in ASL.
Table 4.40 shows mean and SD duration values of all accents and syllables. Duration in the accented syllable varied mainly between long and short accents, with LR being considerably longer than LF. The average ratio between long and short accented syllables was 1.41. A one-way ANOVA showed a main effect on Duration (log-transformed) for *accent*, $F(3, 299) = 58.62$, $p < .0001$. A post hoc test revealed that the short accents behaved as a group against LF and LR, of which the latter was significantly longer (all comparisons had a *p*-value of <.0001).

Table 4.40. Mean and SD values of duration in medial 3a words

Accent	Acc.	Post. 1	Post. 2
LF	96.68 (20.33)	50.82 (14.68)	57.18 (17.54)
LR	117.27 (24.31)	51.53 (13.93)	52.8 (18.55)
SF	77.03 (23.27)	56.09 (15.36)	55.52 (17.45)
SR	74.41 (16.51)	48.45 (12.75)	54.31 (17.45)

In the first posttonal syllable, duration varied quite little between the accents. SF had the longest duration by a small margin, while SR was the shortest. A main effect was found on Duration (log-transformed) for *accent*, $F(3, 300) = 3.83$, $p = .0102$, but only the difference between SF and SR was significant ($p = .006$). In post. 2, duration was almost identical in all accents, which was confirmed by the lack of significance in a one-way ANOVA. These results suggest that, like in bisyllabic words, duration is salient mostly in the accented syllable.

d) Summary

The production of tone in medial 3a words is in many aspects the same as in the initial condition. The same patterns as in other contexts are clearly discernable, which is why they will not be repeated in detail here. However, the considerably longer duration, lower overall pitch and pitch peaks of LR, which are also found in the previous condition, appear to be a characteristic of 3a words.

4.3.1.3 Final 3a Trisyllabic Words

a) Contour shape and overall pitch

Figure 4.22 displays the pitch contours of all final 3a patterns. Compared with the previous conditions, contours in final 3a words vary much less across patterns. Most accents' pitch values are very similar except for LR, which is noticeably lower. Only in the ALS pattern is LR together with the other accents. In the ASS, ASL and ALS patterns, rising accents in post. 1 are higher than falling accents, except for ALL, where only SR is.

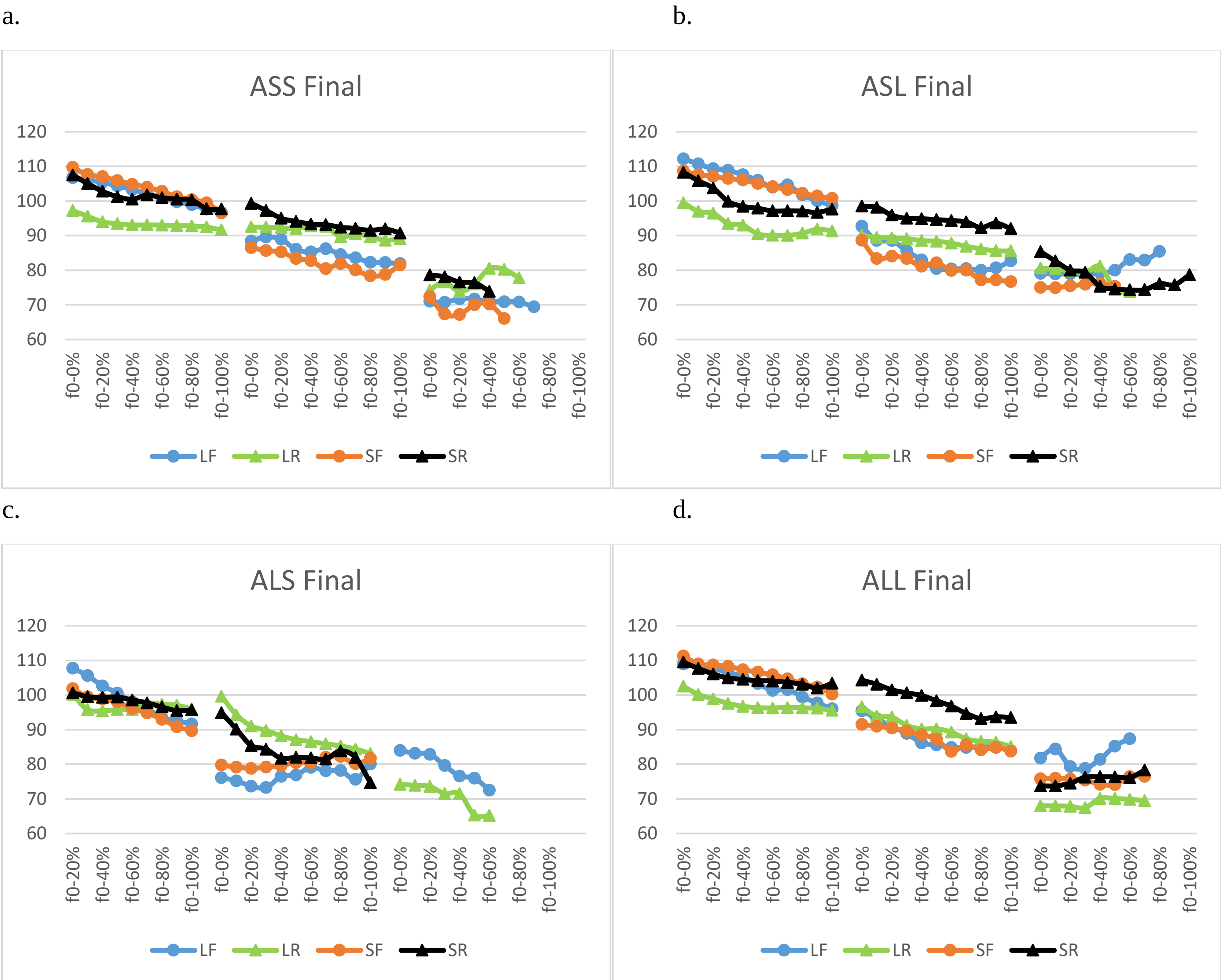


Figure 4.22. Mean F_0 tracks of final 3a words in all four patterns

An interesting and unexpected variation is found in ALS, where post. 1 actually starts with higher pitch than the previous syllable ends. Another thing all patterns have in common is an abundance of missing values in the second posttonal syllable, which can be seen best in ALS, which has no measurements for SF and SR. Generally, short accents tended to have more missing values. This resulted in very skewed and unrealistic contours. Otherwise, patterns in final 3a words were much more similar to each other when compared to other conditions. Mean F_0 tracks of combined final 3a words are shown in Figure 4.23 and the sample size in Table 4.41. In the accented syllable, all accents have a distinctly falling contour. Accents are mostly grouped around each other, except for LR, which stands out with its lower pitch. A one-way ANOVA revealed a main effect on OvMean (log-transformed) for *accent*, $F(3, 285) = 13.96$, $p < .0001$. LR's overall pitch was significantly lower than the rest of the accents, which behaved as a group (all comparisons had a *p*-value of <.0001). These results indicate only a marginal tonal contrast in the accented syllable. In post. 1, falling accents had an identical falling contour. Rising accents were also falling and grouped around each other, with RS having higher pitch. There was a statistical main effect on OvMean (log-transformed) for *accent*, $F(3, 245) = 9.41$, $p < .0001$. A post hoc test showed that SR was significantly higher than SF ($p < .0001$) and LF ($p = .0009$) and that LR was higher than SF ($p = .0081$), indicating an almost full tonal contrast in that syllable.

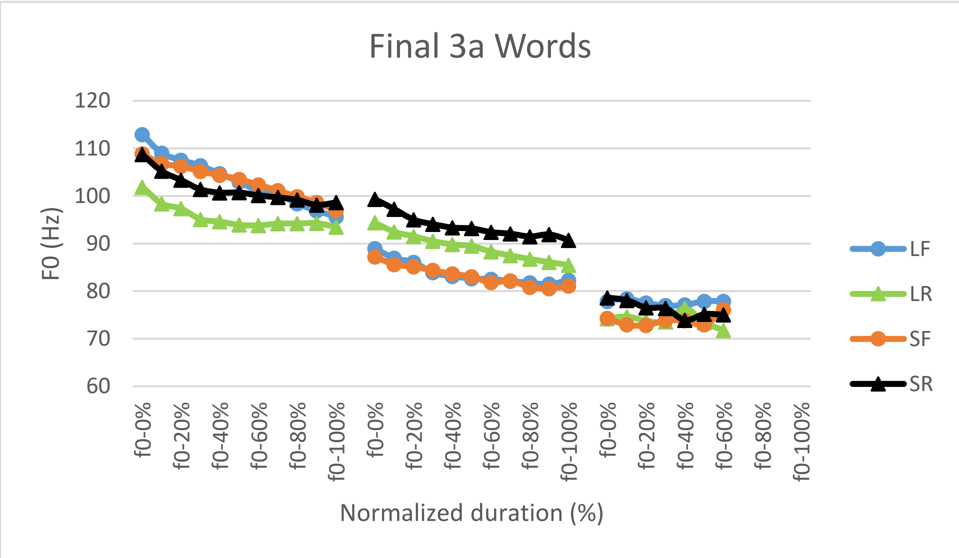


Figure 4.23. Mean F_0 tracks of final 3a words

In the final syllable, all measurement points after *f0-60%* were removed from the analysis because of their very erratic nature (for instance, LR or SF in the ASS pattern), which is attributed to many missing values causing the overall contour to be skewed. As seen in the Figure above, all accents in post. 2 are grouped tightly around each other and have a level contour, with no apparent differences. Consequently, no significant effect was found for *accent*.

Table 4.41. Number of samples in measurement points in final 3a words across the four accents

Accent	Syllable	f0-0%	f0-10%	f0-20%	f0-30%	f0-40%	f0-50%	f0-60%	f0-70%	f0-80%	f0-90%	f0-100%
LF	Acc.	70	74	74	74	74	74	74	74	74	73	69
	Post. 1	44	48	49	49	51	51	47	45	42	39	35
	Post. 2	23	24	25	26	22	21	19	**15**	**10**	**6**	**3**
LR	Acc.	74	76	76	76	77	77	77	76	75	73	72
	Post. 1	65	71	71	71	69	67	66	65	65	59	53
	Post. 2	27	26	27	26	22	19	17	**11**	**9**	**7**	**4**
SF	Acc.	66	69	72	72	72	72	72	72	72	71	70
	Post. 1	55	57	59	59	57	58	55	52	52	48	41
	Post. 2	22	23	24	21	20	20	16	**15**	**12**	**9**	**6**
SR	Acc.	63	74	74	75	75	75	75	75	72	70	66
	Post. 1	65	67	68	68	69	67	67	64	61	56	49
	Post. 2	25	26	28	27	27	25	23	**21**	**14**	**11**	**8**

b) Pitch range and PPA%

Mean values of pitch range and PPA% are shown in Table 4.42. In the accented syllable, pitch range was greatest in LF, followed by SF, SR and lowest in LR. A one-way ANOVA had a main effect for *accent*, $F(3, 285) = 13.19$, $p < .0001$. A post hoc test showed that LF's range was significantly greater than all other accents (LF vs. LR $p < .0001$, LF vs. SR $p = .0016$, LF vs. SF $p = .0174$) and that SF was significantly higher than LR ($p = .0078$).
Pitch range in post. 1 was much smaller than in the accented syllable and did not vary much between different accents, which is why there was significant effect found. In the final syllable, pitch range was even smaller than in the medial syllable, except for SR, which had a value almost twice as high as the rest. Nevertheless, these differences were also not significant.
PPA% did not vary at all between the accents, with all peaks being realized right at the beginning of the accented syllable. A Van der Waerden test found no significance neither for *accent* nor for *accent type*. This suggests that PPA% is not salient in distinguishing between rising and falling accents in final 3a words.

Table 4.42. Mean pitch range and PPA% values in final 3a words

Accent	Syllable	Range	PPA%
LF	Acc.	19.55	-100
	Post. 1	8.52	
	Post. 2	4.71	
LR	Acc.	10.21	-100
	Post. 1	9.01	
	Post. 2	3.42	
SF	Acc.	13.38	-100
	Post. 1	10.21	
	Post. 2	3.86	
SR	Acc.	12.55	-100
	Post. 1	9.88	
	Post. 2	7.65	

c) Duration

Mean and SD duration values of all accents and patterns are displayed in Appendix D under Table D.16. The distribution of duration across patterns appears to be as undefined as in other conditions, but several differences can be observed. Due to the presence of final lengthening, as can be seen in previous final contexts, almost all segments are longer. In the accented syllable, LR has by far the longest duration in all patterns, which is especially obvious in ASL, where LR is 50 ms longer than LF. SR's accented syllable has the shortest duration, except in ALL, where SF is slightly shorter. Distinguishing duration in the final condition is the fact that in almost every pattern and almost for every accent, the final syllable is substantially longer than the first posttonal. In one case, namely SR in ASS, post. 2 surpasses the accented syllable in duration. This is, however, clearly a result of final lengthening, and not a feature of tone.

Table 4.43 shows mean and SD duration values of all accents and syllables. In the accented syllable, LR had the longest duration, which was noticeably higher than LF's. Short accents, on the other hand, had almost the same values. The average ratio between long and short accents was 1.41. A one-way ANOVA had a main effect on Duration (log-transformed) for *accent*, $F(3, 287) = 56.54$, $p < .0001$. All comparisons except SF vs. SR were statistically significant with a *p*-value of <.0001. Differences in post. 1 were much less pronounced, with SF having a slightly higher duration than the rest. A main effect was found on Duration (log-transformed) for *accent*, $F(3, 287) = 3.77$, $p = .011$. A post hoc test showed that SF's duration was significantly longer than SR's ($p = .0067$). In post. 2, values were also very similar to each other, with only LR standing out as the shortest one. Furthermore, all post. 2 syllables were longer than their corresponding post. 1 syllables. A significant main effect was found on Duration (log-transformed) for *accent*, $F(3, 287) = 6.54$, $p = .0003$. LR's duration was significantly shorter than all other accents: SR ($p = .0003$), SF ($p = .0031$) and LF ($p = .048$). This is a further indication that duration is relevant only in the accented syllable.

Table 4.43. Mean and SD values of duration in final 3a words

Accent	Acc.	Post. 1	Post. 2
LF	111.22 (27.09)	59.13 (15.13)	70.09 (19.24)
LR	134.68 (22.87)	61.79 (16.78)	62.89 (19.3)
SF	88.18 (27.49)	66.93 (21.21)	74.14 (21.68)
SR	86.14 (23.47)	56.85 (17.73)	75.82 (22.03)

d) Summary

In conclusion, contours in the accented syllable are universally falling and LR has the lowest pitch, while the rest of the accents are grouped around each other. All accents' pitch peaks were produced at the beginning of the accented syllable, showing no difference between types. LR had a noticeably higher duration than other accents, followed by LF and lowest for SF and SR. In post. 1, the contours continue to fall with a compressed pitch range. Falling accents have identical pitch and are lower than rising accents. This way, tonal contrast is preserved (at least marginally) in both syllables. In the final syllable, pitch range is even more compressed, which gives a uniform level contour to all accents, without any further major differences. Duration varied little in both posttonals, indication no durational contrast.

4.3.1.4 Overview and Comparison of 3a Trisyllabic Words

a) Contour shape and overall pitch

Patterns seen in previous contexts are mainly the same as in 3a words. Non-initial conditions exhibit a rising contour for all accents in the accented syllable. In bisyllabic words, opposition between the individual accents was usually realized as a combination of duration (distinguishing mainly between long vs. short) and F_0 (differentiating between rising and falling accents). In 3a words, LR is distinguished from SR not only through longer duration, but also through lower pitch. Falling accents, on the other hand, have nearly identical contours and pitch. The first posttonal syllable follows the same patterns as in previous contexts: contours are all falling and rising accents have higher overall pitch. The same falling-level trend and higher pitch for rising accents is continued, albeit to a much lesser degree, in the final syllable. As seen in the previous subsections, tonal and durational opposition in the final syllable is generally quite weak, which makes it somewhat redundant. A one-way ANOVA with *accent type*, *syllable type*, *sentence* and their respective interactions was conducted. There was a statistical main effect for the interaction *sentence* x *syllable type*, $F(4, 2327) = 65.19$, $p < .0001$. A post hoc test showed that all comparisons except for medial post. 1 vs. medial acc. were highly significant with a *p*-value of <.0001. Syllables in the initial condition had a higher overall pitch (first post. 1 and then acc.), followed by the first two medials, initial and medial post. 2 and finally, all three syllables in the final condition. The interaction between *syllable type* and *accent type* was also significant, $F(2, 2327) = 150.42$, $p < .0001$. A post hoc test differentiated between all accent/syllable combinations except for rising post. 1 and falling acc., which also had the highest overall pitch. Following these two were rising acc., falling post. 1 and post. 2 of both accent types (almost all comparisons had a *p*-value of <.0001). These results confirm the existence of distinct pitch patterns for every sentence position across accent type and syllable type.

b) Pitch range and PPA%

Table 4.44 displays mean pitch range and PPA% values for accent types across all conditions. The distribution of pitch range was as follows: largest in the initial condition, intermediate in the final and smallest in the medial. Note that this is more correct for accented syllables, since posttonals in the final condition had a substantially smaller range than in all other contexts. Using the same statistical model as above, a main effect on Range was found for *sentence* x *syllable type* - $F(4, 2312) = 29.93$, $p < .0001$ and *syllable type* x *accent type* - $F(4, 2311) = 15.71$, $p < .0001$. These results show that, in general, pitch range tended to be greater in initial accented syllables, usually followed by medials and then finals. Within each condition, pitch range was higher in acc. than in post. 1, which was then higher than in post. 2. Furthermore, there were no significant differences between rising and falling within each syllable.

PPA% values can be divided into final and non-final conditions. In the final, no difference in the median value of PPA% between the accent types can be observed, with both realizing their pitch peaks right at the start of the accented syllable. The tonal contrast in the final position is expressed through a difference in overall pitch, as previously explained. In non-final conditions, a clear distinction is seen between initial and medials: falling accents placed their peaks closer to the end of the accented syllable in the initial condition. Rising accents, on the other hand, show no such variation, with peaks produced at the beginning of the first posttonal in both conditions. Comparing all sentence positions in a Van der Waerden test ($p < .0001$) shows that all differences are statistically significant: initial vs. final $Z = 15.57$ *p*

<.0001, medial vs. final Z = 13.76 *p* <.0001, initial vs. medial Z = 4.48 *p* <.0001. Notice that the difference between initial and medial is the smallest. The difference between accent types alone was also highly significant, Z = 9.71 *p* <.0001.

Table 4.44. Mean pitch range and PPA% values of accent types in 3a words across sentence conditions

Condition	Acc. Type	Syllable	Range	PPA%
Initial	Falling	Acc.	23.53	-10
		Post. 1	15.74	
		Post. 2	11.49	
	Rising	Acc.	22.67	0
		Post. 1	11.08	
		Post. 2	14.42	
Medial	Falling	Acc.	10.87	-30
		Post. 1	12.14	
		Post. 2	8.11	
	Rising	Acc.	12.47	0
		Post. 1	10.44	
		Post. 2	11.84	
Final	Falling	Acc.	16.5	-100
		Post. 1	9.41	
		Post. 2	3.88	
	Rising	Acc.	11.36	-100
		Post. 1	9.44	
		Post. 2	5.23	

c) Duration

Mean and SD values of duration across accent types and sentence positions are shown in Table 4.45. Generally speaking, duration in the initial and medial conditions was very similar and varied little between accent types. In the final condition, however, everything is longer, which suggests a final lengthening effect. Furthermore, all post. 2 syllables had a longer duration than their respective post. 1 syllables. With Duration as an independent variable, a significant main effect was found for *sentence* x *syllable type* - $F(4, 2748) = 4.46$, $p = .0014$ and *syllable type* x *accent type* - $F(2, 2748) = 23.81$, $p < .0001$. A post hoc test revealed that for the most part, accented syllables had the longest duration (final > medial > initial), followed by final posttonals and then non-final posttonals, which behaved as a group. In the accented syllable, rising accents had a longer duration, while the reverse was true for both posttonals.

Table 4.45. Mean and SD values of duration across accent types and sentence conditions in 3a words

Condition	Acc. Type	Acc.	Post. 1	Post. 2
Initial	Falling	87.52 (29.55)	55.07 (18.71)	63.15 (20.5)
	Rising	90.7 (33.56)	51.74 (17.38)	54.71 (21.63)
Medial	Falling	86.86 (23.91)	53.46 (15.21)	56.34 (16.49)
	Rising	95.84 (29.85)	50 (13.4)	53.55 (17.96)
Final	Falling	99.94 (24.61)	62.95 (16.03)	72.07 (15.49)
	Rising	110.57 (27.94)	59.33 (16.31)	69.31 (16.16)

d) Summary

A summary of the acoustic characteristics of 3a words is shown below in Table 4.46. Entries under Contour, Pitch and Duration are given for the accented, first posttonal and second posttonal syllables, separated by a hyphen. Note that entries under Pitch are in relation to the other accents. For instance, the low-high-low of final LR means that pitch was lower in relation to the other accents in the accented syllable and higher than the rest in post. 1. Since pitch in final post. 2 was practically the same for all accents, it was entered as "low" in all cases. For duration, values over 90 ms were defined as "long", between 60 ms and 90 ms as "inter." (intermediate) and everything below 60 ms as "short".

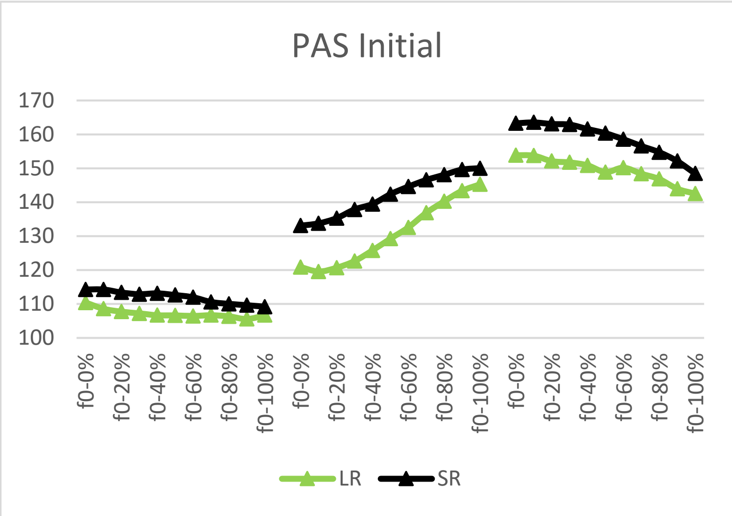
Table 4.46. Summary of the acoustic characteristics of falling and rising accents in 3a words

Condition	Parameter	LF	LR	SF	SR
Initial	Contour	steep rise-fall-fall	steep rise-fall-fall	rise-fall-fall	rise-fall-fall
	Pitch	high-low-low	low-high-low	high-low-low	low-high-low
	PPA%	-10	10	0	0
	Duration	long-short-inter.	long-short-short	inter.-short-inter.	inter.-short-short
Medial	Contour	rise-fall-fall	steep rise-fall-fall	rise-fall-fall	rise-fall-fall
	Pitch	high-low-low	low-high-low	high-low-low	high-high-low
	PPA%	-20	0	-40	0
	Duration	long-short-short	long-short-short	inter.-short-short	inter.-short-short
Final	Contour	fall-fall-level	fall-fall-level	fall-fall-level	fall-fall-level
	Pitch	high-low-low	low-high-low	high-low-low	high-high-low
	PPA%	-100	-100	-100	-100
	Duration	long-short-inter.	long-inter.-inter.	inter.-inter.-inter.	inter.-short-inter.

4.3.2 3b Trisyllabic Words

Since 3b words have two patterns and two accents, their respective mean F_0 tracks are presented side-by-side in Figure 4.24. The resemblance between the patterns is quite obvious. The only major difference can be observed in the initial and medial conditions.

a.



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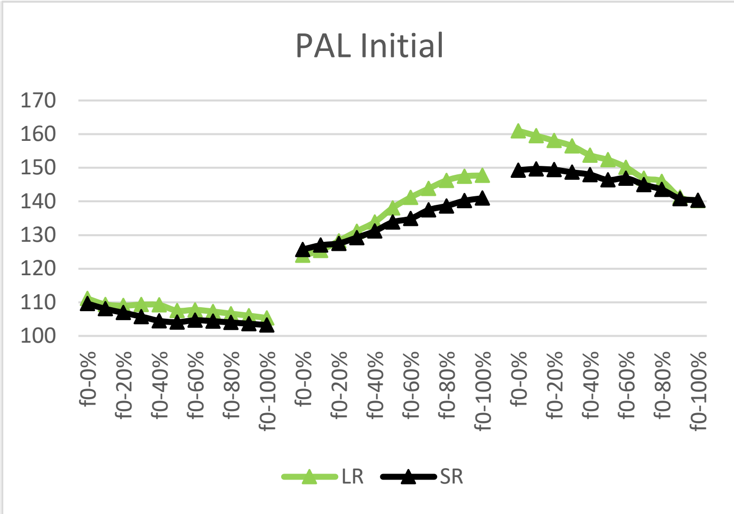

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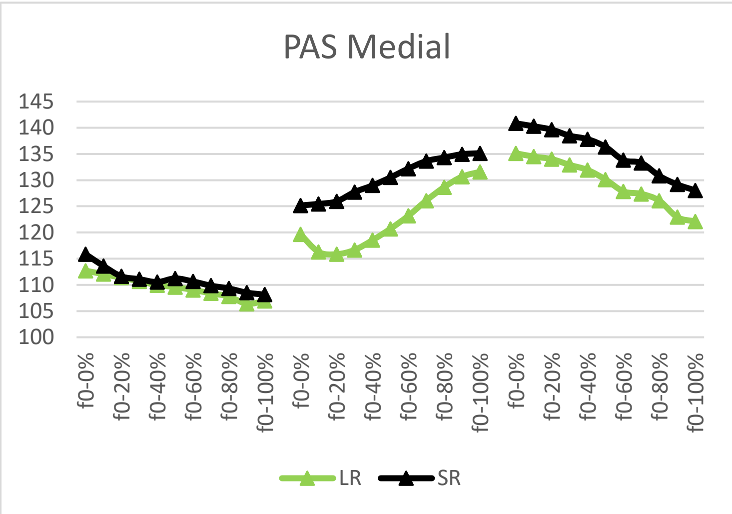

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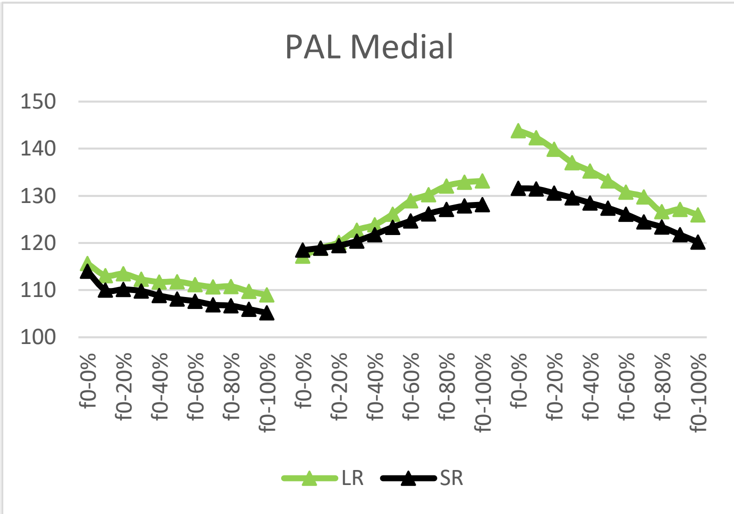

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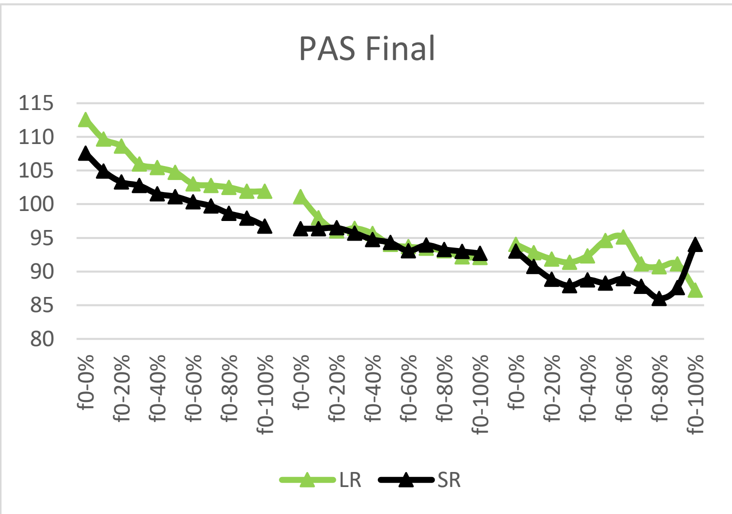

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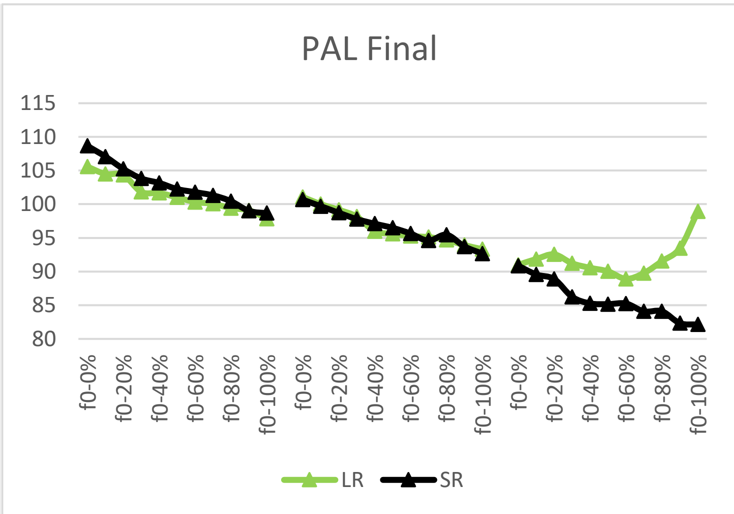

Figure 4.24. Mean F_0 tracks of 3b words in all conditions and patterns

LR's accented syllable in PAS has a level (initially) or falling contour (medially) at the beginning of the vowel, with noticeably lower pitch, which is also seen in the posttonal. In PAL, however, LR's contour shape and overall pitch is much more like SR's, actually being slightly higher and steeper in the accented and posttonal syllables.

In the final condition, some values (especially LR in PAL) were skewed upwards due to missing values in the last 40% of the posttonal. Due to the high similarity between patterns, 3b words will be discussed together in the following subsection. Furthermore, since the only accents represented in this word type are rising, PPA% values should be predominantly positive, judging by the results in the previous sections. A comparison of both accents' PPA% distribution in Figure 4.25 confirms this.

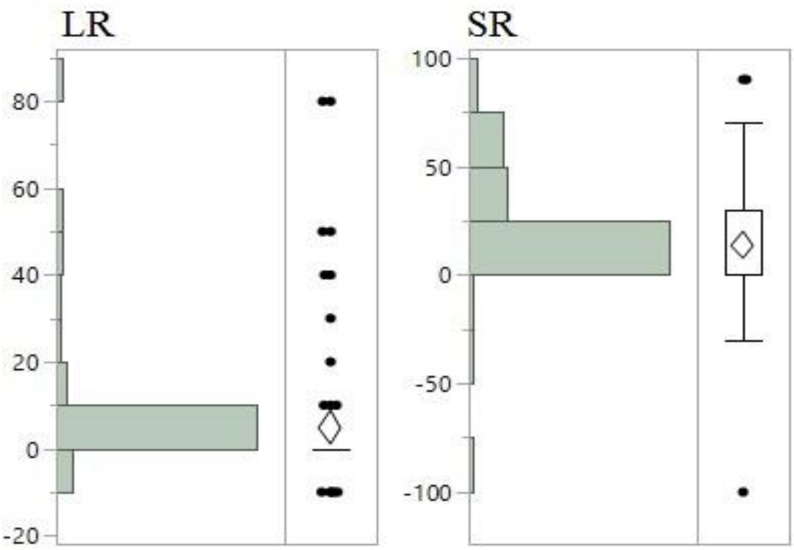

Figure 4.25. Distribution of rising accents' PPA% values in initial 3b words

This distribution means that interference from high negative values (as seen in bisyllabic words, for instance), is reduced to a minimum when only rising accents are in question. As seen in Table 4.47 below, the statistical mean is a much better representative for PPA% than the median. For this reason, ANOVAs (and not Van der Waerden tests) will be conducted in the following sections.

4.3.2.1 Initial 3b Trisyllabic Words

a) Contour shape and overall pitch

Mean F_0 tracks are displayed in Figure 4.26 and the sample size in Table 4.47. In the pretonal syllable (henceforth pre. 1), both accents have the exact same mildly falling contour, with no differences in pitch between SR and LR. As expected, there was no statistical main effect for *accent*. The accented syllable exhibited slightly different contours and overall pitch values for each accent: LR's contour started with a short plateau, after which a steep rise could be observed, whereas SR was more straightforward, without any delay in the rising movement. Furthermore, LR's pitch was slightly lower than SR's up until the 70%-point, where the accents then merged. A main effect was found for *accent*, $F(1, 143) = 4.42$, $p = .0371$. A post hoc test showed that SR had significantly higher pitch, even though the difference was only ca. 3 Hz. In post. 1, both contours were falling, which was somewhat steeper than in pre. 1. However, since the accents were so close to each other, no statistical differences between them with respect to OvMean were found.

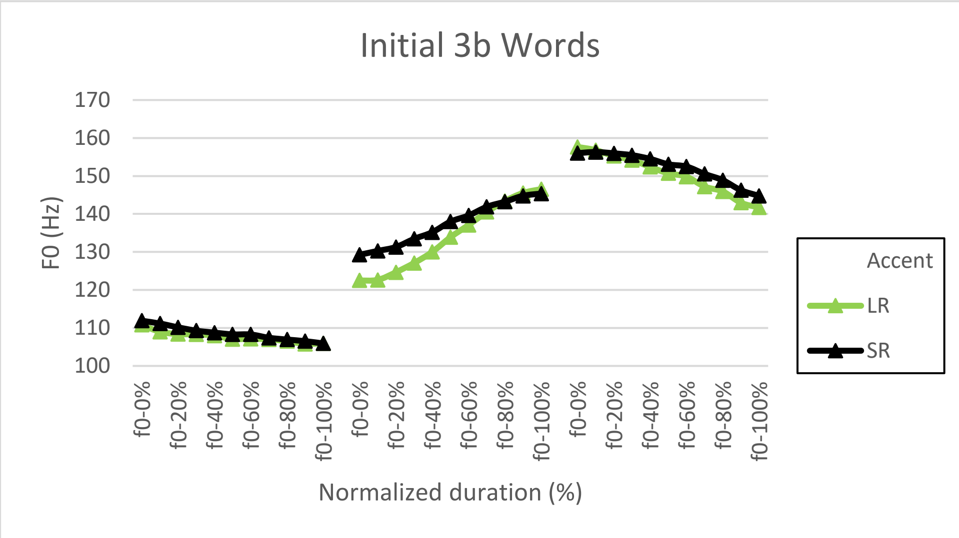

Figure 4.26. Mean F_0 tracks of initial 3b words

Table 4.47. Number of samples in measurement points in initial 3b words across the two rising accents

Accent	Syllablle	f0-0%	f0-10%	f0-20%	f0-30%	f0-40%	f0-50%	f0-60%	f0-70%	f0-80%	f0-90%	f0-100%
LR	Pre. 1	73	74	75	75	75	76	75	75	74	72	72
	Acc.	74	76	76	76	76	76	76	76	76	76	76
	Post. 1	75	75	76	76	76	76	75	74	74	72	72
SR	Pre. 1	72	74	74	75	75	75	75	74	74	73	69
	Acc.	77	78	78	78	78	78	78	78	78	78	78
	Post. 1	77	77	77	77	77	77	77	77	77	77	76

b) Pitch range and PPA%

Mean values of pitch range and PPA% are shown in Table 4.48. For both accents, pitch range is consistently smallest in the pretonal, followed by the posttonal and highest in the accented syllable. Much like in 3a and bisyllabic words, LR had a greater pitch range throughout the entire word, which is best seen in the accented syllable. Consequently, there was a main effect for *accent* only in the accented syllable, $F(1, 143) = 21.57$, $p < .0001$.

Table 4.48. Mean pitch range and PPA% values in initial 3b words

Accent	Syllable	Range	PPA%
LR	Pre. 1	9.98	
	Acc.	25.76	3.81
	Post. 1	17.16	
SR	Pre. 1	7.78	
	Acc.	17.26	13.63
	Post. 1	14.33	

As seen by the mean PPA% values above, both accents produced their pitch peaks in the posttonal syllable, exactly like in previous contexts. The peak in SR was realized almost 10% later than in LR. This was confirmed statistically by a one-way ANOVA, which had a main effect for *accent*, $F(1, 142) = 10.42$, $p = .0015$. These results indicate a tonal contrast between LR and SR in 3b words .

c) Duration

Mean and SD values of duration of accents and syllables across patterns are displayed in Table 4.49. In both patterns, LR was longer than SR, although the difference in PAL was surprisingly small. Pre. 1 was also always shorter than post. 1, regardless of phonological length. However, it can be seen that the difference between these two syllables is much bigger for SR. A one-way ANOVA with *accent*, *pattern*, *syllable type* and their interactions was conducted. There were main effects for *accent* x *pattern*, $F(1, 441) = 58.19$, $p < .0001$, *accent* x *syllable type*, $F(2, 441) = 33.18$, $p < .0001$ and *syllable type* x *pattern*, $F(2, 441) = 4.32$, $p = .0138$. Post hoc tests showed that LR in PAS was significantly longer than both accents in PAL, with SR in PAS having the shortest duration. Syllable types' duration did not vary significantly between patterns. Furthermore, accented syllables in both patterns were the longest, followed by both post. 1 syllables and then both pretonals.

Table 4.49. Mean and SD duration values in initial 3b words across patterns

Pattern	Accent	Syll. Type	Duration (ms)
PAS	LR	Pre. 1	56.01 (20.91)
		Acc.	115.18 (21.87)
		Post. 1	59.49 (18.89)
	SR	Pre. 1	40.64 (11.06)
		Acc.	72.61 (22.44)
		Post. 1	58.47 (20.5)
PAL	LR	Pre. 1	44.83 (10.87)
		Acc.	88.99 (16.85)
		Post. 1	55.03 (12.99)
	SR	Pre. 1	49.15 (11.5)
		Acc.	82.73 (21.44)
		Post. 1	69.95 (14.7)

Table 4.50 shows mean and SD duration values of all accents and syllables. Like in the comparison above, LR's accented syllable was longer than SR's, with a ratio of 1.3. Pretonal syllables were the shortest in the entire word and were also shorter than the posttonal, which is best seen in SR. Main effects were found for *accent* in all three syllables: pre. 1, $F(1, 142) = 5.21$, $p = .0239$; acc. , $F(1, 142) = 45.91$, $p < .0001$; post. 1, 1, $F(1,143) = 7.45$, $p = .0071$. Post hoc tests confirmed that LR's pretonal and accented syllables were significantly longer and that SR's posttonal was longer. These results indicate a unique durational pattern for each accent in every syllable.

Table 4.50. Mean and SD duration values in initial 3b words

Accent	Syll. Type	Duration (ms)
LR	Pre. 1	50.05 (17.17)
	Acc.	101.56 (23.36)
	Post. 1	57.14 (16.1)
SR	Pre. 1	45 (12)
	Acc.	77.8 (22.38)
	Post. 1	64.36 (18.56)

d) Summary

In conclusion, both accents exhibit a mild fall in the pretonal, which lasts slightly longer in LR. In the accented syllable, LR has slightly lower pitch and a steeper contour with a short delay at the beginning. Additionally, LR's pitch range and duration is higher than SR's. The posttonal has a falling contour for both accents, which is steeper and longer than in the pretonal. These results show that the contrast between LR and SR in this context is both tonal and durational.

4.3.2.2 Medial 3b Trisyllabic Words

a) Contour shape and overall pitch

Mean F_0 tracks are displayed in Figure 4.27 with the sample size in Table 4.51. The contour shape and overall pitch values in the medial condition are strikingly similar to the initial condition. For both accents, the pretonal has a mild falling contour, followed by a rising one in the accented syllable. LR has a slight delay at the beginning, whereas SR is more straightforward. In the posttonal syllable, both accents have a steeper fall than in pre. 1, with LR having slightly higher pitch at the beginning. However, no significant differences were found in any of the syllables, indicating that both accents have the same contour and overall pitch in the medial position.

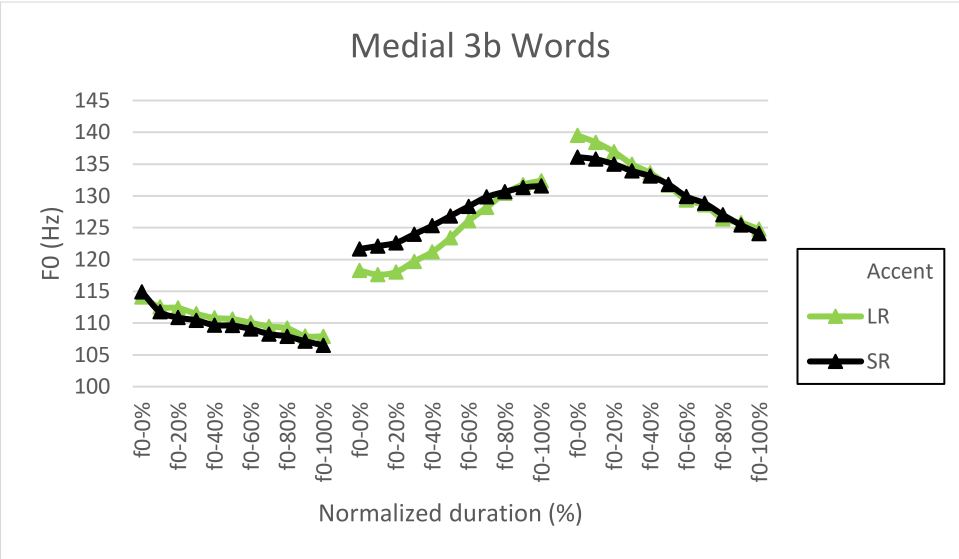

Figure 4.27. Mean F_0 tracks of medial 3b words

Table 4.51. Number of samples in measurement points in medial 3b words across the two rising accents

Accent	Syllable	f0-0%	f0-10%	f0-20%	f0-30%	f0-40%	f0-50%	f0-60%	f0-70%	f0-80%	f0-90%	f0-100%
LR	Pre. 1	74	75	76	76	76	75	75	75	73	73	72
	Acc.	75	79	79	80	80	80	80	80	80	80	80
	Post. 1	80	80	80	80	80	80	80	80	79	77	75
SR	Pre. 1	76	76	77	77	77	76	76	75	74	74	73
	Acc.	74	78	78	78	78	78	78	78	78	78	78
	Post. 1	78	78	78	78	77	77	77	77	77	77	75

b) Pitch range and PPA%

Mean values of pitch range and PPA% are shown in Table 4.52. Pitch range in the pretonal was consistently lower than in the other syllables, and the difference between SR and LR was not significant. In the accented syllable, LR's range is noticeably larger than SR's and there was a main effect for *accent* in the accented syllable, $F(1, 147) = 16.3$, $p < .0001$. In post. 1, range was very similar to the accented syllable and larger than the pretonal, being higher for LR. A main effect was found for *accent*.

Table 4.52. Mean pitch range and PPA% values in medial 3b words

Accent	Syllable	Range	PPA%
LR	Pre. 1	9.04	
	Acc.	18	-1.5
	Post. 1	16.32	
SR	Pre. 1	8.79	
	Acc.	12.18	-1.41
	Post. 1	13.13	

PPA%'s mean values were slightly skewed due to some negative values. However, with a median of 0% for both accents, these values can still be considered typical for rising accents, with peaks being realized at the beginning of the posttonal syllable. Nevertheless, a one-way ANOVA showed no main effect for *accent*. Compared to initial 3b words, tonal contrast and overall values in the medial position were smaller.

c) Duration

Mean and SD values of duration of accents and syllables across patterns are displayed in Table 4.53. The accented syllable of LR had the longest duration in both patterns, even though the difference in PAL was only a few ms. Pre. 1 was shorter than post. 1, which was more pronounced in SR. In general, the only major differences between PAS and PAL were in the duration of the pretonal and accented syllables of LR, which were shorter in the latter. There was a statistical main effect for the interactions *accent* x *pattern*, $F(1, 452) = 45.93$, $p < .0001$, *accent* x *syllable type*, $F(2, 451) = 48.6$, $p < .0001$ and *syllable type* x *pattern*, $F(2, 451) = 11.83$, $p < .0001$. Post hoc tests revealed that LR in PAS was statistically longer than all other accents, followed by both accents in PAL and then SR in PAS. Differences between the last three accents were significant only between SR in PAL and SR in PAS. LR's acc. was significantly higher than SR's, which was reversed in the posttonal, while pretonal showed no differences between accents. Additionally, the accented syllables in PAS and PAL were significantly different from each other and all other constituents, followed by both post. 1 and then both pre. 1 syllables.

Table 4.53. Mean and SD duration values in medial 3b words across patterns

Pattern	Accent	Syll. Type	Duration (ms)
PAS	LR	Pre. 1	53.57 (13.21)
		Acc.	120.44 (21.76)
		Post. 1	54.07 (15.38)
	SR	Pre. 1	44.36 (11.73)
		Acc.	76.57 (18.37)
		Post. 1	61.48 (15.16)
PAL	LR	Pre. 1	42.56 (10.51)
		Acc.	89.87 (19.28)
		Post. 1	57.9 (12.5)
	SR	Pre. 1	49.95 (12.32)
		Acc.	84.12 (15.4)
		Post. 1	67.96 (15.38)

Table 4.54 shows mean and SD duration values of all accents and syllables. The pretonal syllable was consistently shorter than all others and had almost the same duration in both accents, which is also why there was no statistical significance found. In the accented syllable, LR had a noticeably longer duration, with a ratio of 1.3. A main effect was found for *accent*, $F(1, 145) = 51.15$, $p < .0001$. Like in the previous condition, the posttonal of SR had a longer duration than in LR, which was also statistically significant, $F(1, 146) = 15.95$, $p < .0001$.

Table 4.54. Mean and SD duration values in medial 3b words

Accent	Syll. Type	Duration (ms)
LR	Pre. 1	47.99 (13.07)
	Acc.	105.15 (25.57)
	Post. 1	56.01 (14.04)
SR	Pre. 1	47.23 (12.28)
	Acc.	80.39 (17.25)
	Post. 1	64.81 (15.52)

d) Summary

The production of tone in medial 3b words did not differ much from the initial position. Both accents showed the same falling, rising and falling contours and overall pitch values (in relation to each other), including even the short plateau at the beginning of LR's accented syllable. The difference between LR and SR in this position can be summed up by two measurements: LR has a a greater pitch range and longer duration in the accented and posttonal syllables.

4.3.2.3 Final 3b Trisyllabic Words

a) Contour shape and overall pitch

Mean F_0 tracks are displayed in Figure 4.28, with sample size in Table 4.55. Pretonal syllables in the final position exhibit a relatively sharp fall for both accents, with minor differences between each other. In the accented syllable, contours for both accents are still falling, although not so steeply. It can also be seen that both accented syllables start with a higher pitch than the end of their pre. 1, with LR starting slightly higher than SR. The only major difference between the two is observed in the posttonal, where LR has a flat contour and higher pitch, while SR is falling. Nevertheless, no significant differences were found between the two accents. Values in the last 30-40% of the syllable are slightly skewed due to missing values, so that the final rising movements can be ignored.

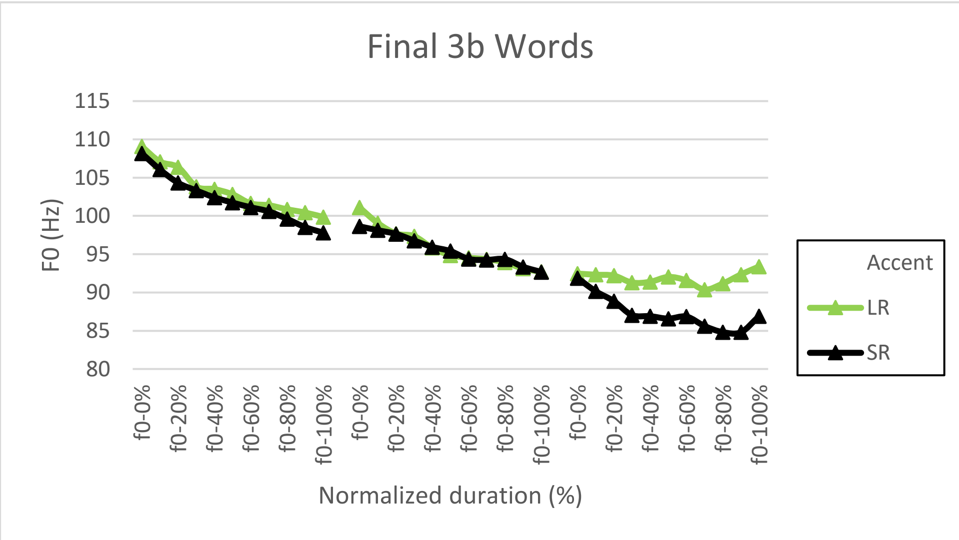

Figure 4.28. Mean F_0 tracks of final 3b words

Table 4.55. Number of samples in measurement points in final 3b words across the two rising accents

Accent	Syllable	f0-0%	f0-10%	f0-20%	f0-30%	f0-40%	f0-50%	f0-60%	f0-70%	f0-80%	f0-90%	f0-100%
LR	Pre. 1	64	66	70	70	70	70	70	70	68	67	63
	Acc.	65	73	73	73	73	73	73	73	73	73	65
	Post. 1	56	54	53	52	49	46	42	34	27	23	19
SR	Pre. 1	72	74	74	75	74	74	74	74	72	71	71
	Acc.	72	76	77	78	79	79	79	78	76	75	72
	Post. 1	58	61	60	62	60	55	53	49	45	30	23

b) Pitch range and PPA%

Mean values of pitch range and PPA% are shown in Table 4.56. Pitch range was largest in the accented syllable for LR and in pre. 1 for SR. As opposed to the previous conditions, the pretonal had a consistently larger range than the posttonal. A small main effect was found for *accent* in the posttonal syllable, $F(1, 104) = 5.63$, $p = .0194$, which showed that SR's pitch range is significantly larger.

Both accents produced their pitch peaks relatively early in the accented syllable. The tendency of SR to place peaks later in the syllable can also be observed in this position. However, the difference between both accents was not significant. These results indicate that there is no tonal contrast between short and long rising accents in final position.

Table 4.56. Mean pitch range and PPA% values in final 3b words

Accent	Syllable	Range	PPA%
LR	Pre. 1	8.11	
	Acc.	12.6	-75.17
	Post. 1	6.98	
SR	Pre. 1	10.79	
	Acc.	10.02	-69.52
	Post. 1	9.21	

c) Duration

Mean and SD values of duration of accents and syllables across patterns are shown in Table 4.57. The accented syllable of LR had by far the longest duration in both patterns, especially in PAS. Syllables in PAL were generally noticeably shorter than in PAS, except for acc. SR, which was substantially longer. Independently of pattern, pretonals were universally shorter than posttonals, which were affected by final lengthening. Interestingly enough, compared with the previous conditions and words, only the accented syllables were noticeably longer, while the rest retained their usual duration. A one-way ANOVA had main effects on Duration (log-transformed) for *accent* x *pattern*, $F(1, 430) = 43.84$, $p < .0001$ and *accent* x *syllable type*, $F(2, 430) = 40.63$, $p < .0001$. A post hoc test revealed that LR in PAS was longer than SR in PAL and that LR/PAL behaved as a group with SR/PAS with significantly shorter duration. Additionally, all accent/syllable type combinations (except pre. 1) differed significantly from each other.

Table 4.57. Mean and SD duration values in final 3b words across patterns

Accent	Syll. Type	PAS	PAL
LR	Pre. 1	55.14 (18.25)	43.64 (12.61)
	Acc.	167.01 (15.16)	131.56 (23.21)
	Post. 1	68.9 (19.54)	57.13 (13.78)
SR	Pre. 1	46.09 (14)	49.25 (10.53)
	Acc.	91.95 (22.07)	111.49 (27.93)
	Post. 1	72.62 (24.32)	79.42 (20.79)

Table 4.58 shows mean and SD duration values of all accents and syllables. Pretonal syllables in both accents have almost the same duration, being also shorter than the other syllables. No significant durational differences were found in pre. 1. The accented syllable shows greater variation, with LR being substantially longer, which was also statistically significant (Duration was log-transformed), $F(1, 130) = 100.43$, $p < .0001$. The ratio between LR and SR was 1.41 on average. Much like in other conditions, SR also had a longer duration in the posttonal. There was a main effect for on Duration (log-transformed) *accent*, $F(1, 143) = 15.5$, $p < .0001$.

Table 4.58. Mean and SD duration values of final 3b words

Accent	Syll. Type	Duration (ms)
LR	Pre. 1	48.92 (16.4)
	Acc.	143.77 (26.74)
	Post. 1	62.54 (17.58)
SR	Pre. 1	47.67 (12.41)
	Acc.	101.72 (26.88)
	Post. 1	76.02 (22.74)

d) Summary

In conclusion, both accents exhibit a steep fall in the pretonal, a milder one in the accented syllable and another moderate fall in the posttonal for SR and a level contour for LR. Pitch range varied with the falls in each syllable, generally being largest in the accented syllable and smallest in the posttonal. LR's accented syllable was significantly longer, while there was little difference in the pretonals. SR's posttonal was, like in other contexts, longer than LR's. However, since there were almost no significant differences in the F_0 measurements, this means that there was also no tonal contrast between the accents.

4.3.2.4 Overview and Comparison of 3b Trisyllabic Words

a) Contour shape and overall pitch

Contours and overall pitch values measured in 3b words are quite similar to rising accents found in 3a and bisyllabic words. Initial and medial accented syllables are rising in both accents, and in both cases LR starts with a short plateau and continues with a steep rise, while SR rises continuously. Otherwise, the medial position is characterized by compressed pitch range in comparison with the initial. Pretonal syllables in both conditions show a moderate fall, which is identical in both accents. The final condition, on the other hand, exhibits falling contours in the first two syllables with a fall for SR and a plateau for LR in the posttonal. Furthermore, compared with the other two conditions, the final has much lower pitch. A one-way ANOVA with *accent, sentence, syllable type* and their interactions was conducted. A main effect was found for *sentence* x *accent*, $F(2, 1323) = 4.05$, $p = .0176$. Post hoc tests showed three statistically different groups: initials had the highest overall pitch, followed closely by medials and then much lower for finals ($p < .0001$). A main effect was also found for *sentece* x *syllable type*, $F(4, 1323) = 227.03$, $p < .0001$. A post hoc test distinguished between all sentence/syllable type combinations except medial pre. 1 vs. initial pre. 1. Initial and medial syllables had higher pitch (the posttonal is higher in both conditions) and were followed by the final syllables (pre. 1 > acc. > post. 1). These results confirm a continuous pitch compression the farther a word is from the beginning of the sentence.

b) Pitch range and PPA%

Table 4.59 displays mean pitch range and PPA% values for accent types across all conditions. Contrary to 3a words, pitch range in the accented syllables of 3b was smallest in the final condition, and not the medial. In the posttonal, barring a few exceptions, range tended to be somewhat smaller than in the accented syllable. Independently of condition, pretonals exhibited a rather uniform pitch range, which was usually between 8 and 10 Hz. Using the same statistical model as above, a one-way ANOVA was conducted. A main effect was found for *sentence* x *accent*, $F(2, 1316) = 8.31$, $p = .0003$. A post hoc test showed that initial LR had the highest pitch range and was statistically different from all other combinations, which was closely followed by the medials and initial SR (which behaved as a group), and lastly, both finals. Additionally, statistical main effects were found for *sentence* x *syllable type*, $F(4, 1316) = 17.04$, $p < .0001$ and *accent* x *syllable type*, $F(2, 1316) = 7.59$, $p = .0005$. Roughly three groups could be significantly distinguished from each other: initial accented; initial and medial posttonals with medial accented and finally, all the other combinations. Accented LR syllables had a significantly larger pitch range than all other combinations, followed by a group consisting of the posttonals and accented SR, and finishing with both pretonals. This indicates that the pitch range of a syllable is dependent on its prosodic position: the higher it is (accented initial syllable), the larger the pitch range.

Table 4.59. Mean pitch range and PPA% values of accent types in 3b words across sentence conditions

Condition	Accent	Syllable	Range	PPA%
Initial	LR	Pre. 1	9.98	
		Acc.	25.76	4.87
		Post. 1	17.16	
	SR	Pre. 1	7.78	
		Acc.	17.26	13.64
		Post. 1	14.33	
Medial	LR	Pre. 1	9.04	
		Acc.	18.00	-1.5
		Post. 1	16.32	
	SR	Pre. 1	8.79	
		Acc.	12.18	-1.41
		Post. 1	13.13	
Final	LR	Pre. 1	8.11	
		Acc.	12.6	-75.18
		Post. 1	6.98	
	SR	Pre. 1	10.79	
		Acc.	10.02	-69.52
		Post. 1	9.21	

PPA% values suggest the same dependence on prosodic position: pitch peaks are produced consistently later with rising prosodic prominence. A major difference, however, must be noted between final and non-final conditions: pitch peaks in the final condition are all shifted to the accented syllable, which has already been observed in all other contexts. A one-way ANOVA with *accent*, *sentence* and their interaction showed a main effect only for *sentence*, $F(2, 416) = 249.68$, $p < .0001$. A post hoc test significantly distinguished between all sentence positions: initial vs. final, medial vs. final ($p < .0001$), initial vs. medial ($p = .013$).

c) Duration

Mean and SD values of duration across accent types and sentence positions are shown in Table 4.60. The greatest variation in duration can be seen in the accented syllable, which is substantially longer in the final condition for both accents. Posttonals were longer than pretonals in all cases, and varied very little between conditions, except for an unusually long SR. A one-way ANOVA conducted revealed a main effect for the interaction between *sentence* and *syllable type*, $F(4, 1357) = 35.57$, $p < .0001$ and *accent* x *syllable type*, $F(2, 1357) = 138.32$, $p < .0001$. A post hoc test showed that final accented syllables were by far the longest, followed by medial and initial accented, all posttonals together, and finally all the pretonals. Furthermore, all accent/syllable type combinations except both pretonals were significantly different from each other. This indicates that duration is also prosodically dependent and also gives the durational hierarchy of syllables in 3b words: accented > posttonal > pretonal.

Table 4.60. Mean and SD values of duration across accents and sentence conditions in 3b words

Condition	Acc. Type	Pre. 1	Acc.	Post. 1
Initial	LR	50.05 (17.16)	101.56 (23.35)	57.14 (16.1)
	SR	45 (12)	77.8 (22.38)	64.36 (18.56)
Medial	LR	47.99 (13.07)	105.15 (25.57)	56.01 (14.04)
	SR	47.23 (12.28)	80.39 (17.25)	64.81 (15.52)
Final	LR	48.92 (16.4)	143.77 (26.74)	62.54 (17.58)
	SR	47.67 (12.42)	101.72 (26.88)	76.02 (22.74)

d) Summary

A summary of the acoustic characteristics of 3b words is presented below in Table 4.61. The parameters in this Table are the same as in Table 4.46, with the addition of Range. „Small“ was defined as a pitch range smaller than 10 Hz, „inter.“ as between 10 and 20 Hz and „large“ as above 20 Hz.

Table 4.61. Summary of the acoustic characteristics of rising accents in 3b words

Accent	Parameter	Initial	Medial	Final
LR	Contour	mild fall-steep rise-steep fall	mild fall-steep rise-steep fall	steep fall-mild fall-level
	Pitch	low-high-low	low-high-low	high-inter.-low
	Range	small-large-inter.	small-inter.-inter.	small-inter.-small
	PPA%	3.81	-1.5	-75.17
	Duration	short-long-short	short-long-short	short-long-inter.
SR	Contour	mild fall-rise-steep fall	mild fall-rise-steep fall	steep fall-mild fall-steep fall
	Pitch	low-high-low	low-high-low	high-inter.-low
	Range	small-inter.-inter.	small-inter.-inter.	inter.-inter.-small
	PPA%	13.63	-1.41	-69.52
	Duration	short-inter.-inter.	short-inter.-inter.	short-long-inter.

4.4 Quadrisyllabic Words

4.4.1 4a Quadrisyllabic Words

Since 4a words have four patterns each (PASS, PASL, PALS and PALL), their mean F_0 tracks will be presented and shortly discussed at the beginning of each subsection's Contour shape and overall pitch part.

4.4.1.1 Initial 4a Quadrisyllabic Words

a) Contour shape and overall pitch

Figure 4.29 displays the pitch contours of all initial 4a patterns. The patterns can be roughly divided into two groups: one where both accents are grouped tightly around each other (PASS and PALS) and another where two or more syllables exhibit different pitch for LR and SR (PASL and PALL). In the latter, PASL has higher pitch for LR in the pretonal and higher pitch for SR in the first posttonal, while in PALL, LR has higher pitch in all syllables.

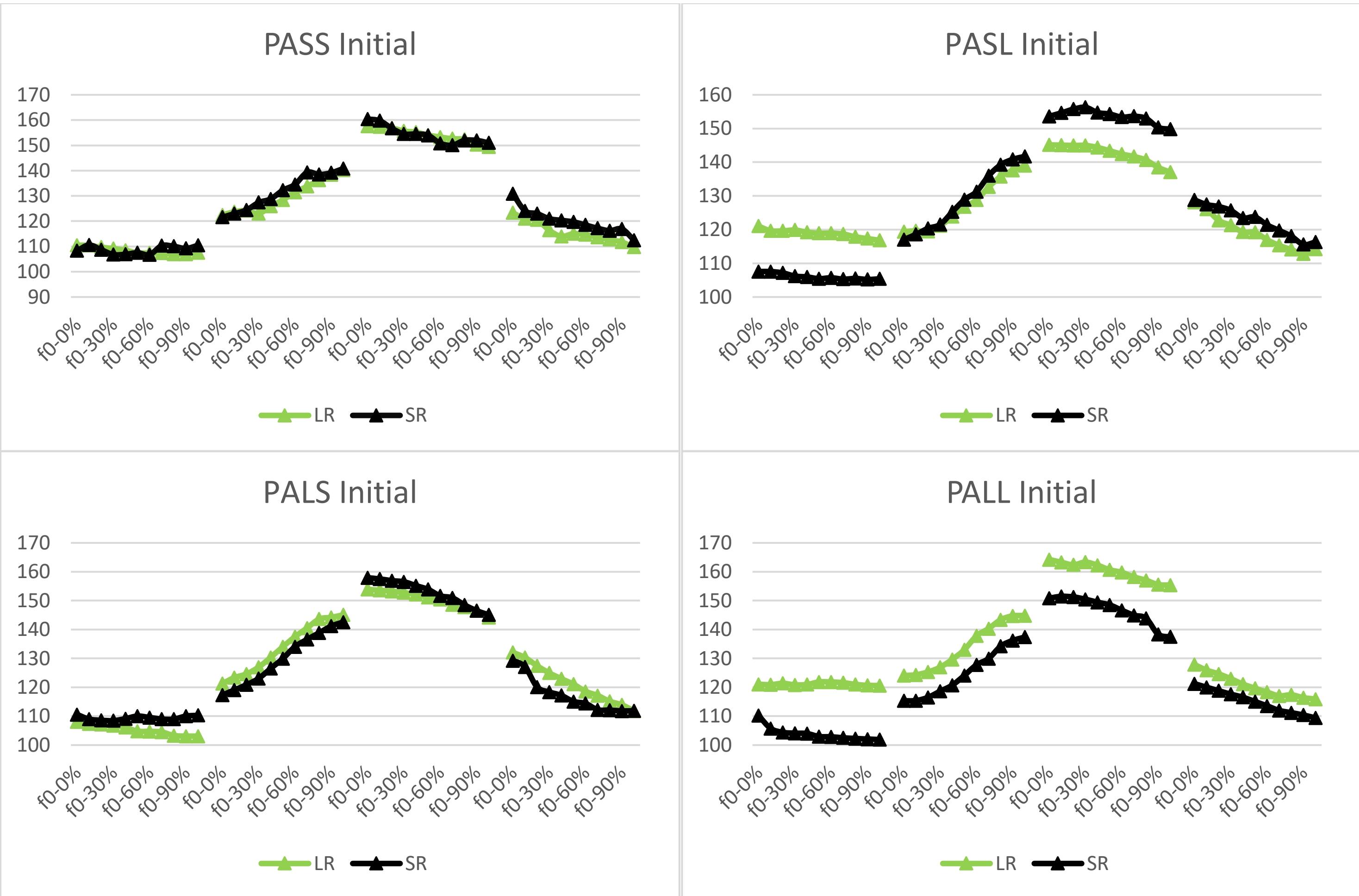

Figure 4.29. Mean F_0 tracks of initial 4a words in all four patterns

Mean F_0 tracks of combined initial 4a words are shown in Figure 4.30 and sample size in Table 4.62. At first glance, tone in this condition looks like a combination of 3b and rising accents in 3a words. Contours in the pretonal syllable can be described as level or only moderately falling, with LR having higher overall pitch than SR. A one-way ANOVA showed a main effect on OvMean (log-transformed) for *accent*, $F(1, 135) = 14.65$, $p = .0002$. In the accented syllable, both accents exhibit a steep rise, which is slightly delayed for LR. LR also has minimally higher pitch, seen especially at the beginning of the syllable. A main effect was found on OvMean (log-transformed) for *accent*, $F(1, 137) = 5.45$, $p = .021$. Both accents in post. 1 have identical contours and pitch, which is moderately falling to a level higher than the maximum in the previous syllable. The same contours and pitch can also be observed in the second posttonal, which has a somewhat steeper fall. Pitch is within the range of the accented and pretonal syllables, which is lower than the same syllable in 3a words. Due to the accents' identical values in the last two syllables, no significant differences were found.

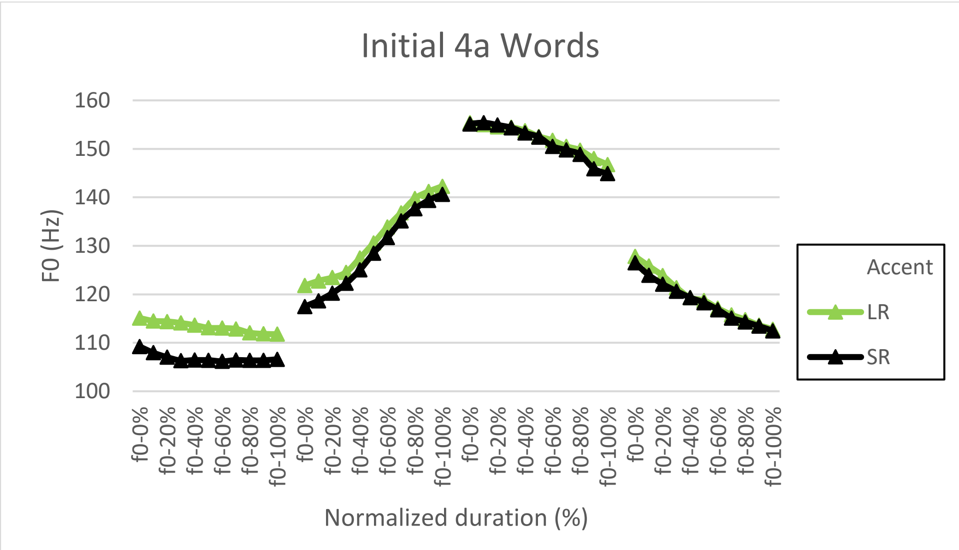

Figure. 4.30. Mean F_0 tracks of initial 4a words

Table 4.62. Number of samples in measurement points in initial 4a words across the two rising accents

Accent	Syllable	f0-0%	f0-10%	f0-20%	f0-30%	f0-40%	f0-50%	f0-60%	f0-70%	f0-80%	f0-90%	f0-100%
LR	Pre. 1	75	75	75	75	75	76	76	76	76	76	74
	Acc.	77	78	78	78	78	78	78	78	78	78	78
	Post. 1	72	72	72	73	73	73	73	73	73	73	73
	Post. 2	78	78	78	78	78	78	78	78	77	77	74
SR	Pre. 1	60	67	67	69	69	70	70	69	69	69	68
	Acc.	70	70	70	70	70	70	70	70	69	69	69
	Post. 1	65	65	65	65	65	65	65	65	63	61	60
	Post. 2	69	69	70	70	70	70	70	70	68	67	63

b) Pitch range and PPA%

Mean values of pitch range and PPA% are shown in Table 4.63. Pitch range values in this condition are quite similar to the ones in 3b words: smallest in the pretonal, highest in the accented syllable and lower in the first posttonal. The greater range in post. 2 is comparable to the one found in 3b post. 1 syllables, which suggests that the steeper fall is a positional feature connected to the word's end, and not to the syllable immediately after the accent, which can be seen by the noticeably low range in 4a post. 1.

Table 4.63. Mean pitch range and PPA% values in initial 4a words

Accent	Syllable	Range	PPA%
LR	Pre. 1	6.85	
	Acc.	22.38	6.98
	Post. 1	9.96	
	Post. 2	16.88	
SR	Pre. 1	7.52	
	Acc.	23.87	11.38
	Post. 1	12.31	
	Post. 2	16.07	

The only major difference seen in the Table is the greater range in SR's post. 1. A one-way ANOVA showed a main effect for *accent*, $F(1, 127) = 4.16$, $p = .0433$, which confirmed this observation. PPA% values show that pitch peaks are produced in the posttonal for both accents, which was slightly later for SR. However, no main effect was found for *accent*.

c) Duration

Mean and SD duration values of all accents and patterns are displayed in Appendix D under Table D.20. As in 3a words, no concrete durational patterns were detected. Duration in the accented syllable varied constantly between patterns and accents, and in one case, SR was even longer than LR (PALS). Phonological length of posttonal syllables was also inconsistent: long syllables were longer than short ones in some patterns (for instance, PASL) and shorter in most others, as in PALS. The syllable with the most stabile duration is pre. 1, which had a rather uniform duration (46-50 ms) in all patterns except PALL, a pattern that generally had longer segments.

Table 4.64 shows mean and SD duration values of all accents and syllables. The only major variation in duration is in the accented syllable, where LR is only 9 ms longer than SR, which was confirmed by a main effect found for *accent*, $F(1, 137) = 8.48$, $p = .0042$. All other syllables have rather similar duration, with post. 2 being the longest, followed by pre. 1 and then post. 1. Otherwise, duration was either slightly longer in SR or equal, and no significant differences were found. These results suggest that duration is relevant mainly in the accented syllable, which bears most of the contrast between accents.

Table 4.64. Mean and SD values of duration in initial 4a words

Accent	Pre. 1	Acc.	Post. 1	Post. 2
LR	52.07 (14.59)	104.58 (20.77)	49.42 (13.25)	59.56 (18.29)
SR	56.47 (14.27)	95.52 (20.64)	54.7 (20.15)	59.35 (17.16)

d) Summary

Pretonal syllables have a level contour with higher pitch for LR. While rising for both accents in acc., LR has slightly higher pitch and a delayed rise. Post. 1 has a fall, which is only slightly steeper for SR, with no other differences between the accents. Finally, the lack of contrast between the accents continues into post. 2, which has a steeper fall than post. 1 and pre. 1. Duration varied little between accents and syllables, being mostly longer in accented long syllables and in post. 2.

4.4.1.2 Medial 4a Quadrisyllabic Words

a) Contour shape and overall pitch

Pitch contours are displayed in Figure 4.31. Whilst having the same contours as in the initial position, more contrast between LR and SR could be observed in the medial condition. The PALS and PALL patterns clearly show higher pitch values for LR in all syllables. These differences were less pronounced in PASL, where only the pretonal and a part of the accented syllable were higher for LR. In PASS, even though quite close to SR, LR had lower pitch in the pretonal and the first posttonal.

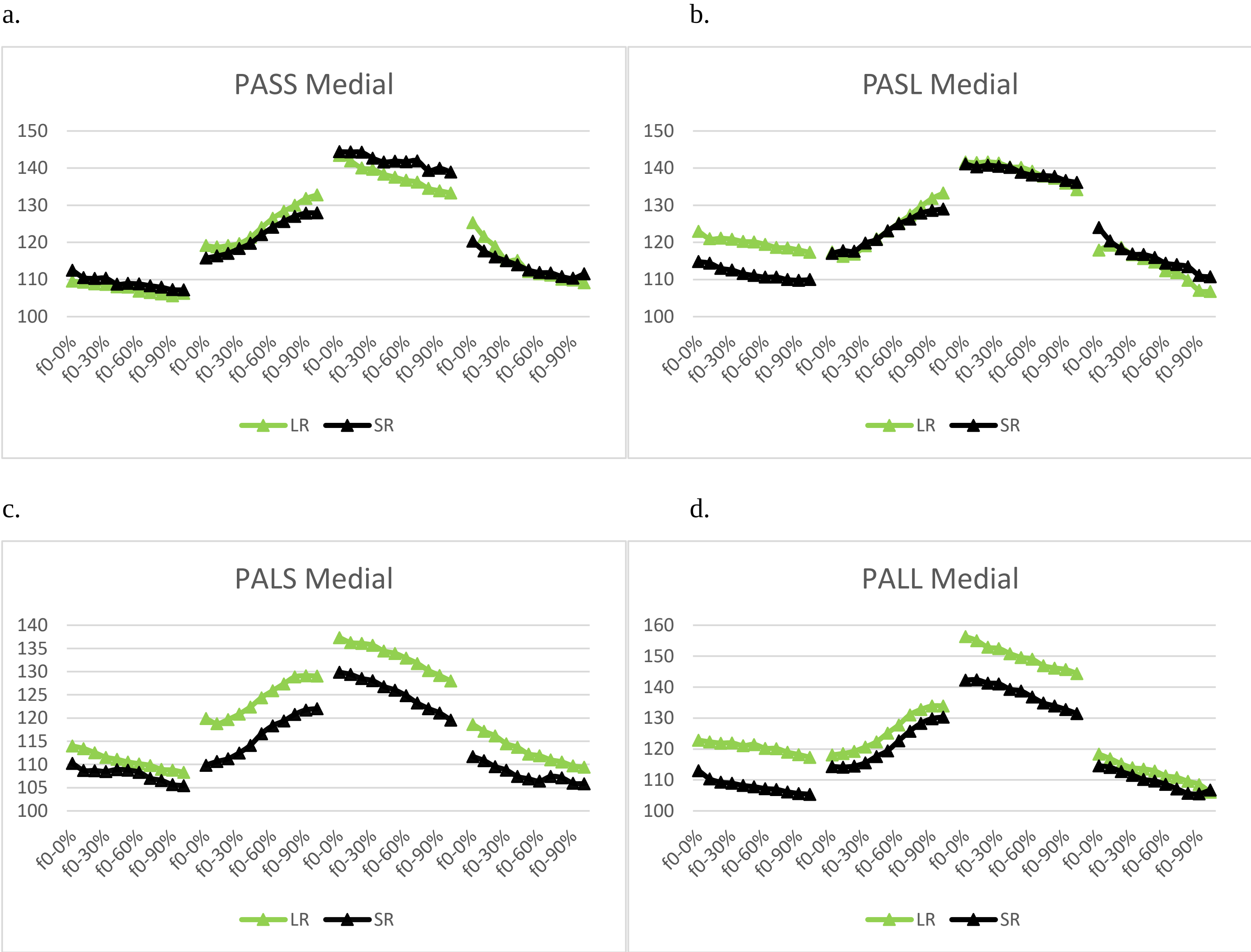

Figure 4.31. Mean F_0 tracks of medial 4a words in all four patterns

Mean F_0 tracks of combined initial 4a words are shown in Figure 4.32 and sample size in Table 4.65. As already mentioned above, contours in the medial and initial position are almost identical. The only major differences are general lower pitch and a slightly more pronounced delay in the accented syllable of LR. Overall pitch values are, however, obviously different, with LR having consistently higher pitch in every syllable. Compared with other word types, this is rather unusual, since the tonal contrast is usually reduced in the medial position. A main effect for *accent* was found in all syllables but post. 2: pre. 1, $F(1, 140) = 10.41$, $p < .0016$; acc. $F(1, 141) = 11.11$, $p = .0011$; post. 1, $F(1, 139) = 8.92$, $p = .0033$.

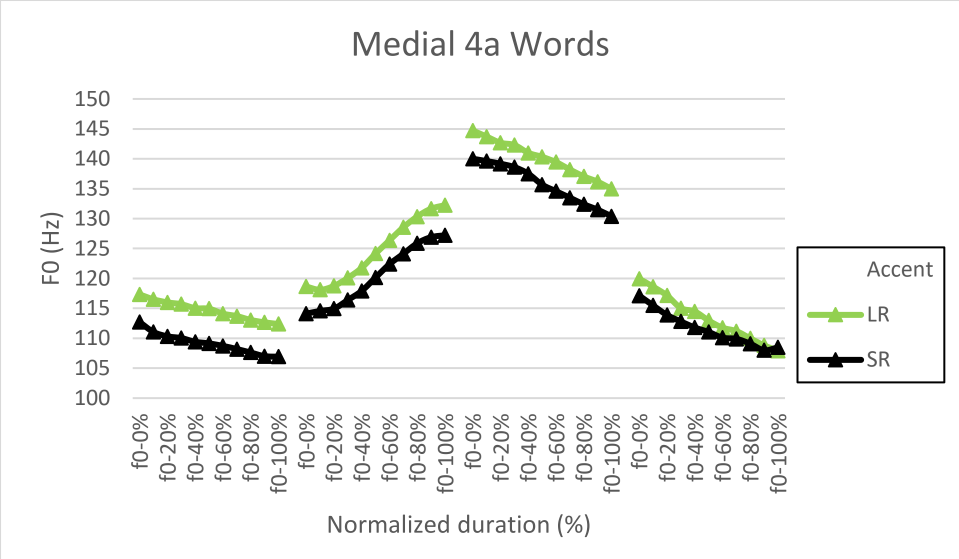

Figure 4.32. Mean F_0 tracks in medial 4a words

Table 4.65. Number of samples in measurement points in medial 4a words across the two rising accents

Accent	Syllable	f0-0%	f0-10%	f0-20%	f0-30%	f0-40%	f0-50%	f0-60%	f0-70%	f0-80%	f0-90%	f0-100%
LR	Pre. 1	76	76	77	79	79	79	79	79	79	78	77
	Acc.	79	79	79	79	79	79	79	79	79	79	79
	Post. 1	79	79	79	79	79	79	79	79	79	79	79
	Post. 2	77	77	77	78	78	78	78	78	78	76	74
SR	Pre. 1	70	71	71	72	72	72	72	72	72	71	71
	Acc.	72	73	73	73	73	73	73	73	73	73	73
	Post. 1	71	70	70	70	70	70	70	69	69	68	68
	Post. 2	68	71	71	71	71	71	71	70	70	69	67

b) Pitch range and PPA%

Mean values of pitch range and PPA% are shown in Table 4.66. Quite like in the previous condition, pitch range was smallest in the pretonal and largest in the accented syllable. The accented syllable in LR had a slightly larger pitch range than SR, which was confirmed statistically with a main effect for *accent*, $F(1, 141) = 4.14$, $p = .0435$. In post. 1, pitch range was compressed for both accents to an almost identical value. The only other major difference between the accents can be seen in post. 2, which in LR had a value between acc. and post. 1, while in SR the two final syllables were equal.

PPA% values were typical for rising accents, placing pitch peaks at the beginning of the posttonal syllable. As in previous contexts, SR had slightly later peaks, although the difference was not statistically significant.

Table 4.66. Mean pitch range and PPA% values in medial 4a words

Accent	Syllable	Range	PPA%
LR	Pre. 1	7.38	
	Acc.	16.79	2.91
	Post. 1	10.16	
	Post. 2	13.78	
SR	Pre. 1	7.95	
	Acc.	14.39	9.71
	Post. 1	10.57	
	Post. 2	10.91	

c) Duration

Mean and SD duration values of all accents and patterns are displayed in Appendix D under Table D.22. Once again, finding a coherent pattern proved to be unsuccessful. Nevertheless, LR's accented syllable was longer than SR's in all cases. SR's unusually short duration in the accented syllable in PALS, which was identical to the pretonal, stands out. The next syllable in the same pattern is also exceptional, being almost thrice as long as in PASS and PASL, but only 18 ms longer than in PALL. All in all, it appears that pre. 1 and post. 2 were the most stabile syllables, with only one unusually short or long value per accent (PALL for LR and PASL for SR).

Table 4.67 shows mean and SD duration values of all accents and syllables. Comparing duration in the medial position with the initial shows a surprising similarity between the two. Not only is the same durational hierarchy (acc. > post. 2 > pre. 1 > post. 1) present, the mean values themselves are nearly identical. This indicates that the difference between initial and medial positions is purely tonal. Statistically significant differences (Duration was log-transformed) were found only in the accented, $F(1, 141) = 14.91$, $p = .0002$ and second posttonal syllables, $F(1, 139) = 12.28$, $p = .0006$.

Table 4.67. Mean and SD values of duration in medial 4a words

Accent	Pre. 1	Acc.	Post. 1	Post. 2
LR	51.53 (15.27)	105.57 (21.26)	49.67 (14.22)	64.64 (13.74)
SR	53.94 (17)	92.86 (17.65)	52.74 (20.09)	56.82 (15.67)

d) Summary

Contours in the medial position were almost identical to the ones produced in the initial. Duration varied little between accents, with only the accented and post. 2 syllables of LR being significantly longer. LR had significantly higher pitch in the first three syllables of the word and higher pitch range in the accented and final syllables. Pitch peaks were realized in post. 1 for both accents, and while SR had a higher PPA%, the difference was not significant.

4.4.1.3 Final 4a Quadrisyllabic Words

a) Contour shape and overall pitch

Figure 4.33 displays the pitch contours of all final 4a patterns. Although patterns in this condition vary slightly more than in others, their common traits are still readily recognizable, i.e. falling contours of varying steepness in every syllable of the word.

a. b.

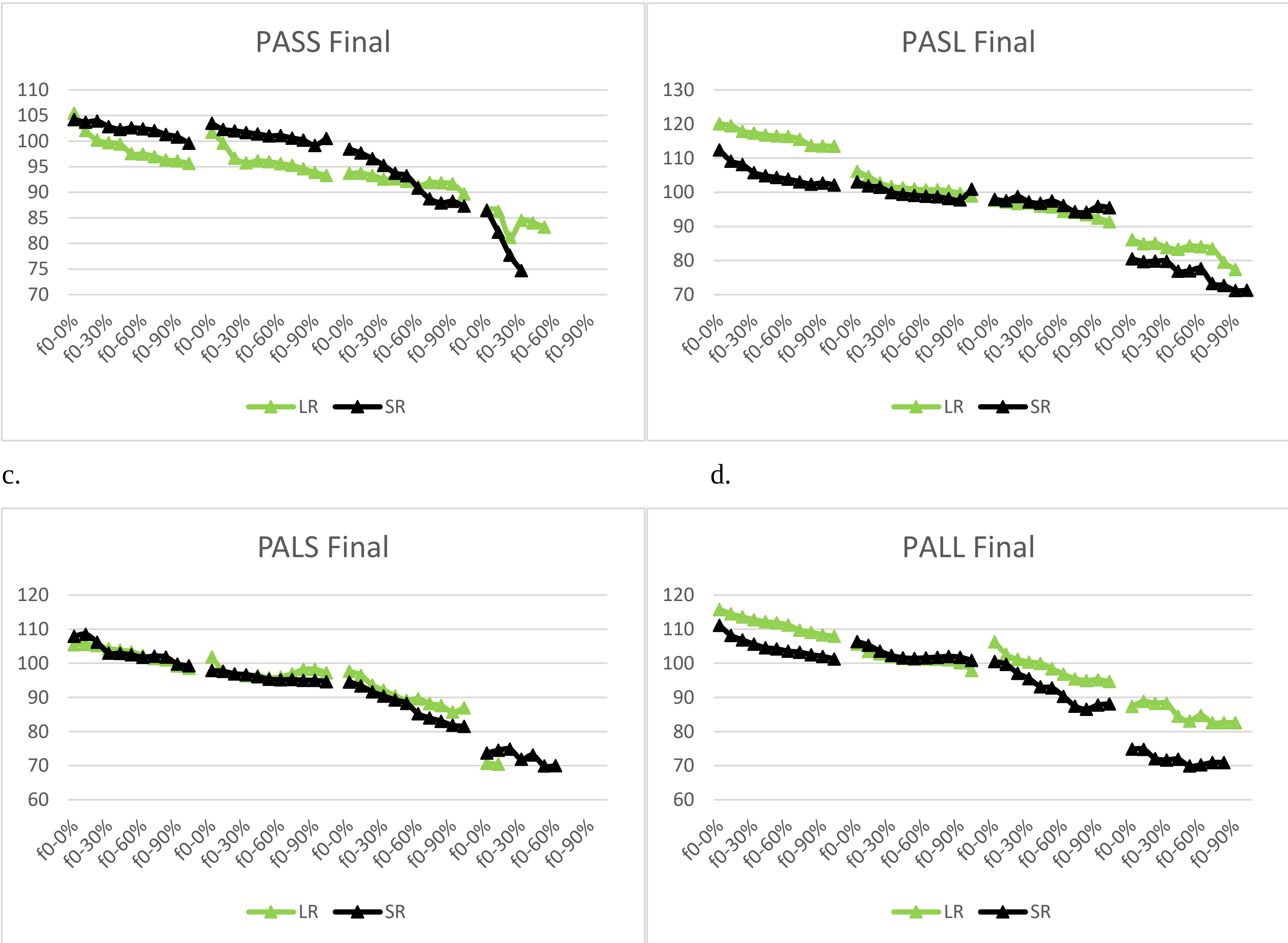

Figure 4.33. Mean F_0 tracks of final 4a words in all four patterns

All patterns except PALS show distinct pitch for LR and SR in one or more syllables, but when combined, as will be seen presently, the differences are quite evened out.

Mean F_0 tracks of combined initial 4a words are shown in Figure 4.34, with sample size in Table 4.68. Production of tone in the final condition is a rather straightforward matter of four falling or level syllables with varying steepness. In the pretonal, LR has slightly higher pitch, but the difference was not significant. The accented syllable shows a rather flat contour with identical pitch for both accents, which can also be seen in post. 1 up until the 50%-point, at which SR becomes lower. The only major difference between the accents is seen in post. 2, in which both accents have a level contour with higher pitch for LR. This was also the only significant difference, as there was a main effect for *accent*, $F(1, 51) = 6.22$, $p = .0159$.

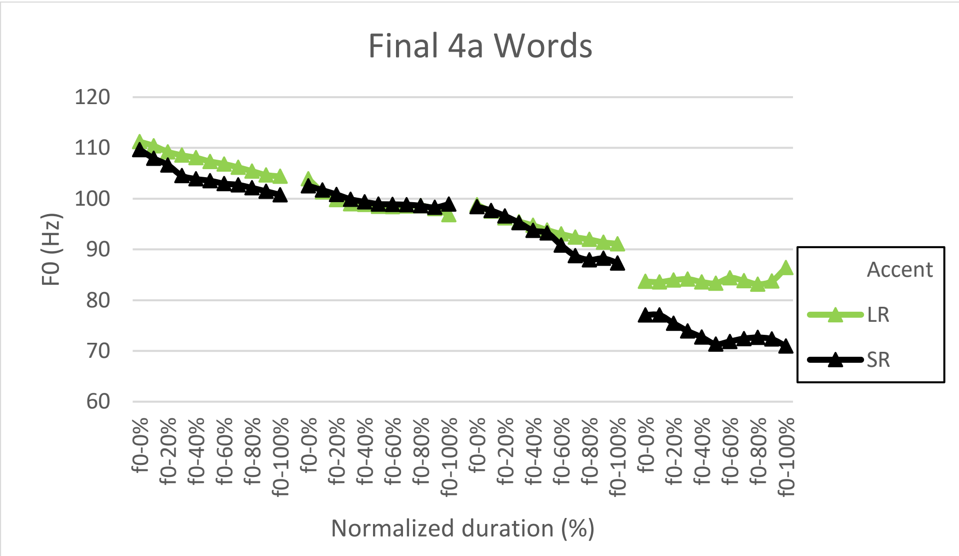

Figure 4.34. Mean F_0 tracks of final 4a words

Table 4.68. Number of samples in measurement points in final 4a words across the two rising accents

Accent	Syllable	f0-0%	f0-10%	f0-20%	f0-30%	f0-40%	f0-50%	f0-60%	f0-70%	f0-80%	f0-90%	f0-100%
LR	Pre. 1	69	71	73	73	73	73	73	71	70	70	69
	Acc.	71	73	74	74	74	74	74	73	73	73	70
	Post. 1	68	69	71	71	71	71	70	69	65	63	57
	Post. 2	31	30	27	26	22	20	17	15	11	9	6
SR	Pre. 1	60	63	63	63	63	63	63	63	63	63	64
	Acc.	64	64	64	64	64	64	64	64	64	64	59
	Post. 1	54	55	55	54	54	53	52	50	49	44	41
	Post. 2	20	23	24	24	22	22	19	14	12	9	5

b) Pitch range and PPA%

Mean values of pitch range and PPA% are shown in Table 4.69. The most noticeable thing about pitch range in the final condition is a substantial pitch compression. This is especially true for LR, in which the accented syllable has almost identical range as in pre. 1 and post. 1. SR shows a different variation in range values: post. 1 is the highest and the accented syllable is the smallest. Main effects for *accent* were found only in the pretonal, $F(1, 125) = 6.84$, $p = .01$ and accented syllable, $F(1, 127) = 8.33$, $p = .0046$. PPA%, as in other final contexts, had negative values for both accents, meaning their pitch peaks were realized close to the beginning of the accented syllable. SR's peaks were produced somewhat later, which was confirmed by a main effect for *accent*, $F(1, 117) = 5.43$, $p = .0215$. These results indicate that tonal contrast in final 4a words is restricted to later peaks and lower pitch in the final syllable for SR.

Table 4.69. Mean pitch range and PPA% values in final 4a words

Accent	Syllable	Range	PPA%
LR	Pre. 1	7.52	
	Acc.	9.29	-75.35
	Post. 1	9.23	
	Post. 2	4.76	
SR	Pre. 1	10.55	
	Acc.	6.09	-57.5
	Post. 1	12.19	
	Post. 2	8.18	

c) Duration

Mean and SD duration values of all accents and patterns are displayed in Appendix D under Table D.24. Final syllables are affected the most by final lengthening, which can be clearly seen in their longer duration. In all but one case (SR in PALL), the duration of post. 2 was clearly longer than in post. 1, sometimes being even more than twice as long. LR's accented syllable was longer than SR's, which grew in duration the more phonologically long vowels were in the word. The pretonal syllables also all had similar duration, independently of pattern.

Table 4.70 shows mean and SD duration values of all accents and syllables. In pre. 1 and post. 1, SR has longer duration, which was statistically confirmed only in the pretonal with a Mann-Whitney *U* test: Z = 2.35 $p = .0185$. Post. 2 was the longest of the non-accented syllables, which was a result of final lengthening. Finally, in the accented syllable, LR was noticeably longer than SR, which was confirmed by a Mann-Whitney *U* test: Z = -5.88 $p < .0001$.

Table 4.70. Mean and SD duration values in final 4a words

Accent	Pre. 1	Acc.	Post. 1	Post. 2
LR	51.91 (14.17)	125.09 (19.75)	57.29 (16.55)	70.22 (20.34)
SR	58.39 (15.76)	101.14 (20.62)	65.48 (30.37)	69.39 (19.98)

d) Summary

The pretonal and first posttonal syllables of both accents have a falling contour, which is slightly steeper for SR. The accented syllable was level for both accents and only showed a durational contrast, in which LR was longer. The only tonal contrasts in this condition are seen in the higher pitch of LR in post. 2 and SR's later pitch peaks in the accented syllable.

4.4.1.4 Overview and Comparison of 4a Quadrisyllabic Words

a) Contour shape and overall pitch

In the initial and medial conditions, which bear a striking resemblance to each other, the sequence of contours is the same: mildly falling in the pretonal, rising in the accented, mildly falling in the first posttonal and steeply falling in the final syllable. Generally, distinguishing between accents in the initial position was rather difficult, since their pitch values were so similar. This was somewhat easier in the medial condition, in which LR had generally higher pitch. The final position, as in previous contexts, had either falling or level contours in all its syllables, with very little difference between accents. A one-way ANOVA with *accent*, *sentence*, *syllable type* and their interactions was conducted. A main effect was found only for *sentence* x *syllable type*, $F(6, 1615) = 164.96$, $p < .0001$. A post hoc test showed that final syllables had the lowest overall pitch, which was statistically different between all syllables in that condition. Initial and medial syllables were mixed together at the top, with a relatively high amount of overlapping pitch values. This suggests that both conditions can be grouped together with regard to OvMean.

b) Pitch range and PPA%

Table 4.71 displays mean pitch range values for accent types across all conditions. As can be seen, there is a clear tendency for the pretonal syllable, especially in SR, to grow in pitch range from initial to final condition. Likewise, the reverse trend is seen in the accented and post. 2 syllables. Pitch range in post. 1 tended to be stabile throughout the sentence positions. A main effect was found for *sentence* x *syllable type*, $F(6, 1606) = 28.75$, $p < .0001$ and *accent* x *syllable type*, $F(3, 1605) = 3.77$, $p = .0103$. Post hoc tests showed that initial and medial post. 2 and accented syllables tended to be significantly higher than their final counterparts. Post. 1 syllables showed no significant differences between each other, and final syllables had a significantly smaller pitch range, which confirms the tendencies observed above. Furthermore, accented syllables had significantly larger pitch range than posttonals, which behaved as a group, and pretonals.

Table 4.71. Mean pitch range values in 4a words across conditions

Accent	Syllable	Initial	Medial	Final
LR	Pre. 1	6.85	7.38	7.52
	Acc.	22.38	16.79	9.29
	Post. 1	9.96	10.16	9.23
	Post. 2	16.88	13.78	4.76
SR	Pre. 1	7.52	7.95	10.55
	Acc.	23.87	14.39	6.09
	Post. 1	12.31	10.57	12.19
	Post. 2	16.07	10.91	8.18

Table 4.72 shows mean PPA% values in the three conditions. Pitch peaks in the initial and medial conditions were all realized in the first posttonal syllable. Medially, peaks were produced closer to the beginning of that syllable. In the final position, much like in other contexts, all peaks were shifted to the accented syllable. A one-way ANOVA with *accent*, *sentence* and their interaction was conducted. A main effect was found only for *sentence*, $F(2, 402)$, = 240.8, p <.0001. When both accents are combined, PPA% could not distinguish between the initial and medial conditions, which behaved as a group against the finals (both comparisons had a *p*-value of <.0001).

Table 4.72. Mean PPA% values of 4a words across conditions

Accent	Initial	Medial	Final
LR	6.98	2.91	-75.35
SR	11.38	9.71	-57.5

c) Duration

Mean and SD values of duration across accent types and sentence positions are shown in Table 4.73. Duration in the pretonal varied little between accents and was also quite stabile across conditions. In the accented syllable, almost no difference is seen between initial and medial, while in the final both accents are clearly longer. The same can be said of the following two syllables, which are longer in the final position. There was a statistical main effect for *sentence* x *syllable type*, $F(6, 1719) = 4.03$, p =.0005. A post hoc test revealed that accented syllables were significantly longer than all others, which was followed by a large group consisting mostly of posttonals and pretonals in different conditions, which did not significantly differ from each other.

Table 4.73. Mean and SD values of duration across accents and sentence conditions in 4a words

Condition	Accent	Pre. 1	Acc.	Post. 1	Post. 2
Initial	LR	52.07 (14.59)	104.58 (20.77)	49.42 (13.25)	59.56 (18.29)
	SR	56.47 (14.26)	95.52 (20.63)	54.7 (20.14)	59.35 (17.16)
Medial	LR	51.53 (15.27)	105.57 (21.26)	49.67 (14.22)	64.64 (13.74)
	SR	53.94 (17)	92.86 (17.64)	52.74 (20.09)	56.82 (15.66)
Final	LR	51.91 (14.16)	125.09 (19.75)	57.29 (16.54)	70.22 (20.34)
	SR	58.39 (15.76)	101.14 (20.62)	65.48 (30.36)	69.39 (19.98)

d) Summary

Generally speaking, contrasts between accents on the one hand, and sentence conditions on the the other, were not as clear-cut in this word type as in other contexts. Since both accents are phonologically rising, the few differences between them are motivated primarily by phonetic factors and restricted mostly to the accented syllable. SR usually had lower overall pitch in non-final conditions and due to the shorter duration of its accented syllable, a steeper and more straightforward rising movement. These combined factors also allow SR to continue its rise farther into the posttonal, which is seen by its consistently higher PPA% values. Differences between initial and medial conditions were expressed mainly by lower F_0 measurements, including earlier pitch peaks. The final condition followed the same pattern as in other contexts: falling or level pitch throughout the word with almost no tonal contrast. Furthermore, pitch peaks were retracted to the beginning or middle of the accented syllable and duration was noticeably longer.

4.4.2 4b Quadrisyllabic Words

The current word type presents a rather unexpected situation, which was discovered during the statistical analysis of the data. Upon comparing the mean F_0 tracks of the two patterns, it became clear that the values of SR in PPAL were very unusual. A side-by-side comparison of initial PPAS and PPAL is presented in Figure 4.35. On the left side in PPAS, both accents show a completely typical realization of rising accents as seen previously through the course of this dissertation. On the other side, LR looks quite the same as in PPAS, but SR is totally different. The reason for this drastically divergent realization lies in the target words recorded. These words were *toleràntnōst*, *kompetèntnōst*, *relevàntnōst* and *turbulèntnōst*, all of foreign origin. As explained in §2.4.2.3, loanwords and words of foreign origin are often pronounced with non-initial falling accents, which is definitely the case here. SR in PPAL not only has noticeably higher pitch in the accented syllable (much higher than in PPAS), it also places its pitch peak at the end of the same segment, which is clearly seen by the substantially lower pitch in the posttonal. As shown in §4.2 and §4.3.1, these are the two most defining characteristics of falling accents. This presents an excellent, albeit unplanned, opportunity to investigate non-initial falling accents, which are considered non-standard by almost all croatists (Vukušić et al., 2007). For this reason, SR in PPAL will be „renamed“ as LF (since its duration was equal to LR’s) and both patterns, now with three accents, will be presented in the following subsections together.

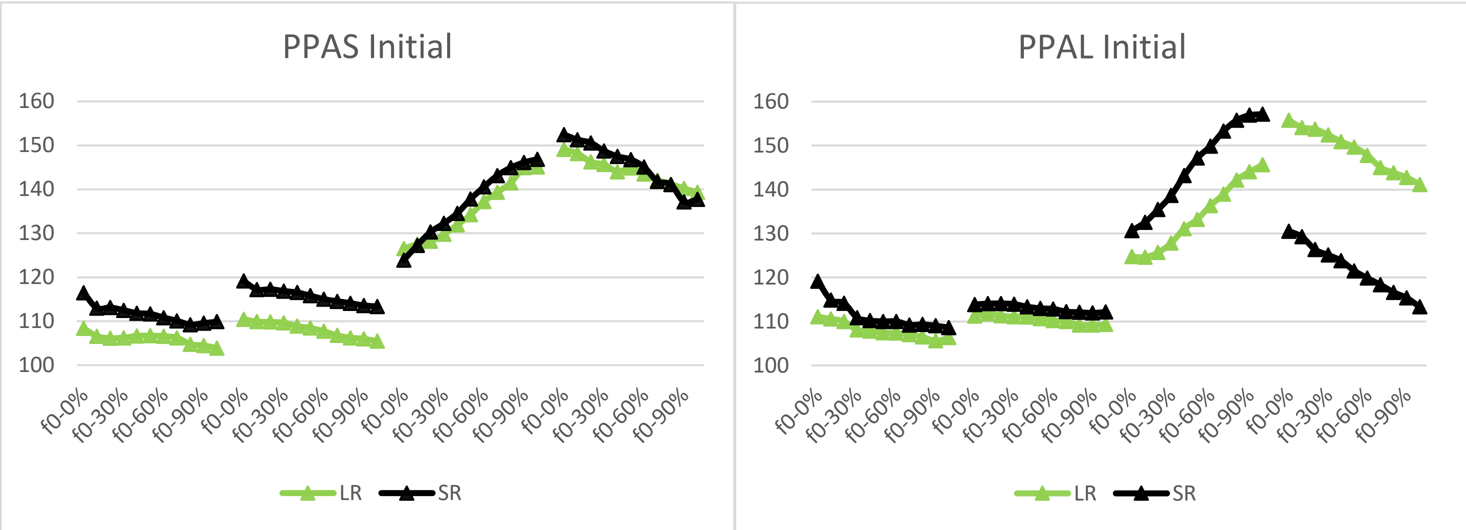

Figure 4.35. Mean F_0 tracks of initial PPAS and PPAL words

4.4.2.1 Initial 4b Quadrisyllabic Words

a) Contour shape and overall pitch

Mean F_0 tracks are displayed in Figure 4.36 with sample size in Table 4.74. The two pretonal syllables exhibit approximately the same moderately falling contour, which is slightly higher in pre. 1 and indicates a slowly rising trend towards the accented syllable. Additionally, LF and SR are grouped around each other, while LR has slightly lower pitch. In the second pretonal (second from the right, meaning the initial syllable, henceforth pre. 2), SR and LF have a short steep fall at the beginning of the vowel. A one-way ANOVA showed a main effect for *accent*, $F(2, 141) = 5.62$, $p = .0045$, which distinguished between SR/LF and LR: SR vs. LR ($p = .0162$), LF vs. LR ($p = .0221$). The same distribution was found in pre. 1, which also showed a main effect for *accent*, $F(2, 143) = 17.33$, $p < .0001$. A post hoc test revealed that LR had significantly lower pitch than the other accents: SR vs. LR ($p < .0001$), LF vs. LR ($p = .0011$). In the accented syllable, rising accents are grouped together and have a relatively straightforward rising contour. On the other hand, LF has a steeper rise and noticeably higher pitch. The statistical significance of these differences was confirmed by a main effect for *accent*, $F(2, 143) = 20.49$, p <.0001. A post hoc test showed that LF had significantly higher pitch than both rising accents, which behaved as a group: LF vs. LR (p <.0001), LF vs. SR (p =.0002). The most major difference is seen in the posttonal, in which the contours for all accents are quite alike, but LF's pitch is ca. 20 Hz lower throughout the vowel, which is one of the most important characteristics of falling accents. A statistical main effect was found for *accent*, $F(2, 143) = 63.83$, p <.0001, which showed that LF had significantly lower pitch than both rising accents, which did not differ from each other: LF vs. LR, LF vs. SR (p <.0001).

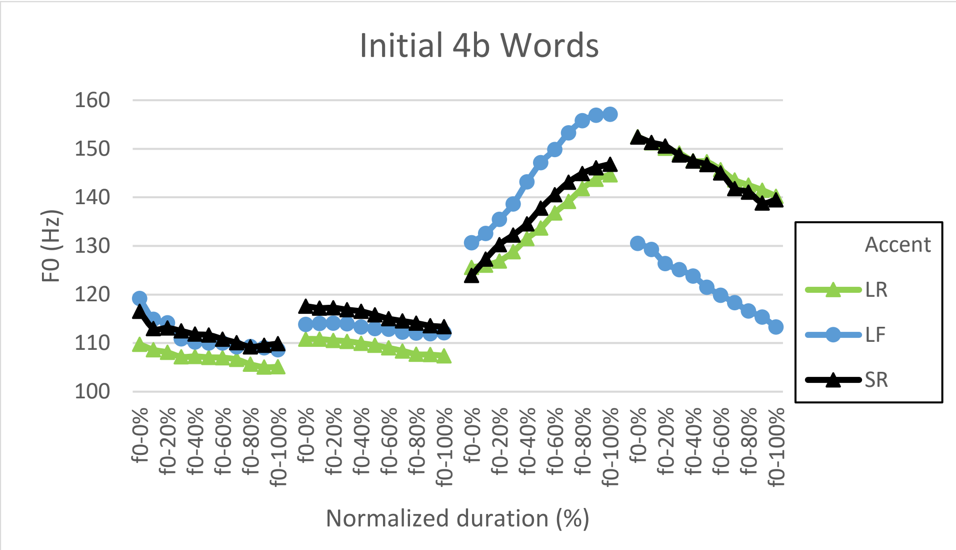

Figure 4.36. Mean F_0 tracks of initial 4b words

Table 4.74. Number of samples in measurement points in initial 4b words across three accents

Accent	Syllable	f0-0%	f0-10%	f0-20%	f0-30%	f0-40%	f0-50%	f0-60%	f0-70%	f0-80%	f0-90%	f0-100%
LR	Pre. 2	73	75	75	76	76	76	76	76	76	76	74
	Pre. 1	76	76	77	77	77	77	77	77	77	77	76
	Acc.	76	77	77	77	77	77	77	77	77	76	76
	Post. 1	76	76	76	76	76	77	77	77	77	76	75
SR	Pre. 2	33	35	37	37	37	37	37	37	37	36	34
	Pre. 1	35	38	38	38	38	38	38	38	38	38	38
	Acc.	38	38	38	38	38	38	38	38	38	38	38
	Post. 1	37	37	37	37	37	38	38	38	38	36	35
LF	Pre. 2	35	37	37	40	40	40	40	40	40	40	40
	Pre. 1	40	40	40	40	40	40	40	40	40	40	39
	Acc.	40	40	40	40	40	40	40	40	40	40	40
	Post. 1	40	40	40	40	40	40	40	40	39	39	36

b) Pitch range and PPA%

Mean values of pitch range and PPA% are shown in Table 4.75. The distribution of pitch range in the pretonals is somewhat like the one found in 4a posttonals: the syllable closest to the edge of the word has a higher range. This suggests a positional quality tied to that syllable. Since range in pre. 2 was almost identical in all accents, no significant differences were found. In pre. 1, SR has a slightly greater range, but the differences are not significant. The accented syllable exhibited the greatest range, and together with post. 1, there was a tendency for pitch range to grow from LR to LF. Relatively weak main effects for *accent* were found in the accented, $F(2, 143) = 4.48$, $p = .0129$ and posttonal syllables, $F(2, 143) = 4.31$, $p = .0151$. Post hoc tests showed that LF's pitch range was significantly higher than LR's in both syllables: acc. $p = .0091$ and post. 1 $p = .0122$.

PPA% showed quite typical values for each of the accents: pitch peaks early in the posttonal in rising accents (slightly later in SR) and late in the accented syllable for falling. A one-way ANOVA was conducted and a main effect was found for *accent*, $F(2, 143) = 5.43$, $p = .0053$. A post hoc test distinguished between LF and the rising accents, which did not differ from each other: SR vs. LF ($p = .0071$), LR vs. LF ($p = .0198$). The results presented until now strongly indicate that production of non-initial falling accents is, when considering only the accented and first posttonal syllable, just like in initial syllables.

Table 4.75. Mean pitch range and PPA% values in initial 4b words

Accent	Syllable	Range	PPA%
LR	Pre. 2	8.99	
	Pre. 1	5.68	
	Acc.	20.8	2.46
	Post. 1	13.73	
SR	Pre. 2	9.79	
	Pre. 1	6.15	
	Acc.	23.06	6.05
	Post. 1	16.42	
LF	Pre. 2	9.71	
	Pre. 1	4.99	
	Acc.	27.16	-9.5
	Post. 1	19.58	

c) Duration

Mean and SD values of initial 4b words across patterns are found in Appendix D under Table D.26. Since differences between patterns were minimal and can still be seen in the combined values, they will not be discussed here to avoid redundancy. Table 4.76 presents combined mean and SD values of duration for all accents and syllables. No major differences in duration in the pretonals and posttonals were found, with the only exception being SR in post. 1.

Table 4.76. Mean and SD values of duration in initial 4b words

Accent	Pre. 2	Pre. 1	Acc.	Post. 1
LR	50.01 (12.96)	48.14 (12.35)	96.29 (24.1)	54.34 (13.97)
SR	54.79 (17.04)	53.32 (13.43)	78.16 (18.23)	65.23 (19.33)
LF	49.89 (13.66)	50.81 (13.57)	96.22 (15.37)	53.32 (13.49)

A Mann-Whitney *U* test was conducted in the posttonal syllable, and a main effect was found for *accent* (p =.0023). Steel-Dwass post hoc tests showed that SR had significantly longer duration than the other accents together: SR vs. LR Z = 3.14 p =.0047, SR vs. LF Z = 3.03 p =.0068. The greatest difference could be observed in the accented syllable, in which LF had the same duration as LR, which is the only reason it was renamed into „LF“, and not „SF“. This makes even more sense when the noticeably shorter duration of SR is considered. This was confirmed statistically with a Mann-Whitney *U* test, which had a main effect for *accent* (p <.0001). As expected, SR’s duration was significantly shorter than LF’s and LR’s together, which did not differ from each other: LF vs. SR Z = 4.09 p =.0001, LR vs. SR Z = 4.78 p =.0005.

d) Summary

In conclusion, pretonal syllables have a moderately falling contour, which was steeper for pre. 2 because it was closest to the word’s edge. LR had lower pitch in the first two syllables, and LF and SR were grouped together. In the accented syllable, both rising accents are grouped together and have a steep rising contour. LF had noticeably higher pitch and an even steeper contour. All accents were falling in the posttonal, but LF had significantly lower pitch, which was also lower than the end of its accented syllable. Pitch peaks in LF were produced at the end of the accented syllable and the rising accents placed them at the beginning of the posttonal. Duration was generally uniform in the pretonals, but was longer for the phonologically long accents in the accented syllable and SR in the posttonal.

4.4.2.2 Medial 4b Quadrisyllabic Words

a) Contour shape and overall pitch

Mean F_0 tracks are displayed in Figure 4.37 and sample size in Table 4.77. Pretonal syllables behave much like in the previous condition: both have a falling contour, which is slightly steeper in pre. 2. LF has higher pitch in pre. 2, but the differences were not significant. In pre. 1, LR had marginally lower pitch, which proved to be significant due to a main effect on *accent*, $F(2, 144) = 5.87$, $p = .0035$. A post hoc test showed that SR and LF behaved as a group against LR: SR vs. LR ($p = .011$), LF vs. LR ($p = .0236$).

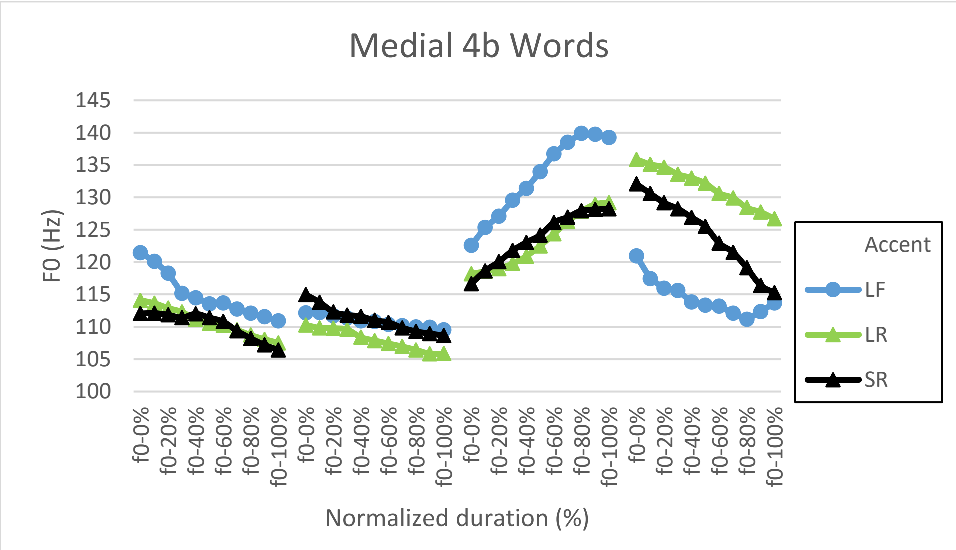

Figure 4.37. Mean F_0 tracks of medial 4b words

Rising accents in the accented syllable were grouped together according to overall pitch and contour, which was rising. LF, on the other hand, exhibited a much steeper rise with a „hook" at the end of the vowel, and also noticeably higher pitch. A main effect was found for *accent*, $F(2, 144) = 21.92$, $p < .0001$. A post hoc test revealed that LF was significantly higher than the rising accents, which did not differ from each other: LF vs. LR, LF vs. SR ($p < .0001$.). In the posttonal syllable, rising accents had similar falling contours, with SR's being not only steeper, but also lower. LF's contour had lower pitch and was falling at the beginning of the vowel but was evened out at the second half, the slight rise at the end can be attributed to several missing values in the last two measurement points. There was a statistical main effect for *accent*, $F(2, 144) = 49.19$, $p < .0001$. OvMean distinguished between all accents (all *p*-values were <.0001), which indicates that the tonal contrast between LR and SR is found mainly in the posttonal. Contrast between rising and falling accents, on the other hand, is located, as usual, in both the accented and posttonal syllable.

Table 4.77. Number of samples in measurement points in medial 4b words across three accents

Accent	Syllable	f0-0%	f0-10%	f0-20%	f0-30%	f0-40%	f0-50%	f0-60%	f0-70%	f0-80%	f0-90%	f0-100%
LR	Pre. 2	78	78	78	78	78	78	78	78	78	77	76
	Pre. 1	77	77	77	78	78	78	78	78	78	76	72
	Acc.	72	78	78	78	78	78	78	78	78	78	78
	Post. 1	78	78	78	77	77	77	76	76	75	74	71
SR	Pre. 2	36	38	38	38	38	38	38	38	38	37	36
	Pre. 1	38	39	39	39	39	39	39	39	39	39	39
	Acc.	39	39	39	39	39	39	39	39	39	39	39
	Post. 1	37	38	38	38	38	38	38	38	39	39	39
LF	Pre. 2	32	37	37	39	39	39	39	39	39	39	39
	Pre. 1	39	39	39	39	39	39	39	39	38	38	38
	Acc.	39	39	39	39	39	39	39	39	39	39	39
	Post. 1	39	39	39	39	39	38	37	36	34	30	25

b) Pitch range and PPA%

Mean values of pitch range and PPA% are shown in Table 4.78. Pitch range in pre. 2 was quite uniform, and like in the previous condition, was greater than in pre. 1. Even though LF's pre. 1 had a smaller range, the differences in the pretonal syllables were not significant. In the accented syllable, LF had the greatest range, followed by SR and LR, which had very similar values. Confirming this, a statistical main effect was found for *accent*, $F(2, 144) = 6.99$, $p = .0013$, which distinguished between LF and the rising accents: LF vs. SR ($p = .0015$), LF vs. LR ($p = .0083$).

Table 4.78. Mean pitch range and PPA% values in medial 4b words

Accent	Syllable	Range	PPA%
LR	Pre. 2	8.51	
	Pre. 1	6.76	
	Acc.	12.78	5.25
	Post. 1	11.31	
SR	Pre. 2	9.81	
	Pre. 1	7.57	
	Acc.	12.15	-4.61
	Post. 1	15.4	
LF	Pre. 2	9.33	
	Pre. 1	4.83	
	Acc.	19.2	-20.51
	Post. 1	13.53	

Post. 1 exhibited greater range for SR due to its steep fall, and a main effect was found for *accent*, *F*(2, 143) = 5.17, *p* =.0068, confirming that SR had a greater span than the other accents (*p* =.0048). PPA% mean values were well within the norm for LR and LF. SR had slightly negative values, which were, however, close to the median of both rising accents: 0%. Peaks were realized somewhat earlier in their respective syllables due to being in a prosodically less prominent position than the initial condition. A one-way ANOVA showed a main effect for *accent*, *F*(2, 144) = 16.16, *p* <.0001, which showed that LF's PPA% was significantly lower than the rising accents': LR vs. LF (*p* <.0001), SR vs. LF (*p* =.0087).

c) Duration

Mean and SD values of accents and syllables across patterns are shown in Appendix D under Table D.28. Combined values are shown in Table 4.79. Much like in the previous condition, duration varied very little in the pretonals and posttonals, and except for SR in post. 1, was equal for all accents. A main effect was found for *accent* only in the posttonal, *F*(2, 144) = 21.77, *p* <.0001, which showed that SR's duration was significantly longer than the other accents, which behaved as a group (both comparisons had a *p*-value of <.0001). In the accented syllable, LR and LF had the same duration, which was noticeably longer than SR's. A significant effect was found for *accent*, *F*(2, 143) = 19.04, *p* <.0001. A post hoc test revealed that SR's duration was significantly lower than LR's and LF's, which did not differ from each other (*p* <.0001). These results, compared with the ones in the previous subsection, show that there no durational differences between the initial and medial conditions.

Table 4.79. Mean and SD values of duration in medial 4b words

Accent	Pre. 2	Pre. 1	Acc.	Post. 1
LR	52.92 (12.4)	48.21 (13.8)	98.92 (27.57)	53.23 (13.88)
SR	46.95 (18.08)	50.05 (14.55)	74.16 (16.33)	69.84 (16.97)
LF	52.58 (11.01)	52.67 (13.39)	100.3 (17.23)	53.98 (11.99)

d) Summary

In conclusion, both pretonals have a falling contour, which is steeper in pre. 2 and higher in pre. 1. LF had slightly higher pitch in pre. 2, whereas the other accents were tightly grouped around each other. In the accented syllable, LF had a steep rise with a short plateau at the end of the vowel and rising accents were characterized by a milder rise with significantly lower pitch. The posttonal syllable showed three distinct patterns: falling for LR, steeply falling with lower pitch for SR and falling-level for LF with the lowest pitch of the three. Pitch peaks were produced at the beginning of the posttonal in the rising accents and at the end of the acccented syllable in falling ones. Duration varied mainly in the accented syllable, being higher for LR and LF, and also in the posttonal of SR, which was ca. 16 ms longer than the other accents.

4.4.2.3 Final 4b Quadrisyllabic Words

a) Contour shape and overall pitch

Mean F_0 tracks are displayed in Figure 4.38, with sample size in Table 4.80. In pre. 2, all accents have a falling contour, which has higher pitch and a steeper beginning for LF and SR. In the following syllable, the same contour can be observed in SR, while LF and LR are somewhat less steep. However, no significant differences were found. LF and LR in the accented syllable are falling, while SR could be better described as level. Furthermore, LF's pitch was significantly higher, as confirmed by a main effect on OvMean (log-transformed) for *accent*, $F(2, 140) = 9.78$, $p < .0001$. A post hoc test showed that SR and LR behaved as a group against LF: LF vs. LR ($p < .0001$), LF vs. SR ($p = .0219$). In the posttonal syllable, LF and LR both had a level contour, with LF having somewhat lower pitch. SR, on the other hand, was clearly falling. It should be noted, however, how the rising accents' *f0-0%* points are closer to each other and to the end of their accented syllables, while LF is noticeably lower. There was a small main effect on OvMean (log-transformed) for *accent*, $F(2, 101) = 5.52$, $p = .0053$, which showed that LF was significantly lower than LR ($p = .005$) and SR ($p = .0124$). In previous word types, falling accents' had a greater pitch fall between the accented and posttonal syllables.

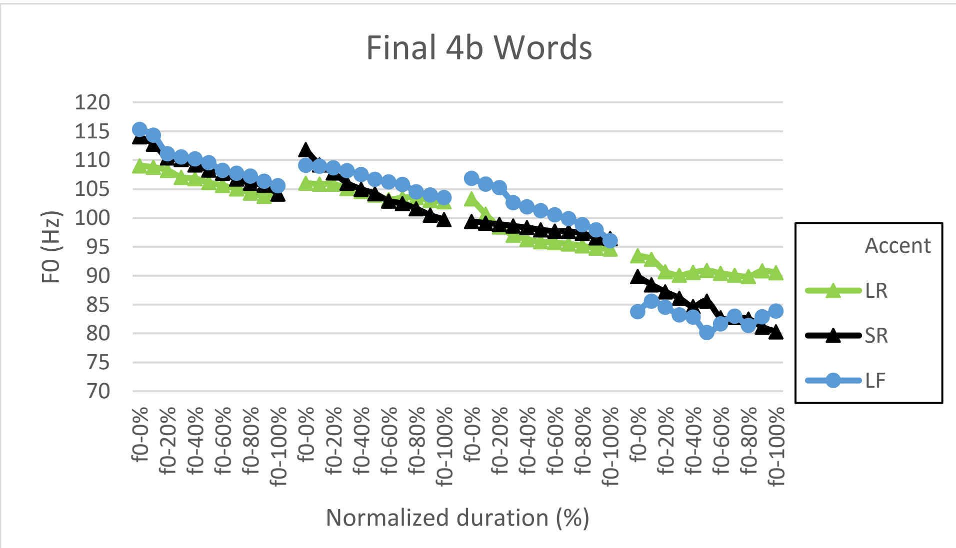

Figure 4.38. Mean F_0 tracks of final 4b words

Table 4.80. Number of samples in measurement points in final 4b words across three accents

Accent	Syllable	f0-0%	f0-10%	f0-20%	f0-30%	f0-40%	f0-50%	f0-60%	f0-70%	f0-80%	f0-90%	f0-100%
LR	Pre. 2	76	78	78	78	79	79	79	79	78	78	76
	Pre. 1	75	75	75	75	75	76	76	75	73	70	68
	Acc.	65	75	78	78	78	78	78	78	78	78	75
	Post. 1	63	63	61	60	58	56	54	48	38	32	23
SR	Pre. 2	29	32	33	32	33	33	33	33	33	32	30
	Pre. 1	34	35	35	35	35	35	35	35	35	35	35
	Acc.	34	34	35	35	35	35	35	35	35	35	34
	Post. 1	29	29	30	30	27	21	14	10	8	6	4
LF	Pre. 2	34	38	39	39	39	39	39	39	39	39	39
	Pre. 1	38	38	38	38	38	38	38	38	38	38	37
	Acc.	39	39	39	39	39	39	39	39	39	39	39
	Post. 1	13	14	16	14	14	13	11	10	5	4	5

b) Pitch range and PPA%

Mean values of pitch range and PPA% are shown in Table 4.81. Generally, pitch range did not vary much in the pretonals and posttonals, except for pre. 1 in SR, which was the only case where it had a larger range than pre. 2. Consequently, there was a main effect found for *accent* in pre. 1, $F(2, 138) = 9.16$, $p = .0002$, which showed that LR and LF behaved as a group against SR: SR vs. LF ($p = .0003$), SR vs. LR ($p = .0015$). The accented syllable had the greatest range for LR and LF, which in SR was quite small since its contour was level. A one-way ANOVA in the accented syllable showed a main effect for *accent*, $F(2, 140) = 11.7$, $p < .0001$. LF and LR behaved as a group against SR: LF vs. SR ($p = .0001$), LR vs. SR ($p < .0001$). This indicates that pitch range was mainly relevant in the accented syllable.

Pitch peaks were all produced in the first half of the accented syllable, which is one of the defining characteristics of the final position. PPA% values are analogous to those seen in other contexts, i.e. earliest for falling accents, followed by LR and somewhat later in SR. A one-way ANOVA found a statistical main effect for *accent*, $F(2, 104) = 4.38$, $p = .0149$. Only the difference between SR and LF proved to be significant: $p = .0129$. This suggests that pitch peak alignment plays at least a partial role in contrasting between non-initial falling and rising accents.

Table 4.81. Mean pitch range and PPA% values in final 4b words

Accent	Syllable	Range	PPA%
LR	Pre. 2	7.07	
	Pre. 1	6.66	
	Acc.	10.63	-80
	Post. 1	5.06	
SR	Pre. 2	9.15	
	Pre. 1	12.35	
	Acc.	5.83	-65.48
	Post. 1	5.66	
LF	Pre. 2	9.49	
	Pre. 1	6.23	
	Acc.	11.37	-95.88
	Post. 1	6.06	

c) Duration

Mean and SD values of accents and syllables across patterns are shown in Appendix D under Table D.30. Combined values are shown in Table 4.82. The first two syllables are almost identical for all accents, and have no significant differences between each other. In the accented syllable, LR has the highest duration and interestingly enough, LF has the same duration as SR, as opposed to the previous two conditions. A main effect was found for *accent*, $F(2, 135) = 73.31$, $p < .0001$, which showed that SR and LF behaved as group against LR ($p < .0001$).

Table 4.82. Mean and SD values of duration in final 4b words

Accent	Pre. 2	Pre. 1	Acc.	Post. 1
LR	55.95 (16.43)	50.8 (14.8)	138.34 (24.94)	56.36 (15.59)
SR	54.58 (18.38)	57.74 (17.49)	95.48 (19.41)	90.33 (23.34)
LF	50.83 (11.58)	51.63 (14.03)	99.97 (18.04)	61.36 (14.47)

In the posttonal, SR had an extremely long duration, almost the same as in the accented syllable. LF's and LR's duration did not differ from each other, as seen by the main effect found for *accent*, $F(2, 142) = 65.53$, $p < .0001$. A post hoc test showed that SR was significantly longer than LF and LR together (both comparisons had a *p*-value of <.0001).

d) Summary

In conclusion, the first three syllables in the word have a falling contour with varying steepness. In pre. 2, no tonal contrast between the accents was detected. RS had a steeper fall in pre. 1, which proved to be significantly different than the other accents'. LR had the longest duration in the accented syllable, while LF and SR were equally long. Additionally, the long accents had an equal pitch range, which was twice as big as SR's. In the posttonal, the long accents had a level contour, and SR's duration was very long, which has also been observed in previous contexts. Pitch peaks were all produced at the beginning of the accented syllable and were located significantly later for SR.

4.4.2.4 Overview and Comparison of 4b Quadrisyllabic Words

a) Contour shape and overall pitch

Generally, differences between SR and LR were much smaller than between rising and falling accents. As in most cases, conditions can be divided into finals and non-finals. In the non-final conditions, the first two pretonals seem to contain relatively little tonally relevant parameters, which are mostly found in the accented and posttonal syllables. In the former, rising accents had identical pitch and contours, while LF had a steeper rise and was noticeably higher. The posttonal syllable exhibits falling contours in all accents, with the rising accents grouped together and higher than LF in the initial condition. Medially, there were distinct patterns for each accent, from highest to lowest: falling in LR, steeply falling in SR and falling-level for LF. The final condition, on the other hand, was in essence a series of falling and level contours, much like in 4a. Contrast between LF and the rising accents was found only in the accented and posttonal syllables, with LF having higher and lower pitch, respectively. In the posttonal, LR and LF had level contours and SR falling. A one-way ANOVA was conducted with *accent*, *sentence*, *syllable type* and their interactions. There were main effects for all interactions: *sentence* x *accent*, $F(4, 1772) = 3.42$, $p = .0085$, *accent* x *syllable type*, $F(6, 1772) = 58.33$, $p < .0001$ and *sentence* x *syllable type*, $F(6, 1772) = 246.11$, $p < .0001$. Post hoc tests showed that each condition behaved as a group against the others, with pitch being significantly higher in initials, followed closely by medials and lowest for finals. Accented LF had the highest pitch of all combinations, followed by post. 1 and acc. of the rising accents and finishing with all pretonals. Additionally, it was revealed that accented and posttonal initials had the highest pitch, followed by the same syllables in the medial condition, then initial and medial pretonals and lastly, all the final combinations together.

b) Pitch range and PPA%

Table 4.83 displays mean pitch range values for all accents and syllables across conditions. Pitch range in pretonals was generally the same, regardless of accent and condition. Most importantly, pre. 2 had greater pitch range than pre. 1, except in final SR. The accented and posttonal syllables had the greatest pitch range and it tended to grow vertically (from LR to LF) and decrease horizontally (from initial to final). Pitch range in general grew smaller with decreased prosodical prominence, i.e. from initial to final. Using the same statistical model as above, a one-way ANOVA was conducted. There was a statistical main effect for *sentence* x *syllable type*, $F(6, 1765) = 28.57$, $p < .0001$ and *accent* x *syllable type*, $F(6, 1765) = 7.76$, $p < .0001$. A post hoc test showed that initial accented syllables had significantly higher range than all other constituents, followed by initial and medial posttonals, and finishing with the rest of the combinations at the bottom of the scale. Accented syllables had the largest range, followed by posttonals and finally, the pretonals.

Table 4.83. Mean pitch range values in 4b words across conditions

Accent	Syllable	Initial	Medial	Final
LR	Pre. 2	8.99	8.51	7.07
	Pre. 1	5.68	6.76	6.66
	Acc.	20.8	12.78	10.63
	Post. 1	13.73	11.31	5.06
SR	Pre. 2	9.79	9.81	9.15
	Pre. 1	7.36	7.57	12.35
	Acc.	23.06	12.15	5.83
	Post. 1	16.42	15.4	5.66
LF	Pre. 2	9.71	9.33	9.49
	Pre. 1	4.99	4.83	6.23
	Acc.	27.16	19.2	11.37
	Post. 1	19.58	13.53	6.06

Mean PPA% values in all accents and conditions are shown in Table 4.84 below. A clear distinction between falling and rising accents can be seen in the initial and medial conditions. Rising accents place their pitch peaks in the posttonal and falling accents in the accented syllable. It can also be seen that all accents have earlier peaks in the medial condition, with SR even having negative values. In the final condition, all peaks are retracted to the accented syllable. A one-way ANOVA with *accent*, *sentence* and their interaction confirmed this with main effects for *accent*, $F(2, 405) = 17.39$, $p < .0001$, *sentence*, $F(2, 406) = 282.09$, $p < .0001$ and *sentence* x *accent*, $F(4, 404) = 3.09$, $p = .0158$. Post hoc tests showed significant differences between rising and falling accents on the one hand, and final and non-final conditions on the other. Rising non-final accents had the highest (positive) values at the top, with all finals at the bottom with negative values.

Table 4.84. Mean PPA% values of 4b words across conditions

Condition	Accent	PPA%
Initial	LR	2.46
	SR	6.05
	LF	-9.5
Medial	LR	5.25
	SR	-4.61
	LF	-20.51
Final	LR	-80
	SR	-65.48
	LF	-95.88

c) Duration

Mean and SD values of duration across accent types and sentence positions are shown in Table 4.85. In contrast to other word types, 4b showed the least variation in syllable duration. As can be seen, both pretonals and the posttonal were almost identical in duration, independently of accent and condition. Even the final condition, which normally always had longer duration, is barely distinguishable from the other sentence positions. The most notable exception is SR, which had a noticeably higher duration in the posttonal, reaching almost the level of the accented syllable in the final condition. In initial and medial accented syllables, LR and LF were substantially longer than SR. In the final position, however, LF had the same duration as SR, while LR was ca. 40 ms longer. There was a main effect found for all interactions: *sentence* x *accent*, $F(4, 1818) = 8.53$, $p < .0001$, *accent* x *syllable type*, $F(6, 1818) = 57.21$, $p < .0001$ and *sentence* x *syllable type*, $F(6, 1818) = 20.66$, $p < .0001$. Post hoc tests showed that final rising accents were significantly longer than all other combinations, which behaved as a group. The three accented syllables and SR's posttonal were each significantly different from all other combinations (LR > LF > SR acc. > SR post. 1), whereas all others formed one group. Additionally, final accented syllables were significantly longer than all other constituents, followed by accented medials and initials, final posttonals and lastly, the rest of the combinations.

Table 4.85. Mean and SD values of duration across accents and sentence conditions in 4b words

Condition	Accent	Pre. 2	Pre. 1	Acc.	Post. 1
Initial	LR	50.01 (12.96)	48.14 (12.35)	96.29 (24.09)	54.34 (13.97)
	SR	54.79 (17.04)	53.32 (13.43)	78.16 (18.23)	65.23 (19.33)
	LF	49.89 (13.66)	50.81 (13.56)	96.22 (15.36)	53.32 (13.48)
Medial	LR	52.92 (12.4)	48.21 (13.79)	98.92 (27.56)	53.23 (13.87)
	SR	46.95 (18.08)	50.05 (14.55)	74.16 (16.32)	69.84 (16.97)
	LF	52.58 (11.01)	52.67 (13.39)	100.3 (17.23)	53.98 (11.99)
Final	LR	55.95 (16.43)	50.8 (14.8)	138.34 (24.94)	56.36 (15.58)
	SR	54.58 (18.38)	57.74 (17.49)	95.48 (19.41)	90.33 (23.34)
	LF	50.83 (11.58)	51.63 (14.03)	99.97 (18.04)	61.36 (14.46)

d) Summary

4b words are characterized by two pretonal syllables with mild falling contours. Pre. 2, being closer to the beginning edge of the word has a moderately steeper fall but lower overall pitch, independantly of condition. In both pretonals, LR usually has lower pitch and LF is mostly higher. Both segments' duration is almost identical at ca. 50 ms, which suggests that all unaccented/unstressed syllables follow the same pattern. The accented and posttonal syllables manifest the full contrast between accent types for this word type: falling accents exhibit pitch peaks, larger range and higher pitch in the accented syllable, with the reverse for rising accents. Long accents' duration was consistently longer in non-final conditions, but LF merged with SR in the final. Additionally, SR's unusually long duration in the posttonal could also be observed, much like in other contexts. Differences between the initial and medial conditions were mostly concentrated in the accented syllable, which had larger range and later peaks in the former. The final condition shows typical characteristics already seen previously: falling-level contours throughout the word with notiecably smaller pitch range and pitch peaks retracted to the beginning of the accented syllable.

5

DISCUSSION AND CONCLUSIONS

In this chapter, the results of the production experiment will be summarized, compared with previous studies and applied to the working hypotheses from §2.4.3.7. Final conclusions will be drawn at the end.

a) Tone in monosyllabic words

The production of lexical tone in monosyllabic words is, by definition, the most unusual of all the word types investigated in this dissertation. Since monosyllabic words can only carry falling accents, the only contrast that can be analyzed in this context is between LF and SF. Furthermore, having only one syllable strips away that which is most crucial for tones in Croatian: context. By this I mean a second syllable in which the full complex of features can be manifested. Contrary to most phonological sources, falling accents have as much a bisyllabic nature as rising ones. In other words, a rising accent requires a higher posttonal (with everything that entails) as much as a falling accent must have a lower posttonal. Nevertheless, when comparing falling accents in monosyllabic and bisyllabic words, the contour of the accented syllables does look somewhat similar: generally rising in the initial position, level in the medial and falling in the final. However, the same can also be said of rising accents in bisyllabic words, which shows that one syllable is still not enough to constitute a contrast. As seen in Chapter 4, the only F_0-related difference between LF and SF in monosyllabic words is higher overall pitch in the former, which was only significant in the initial condition. More extreme pitch values in phonologically long accented syllables can be observed in almost all conditions and word types, which is an intrinsic quality of long vowels, much like formant values (Reetz & Jongman, 2009). When applied to this investigation, this is the same as saying higher pitch is a property of long accents. Quite surprisingly, there were no durational differences initially and medially, with LF and SF being equally long. The complete lack of significant differences between SF and LF both temporally and tonally in the medial position could be attributed to that condition's lower prosodic prominence, but further research on this specific subject is needed before a definitive explanation can be given. Only in the final position does LF truly live up to its name, where it is significantly longer than SF. Disregarding final lengthening, which also affects SF, the significant difference in duration between the two accents can be attributed to the general lack of contrast caused by falling contours in all syllables and mostly decreased measurement values. That is, since no tonal contrast is produced in non-final conditions, at least one factor, in this case duration, must be different in order to maintain the distinction. For these reasons, I conclude that monosyllabic words have no lexical tone. In order to be lexical, a tone in Croatian requires at least two syllables. Since there is no phonological distinction between rising and falling accents in monosyllabic words, there is also no reason for lexical tone to be present in that context. Phonologically speaking, both accents can be defined as a post-lexical H*, which is also comparable to the post-lexical H of Accent 1 in Limburgian. This H* moves around in the syllable depending on sentence position: close to the end of the word initially, close to the beginning finally and spread out throughout the vowel medially. It would be most interesting to see if and how rising accents in reduced bisyllabic words like **bác* and **pùst* (*báci* and *pùsti*) differ from a) falling accents in monosyllabic words and b) naturally occurring rising accents in bisyllabic words. Additionally, the subject of narrow vs. broad focus in monosyllabic words requires more investigation in order to see if lexical tone is present.

A comparison with Purcell (1973), which was the only one to analyze monosyllabic words (see Figure 2.24), shows more differences than similarities. First, Purcell's falling accents all had a rising-falling contour in all sentence positions. Second, LF was approximately 50% longer than SF. The most significant similarity to the current investigation was the lack of difference between the overall pitch of the two accents. It is, however, vital to point out that Purcell measured pitch in only four locations (beginning, middle, end and pitch peak). This, together with the lack of statistical analysis, provides much less useful information than the methods used in this dissertation.

b) Initial accentuation in polysyllabic words

Since production of tone in syllabic /r̩/ words was one of the main themes of this dissertation, it will be discussed here first. As demonstrated in §2.4.3.5 and §4.2.1, a syllabic /r̩/ contains three parts: two equally long [ə]-vocoids and the /r/ itself, which mostly had one or two taps. The duration of the two vocoids was sufficient to produce distinct pitch movements, and was mostly identical to the duration in vocalic bisyllabic words. Characterized by an intensity dip and irregular spectral properties, the consonantal element of syllabic /r̩/ also induced somewhat lower pitch, which was seen especially in words with SR. Nevertheless, this pitch dip was quite short and localized, so that it didn't significantly lower pitch around it. This is, as far as can be seen, the extent of the specifics of tone production in syllabic /r̥/ words. As in monosyllabic words, it would be interesting to see if narrow focus has any effect on tone. In my experience, narrow focus causes the first vocoid to become noticeably longer, which could contain potential differences when compared with broad focus as in this dissertation. As already mentioned above, the full spectrum of tone is realized only in polysyllabic words. This is best observed in the initial sentence condition, since being in a more prominent prosodic position strengthens all contrasts. Seen not only in bisyllabic, but also in 3a words, the opposition between falling and rising accents can be restricted to the accented and first posttonal syllables. That is, pretonals and further posttonals still show contrast between accent types (which will be discussed later), but they are secondary when compared to the most prominent syllables in the word. All accented syllables have a rising contour in non-final conditions. Confirming the prominence of the tonal (rising vs. falling) contrast over the durational (long vs. short), accents were grouped around each other according to their accent type. Furthermore, falling accents had universally higher overall pitch than rising accents in the accented syllable. For the short-long contrast, the most distinguishing parameter was duration. Apart from being longer, phonologically long accented syllables in some cases tended to have more extreme pitch values, depending on the accent type: LF was often higher than SF and LR was often lower than SR. It should be noted that this was more often the case for LR than LF. Pitch range also tended to be proportional to overall pitch, being mostly greater for long accents, i.e. short accents usually had flatter contours. In the posttonal syllable, contours are universally falling and overall pitch values for accent types are reversed: falling accents are significantly lower than rising ones. However, inter-syllabic differences were only one part of the contrast. More specifically, the beginning of a rising posttonal was higher than the end of its accented syllable, and the beginning of a falling posttonal was lower than its entire accented syllable. This twofold distribution varied somewhat between conditions and word types and was not always so pronounced in all cases, but generally, at least one part of it, i.e. higher rising or lower falling posttonal, was realized, which was sufficient for a contrast to be produced. This distribution is also directly tied to pitch peak alignment: a lower posttonal coincided with pitch peaks in the accented syllable, and a higher posttonal was accompanied by pitch peaks in the same segment. Therefore, falling accents had negative PPA% values, indicating peaks at the end of the accented syllable and rising accents had positive PPA% values, meaning peaks at the beginning of the posttonal. It should also be noted that differences in PPA% between short and long accents were much more pronounced in the falling type. SF usually had earlier peaks in the accented

syllable than LF, while in the rising accents, peaks were placed in the first 10% of the posttonal. This is the basic pattern of tone production in Croatian, and it is found in all polysyllabic contexts, including the non-initial rising accents in 3b, 4a and 4b.
Comparing the results of bisyllabic words in this dissertation with ones found in other investigations reveals quite a few similarities, but also several differences, which can be attributed to regional variation and methodology. Purcell (1973) and Lehiste & Ivić (1996), who recorded speakers from Vojvodina in Serbia and Bosnia and Herzegovina, can be considered together, since their results are so similar. The largest difference is seen in the production of falling accents. In the above investigations, falling accents have a much earlier pitch peak, and their contour can be therefore more accurately described as rising-falling, as opposed to rising in this dissertation. In Purcell (1973) these differences are more pronounced in SF, whereas in Lehiste & Ivić (1996) it is LF that stands out in this regard. On the other hand, the same universally falling contour in the posttonal and the relation between overall pitch in both syllables have been observed in the current and the above two works. The results in Pletikos (2008) are not as easily comparable due to the immense heterogeneity of the speakers and material recorded, but the contours of the various accents bear a striking similarity to the ones produced in the final condition here: almost no tonal contrast in the accented syllable, which is characterized by a more level contour for rising accents. The contrast is seen in the posttonal, which has higher overall pitch values for rising accents. Zintchenko Jurlina (2013), who only recorded initial bisyllabic words, shows results almost identical to the ones here, since both the dialect and most methods used were largely the same. The only observable divergence is a slightly different relation between the end of the accented and the beginning of the posttonal for accent types: Delta-Start was close to 0 for falling accents and negative for rising ones. Turning to trisyllabic words with initial accentuation, the results of Lehiste & Ivić, as seen at the bottom of Figure 2.21 are very much compatible with results seen in this dissertation. In all accents but LF, the same rising and falling contours in the various syllables can be observed. Likewise, falling accents had higher overall pitch in the accented syllable, which was reversed in the two posttonals. Pitch peaks were produced in the accented syllable for falling accents and in the posttonal for rising. The only exception is LF, which has a much earlier peak than in this investigation, causing its contour to be rising-falling, thus lowering its overall mean throughout the accented syllable. Results in Purcell (1973), as seen in Figure 2.25, are even more compatible with the current investigation, including the similarity between initial and medial conditions. A major difference can be observed, however, in the steepness of the fall throughout the entire word.

Posttonals have a much smaller pitch range and their overall pitch is usually within the range produced in the accented syllable. For instance, the second posttonal syllable in LF in the final condition has higher pitch than the first posttonal, as opposed to a much lower pitch in this experiment.

c) Tone in sentential positions

As seen throughout the fourth chapter, tone production can be roughly divided into final and non-final conditions. That is, the initial and medial conditions can be considered variations of each other, while the final position is clearly different. First, the non-final positions are characterized by rising (or at least not falling) contours in the accented syllable. Second, overall pitch was much higher than in the final condition. Mostly true for bisyllabic and 3a words, the rising contour is truncated in the medial position, being noticeably flatter. This can also be seen in monosyllabic words, which indicates that this is a positional property (due to being less prominent), and not a tonal one. Not only is the overall pitch lower and the contour less rising, pitch range and PPA% in the medial position are lower. This can best be seen in falling accents, which produce their pitch peaks earlier in the accented syllable. Rising accents tended to have only slightly earlier peaks. This is also an indication of the importance of PPA for rising accents: except for the final condition, the peak must be placed on the posttonal. In general, differences between initial and medial positions tended to be minimal in words with non-initial rising accents, like 3b, 4a or 4b.

The final condition is characterized by universally falling or level contours with considerably lower pitch throughout the word. Additionally, tonal contrast was substantially reduced. This does not mean, however, that the contrast is neutralized, as seen in Lehiste & Ivić (1996). Rather, falling accents in the accented syllable were definitely falling and usually had slightly higher pitch, while rising accents tended to be noticeably less steep, although this was hardly significant. More importantly, however, is the relation to the posttonal. Rising posttonals had higher pitch than falling accents, which indicates the presence of a tonal contrast at least in one syllable. Because of the falling contours, pitch peaks were shifted to the beginning of the accented syllable for all accents. In some cases, there was a distinction between falling and rising, with the latter having peaks slightly closer to the end of the vowel, but these were too few for a concrete pattern.

Additional characteristics of the final condition include higher duration, which is attributed to final lengthening. Pitch range in the accented syllable tended to be between initials and medials, and much lower in non-accented syllables. Due to final lowering, which often caused laryngealization and devoicing of vowels, many final syllables had a large amount of missing values. There was a tendency for falling and short accents to have more missing values because of the already low pitch on the one hand, and the higher probability of deletion due to shorter duration on the other. For the most part, however, combined measurements from different patterns were enough to measure pitch throughout the entire vowel. Distinctions between long and short accents were chiefly durational.

In Lehiste & Ivić (1996), production in various sentential positions is generally the same as in this dissertation and can be summed up by three factors: higher overall pitch and greater pitch range in initial position, becoming gradually lower in the medial and lowest in the final position. Pitch peaks were produced the latest in the initial condition, followed by medials and earliest in the final position. As already mentioned, very little difference is found between rising and falling accents in the final position, which leads the authors to assume a neutralization of tonal contrast in this condition. Rather, the contrast is tentatively expressed as more (falling accents) or less (rising accents) frequent laryngealization, which has also been observed in this dissertation. Purcell (1973) found tonal contrast in both syllables, as opposed to only the posttonal in the current investigation. In both of the above works, duration was slightly longer in rising accents, while no such distinction was found here.

d) Pretonals, patterns and non-initial falling accents

As mentioned at the beginning of this dissertation, the production of tone in pretonal syllables has never been phonetically investigated. All pretonal syllables are falling, which is the default contour for non-accented syllables in Croatian. Furthermore, pretonals are substantially lower than accented and all posttonal syllables, which can also be attributed to the presence of a word-initial boundary tone, as explained in §2.4.2.4. In 3b or 4a words, where the pretonal is located immediately to the left of the accented syllable, little or no durational or tonal contrasts were found. In 4b words, however, where there were two pretonal syllables, the one next to the accented syllable had higher pitch. In such cases, the second pretonal (i.e. pre. 2) almost always had a greater pitch range, and thus a steeper fall, which indicates higher prosodic prominence. Seen in Appendix D, the standard deviation of F_0 in all pretonals was relatively small (ca. 15 Hz) and was usually identical to the accented syllable, which shows lesser variation, indicating specific tonal targets for these segments. For comparison, SD in posttonals was usually twice as high. Duration in the pretonals was very stabile and uniform in all contexts, and was rarely lower or higher than 50 ms. This general lack of variance in the pretonals leads me to conclude that they are inherently toneless.

Various tonal patterns in most word types were included in this dissertation mainly to have a large and diverse corpus. The results in Chapter 4 have shown that patterns have very little effect on the posttonal syllables, both durationally and tonally. For the most part, no concrete tendencies could be detected. Phonologically short posttonals very often had a higher duration than phonologically long ones, which also varied quite frequently within each pattern, word type and accent. The only exception can be seen in SR, whose posttonal usually had a significantly higher duration than all others. It would therefore be quite interesting to compare PTL in Croatian to Bosnian, where, in my experience, it is still a vital part of the prosodic system. In any case, the results here show that a reconsideration of the status and role of PTL in Croatian is in order.

Although originally not part of this dissertation, an excellent opportunity to investigate non-initial falling accents presented itself in 4b words of foreign origin (e.g. *tolerantnost*). The results showed that, disregarding the presence of pretonal syllables, falling accents in non-initial syllables are produced much in the same way as they are initially. Namely, pitch in the accented syllable is much higher and the contour is also steeper than in initial context, which is possibly done to increase the contrast between accent types. Additionally, the gap between the end of the accented syllable and the beginning of the posttonal was considerably larger than in “normal” falling accents. As with PTL, there is a clear disagreement between the official prescriptive phonology and the phonetic reality. At the very least, the presence of non-initial falling accents in Croatian should be acknowledged, instead of explained away as sub-standard or ignored altogether.

Five hypotheses were posited in §2.4.3.7 for how lexical tone will likely be produced in Croatian, based on previous investigations and my own personal observations. I will now address each of them separately:

Hypothesis 1: „Only two phonological categories – falling and rising. Different acoustic parameters for accent quality and quantity.“ **Confirmed** - Accents were grouped according to quality. Pitch Peak Alignment and mean pitch contrasted between accent quality, duration and pitch range between accent quantity. Differences between qualities were phonetic due to longer duration.

Hypothesis 2: „Accented syllables are rising and posttonals are falling.“ **Confirmed** – All four accents followed the same basic pattern as in Zintchenko Jurlina (2013).

Hypothesis 3: „Initial and medial sentence positions form one pattern, which differs from the final. Complete or partial neutralization of tonal contrast in the final position.“ **Confirmed** – The medial position was akin to the initial, but less pronounced and with greater variation due to lower prosodic prominence. The final position was distinct in that all contours were falling, with partial neutralization of the tonal contrast. This contrast was almost completely neutralized in the accented syllable, but was mostly maintained in the posttonal through overall pitch and PPA%.

Hypothesis 4: „Pitch in pretonals is lower than accented, but higher than posttonal syllables.“ **Partially confirmed** – In non-final conditions, pitch in pretonals was indeed lower than in accented syllables, but except for one context (medial 4a words), was also much lower than posttonals.

Hypothesis 5: „Primarily durational differences between tonal patterns with and without PTL, tonal contrasts only optional.“ **Not confirmed** – No systematic durational or tonal differences found between words with short or long posttonal syllables. A review of the phonological distribution of PTL in Croatian is required.

It is important to stress that the results presented in this dissertation are relevant only to the production of tone. In order to acquire a complete picture of this phenomenon, acoustic perception experiments are required, which will show which parameters are crucial to identifying and distinguishing between the four accents. Testing the perception of tone by L2-speakers of Croatian could also greatly improve the entire learning process.

Returning once more to the basic pattern of tone production in Croatian, I would like to emphasize that there is a distinct prosodic hierarchy present. The major distinction between accents in Croatian is primarily one of rising vs. falling accents, which is best defined by (in order of importance): pitch peak alignment, overall pitch and pitch range. The long vs. short distinction is chiefly one of duration, but also overall pitch (more extreme values in long accents) and pitch range (greater in long accents). In other words, accents types are distinguished mainly by tonal features and accent length, on the other hand, by duration and only secondarily by F_0.

APPENDIX A – PARTICIPANT QUESTIONNAIRE (CROATIAN)

GOETHE UNIVERSITÄT FRANKFURT AM MAIN

Osobni podaci

1) Ime i prezime: ____

2) Spol: ____

3) Dob: ____

4) Maternji jezik: ____

5) U kojem ste gradu rođeni?: ____

6) U kojem ste gradu odrasli?: ____

7a) Da li su vaši roditelji iz istog grada?: ____

7b) Ako ne, odakle su?: ____

8) Gdje ste se školovali?: ____

9) Zanimanje: ____

Izjava o suglasnosti

Ovim izjavljujem da sam suglasan da se tonski zapis sa mojim glasom koristi u ovom znanstvenom radu i istraživanju. Poznato mi je da će moji osobni podaci ostati anonimni te da će biti poznati samo osobi koja me snima.

Datum i mjesto: ______________________________ Potpis: ______________________

APPENDIX A – PARTICIPANT QUESTIONNAIRE (ENGLISH)

GOETHE
UNIVERSITÄT
FRANKFURT AM MAIN

Personal information

1) Name and surname: ____

2) Gender: ____

3) Age: ____

4) Mother tongue: ____

5) In which city were you born?: ____

6) In which city did you grow up?: ____

7a) Are your parents from the same city?: ____

7b) If not, where are they from?: ____

8) Where did you go to school?: ____

9) Profession: ____

Statement of agreement

I hereby declare that I agree to the use of the audio recording with my voice in this scientific work and investigation. I am aware that my personal information will be left anonymous and will be known only to the person who records me.

Date and place: ___________________________ Signature: _______________________

APPENDIX B – RECORDED MATERIALS

B1 - The following table contains all target words recorded in the production experiment. Tonal patterns with a short accented syllable are colored gray.

Syll.	Pattern	Items	Syll.	Pattern	Items
1	V̏	pȁs, brȁt, dȉm, pȍd		V̀ V̄ V̆	kòšārka, pòdrūčje
	V̂	pût, sîn, hrâst, brôd		V̀ V̆ V̄	kònobār, kèmičār
2s	V̏ V̆	čȁša, kȉša		V̀ V̄ V̄	Dùbrōvnīk, bèstīdnōst
	V̂ V̆	mêso, môre		V́ V̆ V̆	nádimak, ráditi
	V̀ V̆	kùpus, sèstra		V́ V̄ V̆	pítānje, nárjēčje
	V́ V̆	prózor, pétak		V́ V̆ V̄	národnōst, nárednīk
2l	V̏ V̄	kȕhār, pȁmēt		V́ V̄ V̄	nástāvnīk, nádzōrnīk
	V̂ V̄	rûdnīk, dnêvnīk	3b	V̆ V̀ V̆	kukùruz, domàčin, tišìna, sredìna
	V̀ V̄	dùhān, bùnār		V̆ V̀ V̄	tambùrāš, predàvāč, partìzān, medènjāk
	V́ V̄	prúgōm, rúkōm		V̆ V́ V̆	komárac, Bosánci, rješénje, paráda
2R	Ȑ V̆	dȑvo, sȑce, bȑdo, pȑsti		V̆ V́ V̄	mogúćnōst, sigúrnōst, sposóbnōst, budúćnōst
	R̂ V̆	cȓkva, sȓpanj, gȓmlje, tȓnje	4a	V̆ V̀ V̆ V̆	kobàsica, djevòjčica
	R̀ V̆	hr̀pa, hr̀đa, pr̀sa, tr̀buh		V̆ V̀ V̄ V̆	kolèbānje, Evànđēlje
	Ŕ V̆	sŕna, vŕba, vŕsta, hŕčak		V̆ V̀ V̆ V̄	fonètičār, daròvitōst
3a	V̏ V̆ V̆	pȍbjeda, gȍdina		V̆ V̀ V̄ V̄	nedòrāslōst, peràdārnīk
	V̏ V̄ V̆	srȅdīšte, pjȅvānje		V̆ V́ V̆ V̆	boróvnica, šahóvnica
	V̏ V̆ V̄	kȉšobrān, rȁzgovōr		V̆ V́ V̄ V̆	zanímānje, naprézānje
	V̏ V̄ V̄	knjȉžēvnīk, hȕmānōst		V̆ V́ V̆ V̄	sunárodnjāk, beskrálježnjāk
	V̂ V̆ V̆	dnêvnica, Đûrđevac		V̆ V́ V̄ V̄	besprijékōrnōst, prenápōrnōst
	V̂ V̄ V̆	sûnčānje, pâmćēnje	4b	V̆ V̆ V̀ V̆	tjestenìna, gotovìna, knjigovòdstvo, kiselìna
	V̂ V̆ V̄	smîrenōst, skrûšenōst		V̆ V̆ V̀ V̄	toleràntnōst, kompetèntnōst, relevàntnōst, turbulèntnōst
	V̂ V̄ V̄	vêzānōst, mâjčīnskī		V̆ V̆ V́ V̆	Dalmatínac, čudotvórac, vatrogásac, maratónac
	V̀ V̆ V̆	grànica, sùpruga		V̆ V̆ V́ V̄	genijálnōst, populárnōst, negatívnōst, produktívnōst

APPENDIX B – RECORDED MATERIALS

B2 - The following table shows the English translation of all target words. Unless otherwise stated, all words are nouns in the nominative singular.

Pattern	Word	Translation	Pattern	Word	Translation
V̏	pȁs	dog	R̀ V̆	tr̀buh	belly
	brȁt	brother	Ŕ V̆	sŕna	roe deer
	dȉm	smoke		vŕba	willow
	pȍd	floor		vŕsta	type, kind
V̂	pût	path, road		hŕčak	hamster
	sîn	son	V̏ V̆ V̆	pȍbjeda	victory
	hrâst	oak		gȍdina	year
	brôd	ship	V̏ V̄ V̆	srȅdīšte	hub
V̏ V̆	čȁša	glass (cup)		pjȅvānje	singing
	kȉša	rain	V̏ V̆ V̄	kȉšobrān	umbrella
V̏ V̄	kȕhār	cook		rȁzgovōr	conversation
	pȁmēt	wisdom	V̏ V̄ V̄	knjȉžēvnīk	writer
V̂ V̆	mêso	meat		hȕmānōst	humaneness
	môre	sea	V̂ V̆ V̆	dnêvnica	daily wage
V̂ V̄	rûdnīk	mine		Đûrđevac	City in Croatia
	dnêvnīk	diary	V̂ V̄ V̆	sûnčānje	sunbathing
V̀ V̆	kùpus	cabbage		pâmćēnje	memory
	sèstra	sister	V̂ V̆ V̄	smîrenōst	composure
V̀ V̄	dùhān	tobacco		skrûšenōst	contrition
	bùnār	well	V̂ V̄ V̄	vêzānōst	attachment
V́ V̆	prózor	window		mâjčīnskī	motherly (adj. m. sg.
	pétak	Friday	V̀ V̆ V̆	grànica	border
V́ V̄	prúgōm	railway track (inst. sg.)		sùpruga	wife
	rúkōm	hand (inst. sg.)	V̀ V̄ V̆	kòšārka	basketball
Ȑ V̆	dȑvo	tree		pòdrūčje	region
	sȑce	heart	V̀ V̆ V̄	kònobār	waiter
	bȑdo	hill		kèmičār	chemist
	pȑsti	fingers (nom. pl.)	V̀ V̄ V̄	Dùbrōvnīk	city in Croatia
R̂ V̆	cȓkva	church		bèstīdnōst	shamelessness
	sȓpanj	July	V́ V̆ V̆	nádimak	nickname
	gȓmlje	bush		ráditi	to work (inf.)
	tȓnje	thorns	V́ V̄ V̆	pítānje	question
R̀ V̆	hr̀pa	pile		nárjēčje	dialect group
	hr̀đa	rust	V́ V̆ V̄	národnōst	ethnic minority
	pr̀sa	breast, chest		náredník	staff sergeant

Pattern	Word	Translation	Pattern	Word	Translation
V́ V̄ V̄	nástāvnīk	teacher, instructor	V̌ V́ V̌ V̌	šahóvnica	Croatian coat of arms
	nádzōrnīk	supervisor	V̌ V́ V̄ V̌	zanímānje	interest, profession
V̌ V̀ V̌	kukùruz	corn		naprézānje	exertion
			V̌ V́ V̌ V̄	sunárodnjāk	compatriot
	domàčin	host		beskrálježnjāk	invertebrate
	tišìna	silence	V̌ V́ V̄ V̄	besprijékōrnōst	impeccability
	sredìna	middle part, environment		prenápōrnōst	excessive arduousness
V̌ V̀ V̄	tambùrāš	a *tambura* player	V̌ V̌ V̀ V̌	tjestenìna	pasta
	predàvāč	lecturer		gotovìna	cash
	partìzān	partisan		knjigovòdstvo	bookkeeping
	medènjāk	gingerbread		kiselìna	acid
V̌ V́ V̌	komárac	mosquito	V̌ V̌ V̀ V̄	toleràntnōst	tolerance
	Bosánci	Bosnians (nom. pl.)		kompetèntnōst	competence
	rješénje	decision, solution		relevàntnōst	relevance
	paráda	parade		turbulèntnōst	turbulence
V̌ V̀ V̌ V̌	kobàsica	sausage	V̌ V̌ V́ V̌	Dalmatínac	Dalmatian (male)
	djevòjčica	girl		čudotvórac	wonder-worker
V̌ V̀ V̄ V̌	kolèbānje	fluctuation, doubt		vatrogásac	firefighter
	Evànđēlje	Gospel		maratónac	marathon runner
V̌ V̀ V̌ V̄	fonètičār	phonetician	V̌ V̌ V́ V̄	genijálnōst	ingenuity
	daròvitōst	giftedness		populárnōst	popularity
V̌ V̀ V̄ V̄	nedòrāslōst	immaturity		negatívnōst	negativity
	peràdārnīk	chicken coop		produktívnōst	productivity
V̌ V́ V̌ V̌	borónica	blueberries			

APPENDIX B – RECORDED MATERIALS

B3 - The following is a list of all Croatian sentences and their English translation recorded in the production experiment. Each target word in every sentence is bold. Sentences without bold words are fillers. Since the syntaxes of English and Croatian are so different, it was not attempted to translate the sentences with the same word order in English. Expressions and some unclear words are given in parentheses in the translation, such as "…Partizan (football club)."

1	Vani je jako hladno.	It is very cold outside.
2	Naš novi **narednik** nije loš.	Our new **staff sergeant** isn't bad.
3	**Brdo** kraj rijeke je visoko.	The **hill** near the river is high.
4	**Tjestenina** se priprema sa sirom.	**Pasta** is prepared with cheese.
5	Njemu je jako bitna životna **sredina**.	His living **environment** is very important to him.
6	Iskustvo i **pamet** su bitni u životu.	Experience and **wisdom** are essential in life.
7	Ruža ima veliko **trnje**.	Roses have big **thorns**.
8	Dugo nisam čuo tako lijepo **pjevanje**.	I haven't heard such beautiful **singing** in a long time.
9	Sviđa mi se tvoje **zanimanje**.	I like your **profession**.
10	Pokazao je veliku **nedoraslost**.	He showed great **immaturity**.
11	U šumi sam vidio veliko **grmlje**.	I saw a big **bush** in the forest.
12	Lisica je ušla u **peradarnik**.	The fox went into the **chicken coop**.
13	Moj stric radi kao **konobar**.	My uncle works as a **waiter**.
14	**Humanost** je ljudska osobina.	**Humaneness** is a human attribute.
15	**Područje** Pireneja je jako brdovito.	The **region** of the Pyrenees is very mountainous.
16	**Brod** plovi niz veliku rijeku.	The **ship** is sailing down a big river.
17	Mnogi **Bosanci** žive i rade u Hrvatskoj.	Many **Bosnians** live and work in Croatia.
18	**Popularnost** nove trgovine je u porastu.	The **popularity** of the new store is on the rise.
19	**Fonetičar** se bavi izgovorom.	A **phonetician** deals with pronunciation.
20	**Nedoraslost** je česta osobina kod mladih.	**Immaturity** is a frequent quality of young people.
21	Knjiga je pala na **pod**.	The book fell on the **floor**.
22	Ova radna **sredina** nije produktivna.	This working **environment** isn't productive.

23	Njegova **smirenost** je začuđujuća.	His **composure** is astonishing.
24	Državna **granica** prolazi preko rijeke.	The state **border** lies across the river.
25	On je uvijek volio nogomet.	He has always loved football.
26	Čitam zanimljivu knjigu.	I am reading an interesting book.
27	**Crkva** na kraju ulice je lijepa.	The **church** at the end of the street is beautiful.
28	Uvijek su joj se sviđali njegovi **prsti**.	She has always liked his **fingers**.
29	Marljivi **konobar** je donio vino.	The diligent **waiter** brought wine.
30	Vojna **parada** će se održati u četiri sata.	The military **parade** will be held at four o'clock.
31	Dolje u luci stoji bijeli **brod**.	Down at the port is a white **ship**.
32	**Produktivnost** je porasla ove godine.	**Productivity** has risen this year.
33	Veseli **sunarodnjak** pleše na zabavi.	The cheerful **compatriot** is dancing at the party.
34	Moj prijatelj je **kuhar** u restoranu.	My friend is a **cook** in a restaurant.
35	Planine su prirodna **granica**.	Mountains are a natural **border**.
36	On ima veliku **sposobnost** za učenje.	He has a great **capability** for learning.
37	**Brat** voli igrati nogomet nedjeljom.	My **brother** loves playing football on Sundays.
38	Jedno **pitanje** je bilo teško na ispitu.	One **question** on the test was hard.
39	**Trnje** se nalazi na mnogo biljaka.	**Thorns** are found on many plants.
40	**Nastavnik** jutros nije došao.	The **teacher** didn't come this morning.
41	Moj prijatelj navija za **Partizan**.	My friend is a fan of **Partizan** (football club).
42	Tata je iskopao novi **bunar**.	Father dug up a new **well**.
43	Iz dimnjaka izlazi **dim**.	**Smoke** is coming out of the chimney.
44	**Narodnost** je etnička manjina.	**"Narodnost"** is an ethnic minority.
45	Petica je za njega **pobjeda**.	A five (school grade) is a **victory** for him.
46	Suprug i **supruga** su došli na večeru.	The man and the **wife** came to dinner.
47	**Bosanci** su stanovnici BiH.	**Bosnians** are residents of Bosnia and Herzegovina.
48	**Hrpa** papira čeka na recikliranje.	A **pile** of paper is waiting to be recycled.
49	Ne volim pretjeranu **skrušenost**.	I don't like excessive **contrition**.
50	Sutra mi počinje godišnji odmor.	My yearly vacation starts tomorrow.
51	Danas idemo u kino.	Today we are going to the movie theater.
52	Dobili smo novog suradnika za **knjigovodstvo**.	We received a new colleague in **bookkeeping**.

53	Za rad treba imati **sposobnost**.	One needs **capability** for work.
54	**Drvo** raste u parku.	The **tree** grows at the park.
55	Staklena **čaša** se razbila.	The glass **cup** shattered.
56	**Srna** trči po šumi.	The **roe deer** is running in the forest.
57	**Put** svile vodi u Kinu.	The Silk **Road** leads to China.
58	Najjužniji grad Hrvatske je **Dubrovnik**.	The southernmost city in Croatia is **Dubrovnik**.
59	**Budućnost** je nepredvidljiva.	The **future** is unforeseen.
60	**Rukom** je dotaknuo njezino rame.	He touched her shoulder with his **hand**.
61	Njihova **nedoraslost** je lako uočljiva.	Their **immaturity** is easily noticeable.
62	**Središte** francuske kulture je u Parizu.	The **hub** of French culture is in Paris.
63	Hrabri **vatrogasac** je ušao u zgradu.	The brave **firefighter** entered the building.
64	**Sunčanje** na plaži je jako popularno.	**Sunbathing** on the beach is very popular.
65	Velika **kompetentnost** je rijetka.	Great **competence** is rare.
66	Stekla je veliku **popularnost**.	She acquired much **popularity**.
67	Kao klinac sam htio biti **kemičar**.	As a child I wanted to be a **chemist**.
68	Papuk Geopark je zaštićeno **područje**.	Papuk Geopark is a protected **region**.
69	Na kraju dvorišta je posađena **vrba**.	A **willow** has been planted at the end of the yard.
70	**Pas** leži na hladnom podu.	The **dog** is lying on the cold floor.
71	Predsjednikova **popularnost** je u padu.	The president's **popularity** is falling.
72	**Peradarnik** se nalazi u dvorištu.	The **chicken coop** is located in the yard.
73	Njezina **besprijekornost** je bezgranična.	Her **impeccability** is boundless.
74	**Rješenje** za sve probleme ne postoji.	A **solution** to all problems does not exist.
75	Pekara je bila zatvorena.	The bakery was closed.
76	Burek sa sirom fino miriše.	Burek with cheese smells great.
77	Dobio sam **medenjak** od bake.	I got some **gingerbread** from grandmother.
78	Prekuhana **tjestenina** ništa ne valja.	Overcooked **pasta** is worthless.
79	Njegovi **prsti** su prljavi od blata.	His **fingers** are dirty with mud.
80	U Istri se govori čakavsko **narječje**.	The Čakavian **dialect group** is spoken in Istria.
81	Zeleno **grmlje** raste u vrtu.	The green **bush** is growing in the garden.
82	**Košarka** je zanimljiv sport.	**Basketball** is an interesting sport.
83	**Pamćenje** mu je uvijek bilo loše.	His **memory** has always been bad.

84	Biljke koriste **trnje** za zaštitu.	Plants use **thorns** for protection.
85	Njen odnos prema meni je **majčinski**.	Her attitude towards me is **motherly**.
86	Ovog ljeta idemo svi na **more**.	This summer we're all going to the **sea**.
87	**Turbulentnost** vode je ogromna.	The water's **turbulence** is huge.
88	Vlada nije donijela praktično **rješenje**.	The government didn't choose a practical **decision**.
89	Vidio sam kako **sin** igra nogomet.	I saw my **son** playing football.
90	Pred spavanje ne čitam **Evanđelje**.	I don't read the **Gospel** before sleep.
91	Ovdje se vrlo rijetko sreće **tišina**.	One rarely encounters **silence** here.
92	**Gotovina** služi za plaćanje.	**Cash** is used for payment.
93	Učio je **knjigovodstvo** u školi.	He studied **bookkeeping** in school.
94	Ona ne jede **meso** već dvije godine.	She hasn't been eating **meat** for two years.
95	Idemo sutra u **Dubrovnik** na ljetovanje.	Tomorrow we're going to **Dubrovnik** for the summer vacation.
96	**Pod** u stanu je hladan.	The **floor** in the apartment is cold.
97	Svoje ime je **srpanj** dobio po srpu.	**July** is named after the word for "Scythe".
98	Sukob je spriječila naša **tolerantnost**.	The conflict was avoided due to our **tolerance**.
99	**Negativnost** je protivna pozitivnosti.	**Negativity** is the opposite of positivity.
100	Novi kompjuter je jako brz.	The new computer is very fast.
101	Volim slušati glazbu.	I love listening to music.
102	Čuo sam njihov **razgovor** u hodniku.	I heard their **conversation** in the corridor.
103	**Supruga** mi se zove Ivana.	My **wife** is called Ivana.
104	**Medenjak** je bio jako ukusan.	The **gingerbread** was very tasty.
105	**Čaša** pada na zemlju.	The **cup** is falling to the ground.
106	**Dalmatinac** pije bevandu.	The **Dalmatian** is drinking watered wine.
107	U idući **petak** mi dolaze prijatelji.	Next **Friday** I have friends coming over.
108	**Duhan** se koristi za proizvodnju cigara.	**Tobacco** is used in the production of cigars.
109	Iz kaputa mu vire **prsa**.	His **chest** is sticking out of his coat.
110	Ovo je bila teška **godina**.	This was a hard **year**.
111	U svatove je došao **tamburaš**.	A **tamburaš** (folk musician) came to the wedding.
112	Poslije odgovora sam osjetio **kolebanje**.	After the answer I felt **doubt**.
113	Posadio sam **drvo** kraj kuće.	I planted a **tree** near the house.

114	Ja svaku večer gledam **Dnevnik**.	I watch the **Diary** (evening news) every evening.
115	On je zaboravio **kišobran** u vlaku.	He forgot the **umbrella** in the train.
116	**Pjevanje** žena se dobro čulo.	The women's **singing** was easily heard.
117	Njegovo **naprezanje** neće biti nagrađeno.	His **exertion** won't be rewarded.
118	**Kemičar** je objavio istraživanje.	The **chemist** published his research.
119	**Majčinski** instinkt je jedan od najjačih.	The **motherly** instinct is one of the strongest instincts.
120	Moj bratić ima jako smiješan **nadimak**.	My cousin has a very funny **nickname**.
121	Dobio je nagradu za **humanost**.	He received a prize for **humaneness**.
122	Octena **kiselina** je slaba.	Vinegar **acid** (acetic acid) is weak.
123	**Kiša** me uvijek podsjeća na djetinjstvo.	**Rain** always reminds me of my childhood.
124	Pojavila se **hrđa** na nožu.	**Rust** appeared on the knife.
125	Bijelo vino ima dobar okus.	White wine tastes good.
126	Profesor je dao domaći zadatak.	The teacher gave homework.
127	**Trbuh** je druga riječ za stomak.	**Belly** is another word for stomach.
128	**Skrušenost** nije uvijek pozitivna.	**Contrition** isn't always positive.
129	**Srce** se nalazi na lijevoj strani.	The **heart** is located on the left side.
130	U našu školu je stigao novi **predavač**.	A new lecturer **came** to our school.
131	**Zanimanje** za ekologiju je u porastu.	**Interest** in ecology is on the rise.
132	Naš otac je dobar **kuhar**.	Our father is a good **cook**.
133	**Granica** sa Mađarskom je duga.	The **border** with Hungary is long.
134	**Vatrogasac** ima crvenu uniformu.	The **firefighter** has a red uniform.
135	Nije htio **raditi** subotom.	He didn't want **to work** on Saturday.
136	Na hrvatskoj zastavi se vidi **šahovnica**.	There is a **šahovnica** (coat of arms) on the Croatian flag.
137	**Rudnik** se nalazi ispod zemlje.	The **mine** is located under the ground.
138	**Srpanj** je sedmi mjesec.	**July** is the seventh month.
139	**Djevojčica** se zove Marija.	The **girl** is called Marija.
140	Brzi **maratonac** je pobijedio u trci.	The quick **marathon runner** won the race.
141	**Naprezanje** počinje od ranog jutra.	The **tension** starts early in the morning.
142	**Vrsta** kista je bitna za slikanje.	The **type** of the brush is important for painting.

143	Moj susjed je **Dalmatinac**.	My neighbor is **Dalmatian**.
144	Njihova **vezanost** je fascinantna.	Their **attachment** is fascinating.
145	Kraj naše škole je prošla **parada**.	The **parade** went near our school.
146	Ovog mjeseca beremo **kukuruz**.	This month we're picking **corn**.
147	**Nadzornik** je stigao na vrijeme.	The **supervisor** came on time.
148	**Beskralježnjak** je jednostavan organizam.	An **invertebrate** is a simple organism.
149	**Sigurnost** i stabilnost su slični pojmovi.	**Security** and stability are similar concepts.
150	Moja majka voli kuhati.	My mother loves to cook.
151	Danas je kišovito vrijeme.	Today's weather is rainy.
152	Malarični **komarac** uzrokuje malariju.	The malaria **mosquito** causes malaria.
153	**Vezanost** za zavičaj je jaka.	The **attachment** to the home country is strong.
154	Kupio sam **duhan** u trgovini.	I bought some **tobacco** in the store.
155	**Petak** je moj omiljeni dan.	**Friday** is my favorite day.
156	**More** se nalazi na jugozapadu Hrvatske.	The **sea** is located in the southwest of Croatia.
157	Na glavnom trgu stoji **hrast**.	An **oak** is standing on the main square.
158	Njegov tata je poznati **fonetičar**.	His father is a famous **phonetician**.
159	**Razgovor** je započela pozdravom.	She started the **conversation** with a greeting.
160	Dečko ima sjajnu **budućnost**.	The boy has a bright **future**.
161	**Borovnica** dolazi u plavoj boji.	**Blueberries** can be blue.
162	Moji susjedi su **Bosanci**.	My neighbors are **Bosnians**.
163	**Kuhar** nam je pripremio večeru.	The **cook** made us dinner.
164	**Predavač** je došao kasno na sat.	The **lecturer** came to class late.
165	Obični **beskralježnjak** je razvijeniji od amebe.	An ordinary **invertebrate** is more developed than an ameba.
166	Kupila je crveni **kišobran**.	She bought a red **umbrella**.
167	Njemačka i Austrija će se povezati novom **prugom**.	Germany and Austria will be connected by a new **railway track**.
168	Na aerodromu me je dočekao **sunarodnjak**.	I was greeted at the airport by a **compatriot**.
169	Ona pokazuje **zanimanje** za umjetnost.	She is showing **interest** in art.
170	**Kolebanje** slijedi poslije treme.	**Doubt** comes after anxiety.

171	Postoji **mogućnost** da će vrijeme biti loše.	There is a **possibility** that the weather will be bad.
172	Od smeća je ostala samo **hrpa**.	Only a **pile** was left of the garbage.
173	Marko je poznati **maratonac**.	Marko is a famous **marathon runner**.
174	Izumrla je posljednja životinjska **vrsta**.	The last animal **species** has died out.
175	Jučer sam bio u kazalištu.	Yesterday I was at the theater.
176	Ova knjiga ima lijep omot.	This book has a pretty cover.
177	Domaća **kobasica** ima fin miris.	The home-made **sausage** has a nice smell.
178	Tomi je moj mali **hrčak**.	Tomi is my little **hamster**.
179	Otišla je u **Đurđevac** vidjeti roditelje.	She went to **Đurđevac** to see her parents.
180	**Sestra** sjedi na školskoj klupi.	My **sister** is sitting on the school bench.
181	U naš vod je stigao novi **narednik**.	A new **staff sergeant** came to our platoon.
182	Šefova **prenapornost** smanjuje učinkovitost.	The boss's **excessive arduousness** is lowering efficiency.
183	Taj osjećaj se zove **vezanost**.	That feeling is called **attachment**.
184	Dobio je **nadimak** po svom zanimanju.	He got his **nickname** because of his work.
185	**Dubrovnik** je smješten na moru.	**Dubrovnik** is located on the sea.
186	**Domaćin** nam je napravio ukusnu večeru.	The **host** made us some tasty dinner.
187	**Dnevnik** rada leži u uredu.	The work **log** is lying in the office.
188	U našem gradu je otvoren novi **rudnik**.	A new **mine** was opened in our city.
189	Osjetila je **kolebanje** iza leđa.	She felt a **fluctuation** behind her back.
190	**Grmlje** šipka raste kraj ceste.	The rose hip **bush** is growing near the road.
191	**Komarac** je uletio u moju sobu.	A **mosquito** flew into my room.
192	Čovjek pokraj semafora je moj **brat**.	The person next to the traffic light is my **brother**.
193	Iznenadila me je tvoja **besprijekornost**.	I was surprised by your **impeccability**.
194	Ljudsko **srce** se sastoji od četiri komore.	The human **heart** consists of four chambers.
195	Mlada **srna** skače po polju.	The young **roe deer** is jumping around in the field.
196	Volim jesti **kukuruz** u svako doba godine.	I like to eat **corn** in every season.
197	U vrtu stoji veliko **drvo**.	A big **tree** is standing in the garden.
198	Drvena **crkva** na brdu je stara.	The wooden **church** on the hill is old.

199	Ona se **majčinski** brinula o njegovom djetetu.	She took **motherly** care of his child.
200	Sutra idem na posao.	Tomorrow I am going to work.
201	On vozi crveni auto.	He drives a red car.
202	U našem selu se uzgaja **kupus**.	We grow **cabbage** in our village.
203	Veseli **tamburaš** svira razne pjesme.	The cheerful **tamburaš** (folk musician) plays different songs.
204	Imamo važni sastanak u **petak**.	We have an important meeting on **Friday**.
205	U moju sobu je ušla **sestra**.	My **sister** came into my room.
206	**Sposobnost** pregovaranja je ključna za diplomate.	The **ability** to negotiate is essential for diplomats.
207	Otvorio sam **prozor** u boravku.	I opened the **window** in the living room.
208	**Prugom** se vuče vlak.	The train is going on the **railway track**.
209	Radim kao **fonetičar** na fakultetu.	I work as a **phonetician** at the university.
210	Iz džepa mu viri **gotovina**.	**Cash** is sticking out of his pocket.
211	Moj stric jako voli **meso**.	My uncle really loves **meat**.
212	Otišla je na plažu na **sunčanje**.	She went **sunbathing** to the beach.
213	Danas je uplaćena **dnevnica**.	The **daily wage** was paid today.
214	**Hrast** u parku je star sto godina.	The **oak** in the park is a hundred years old.
215	Sve što vidi je **negativnost**.	Everything he sees is **negativity**.
216	**Kukuruz** je uvezen iz Sjeverne Amerike.	**Corn** is imported from North America.
217	**Kiselina** se miješa s vodom.	The **acid** is mixing with the water.
218	**Šahovnica** se sastoji od crvenih i bijelih polja.	The **šahovnica** (coat of arms) is made up of red and white fields.
219	Čistačica je prala **pod** u uredu.	The cleaning lady was cleaning the **floor** in the office.
220	**Đurđevac** je naselje u Podravini.	**Đurđevac** is a settlement in Podravina.
221	Bijeli **hrčak** vrti kolo.	The white **hamster** is running in the wheel.
222	Moj brat ima veliku **darovitost**.	My brother has a lot of **giftedness**.
223	Pokazao je veliku **kompetentnost**.	He showed great **competence**.
224	Kažu da je **humanost** rijetka vrlina.	They say that **humaneness** is a rare virtue.
225	Zidovi u spavaćoj sobi su zeleni.	The walls in the bedroom are green.

226	Drvena koliba stoji kraj potoka.	The wooden hut stands near the stream.
227	Kišna glista je **bezkralježnjak**.	An earthworm is an **invertebrate**.
228	**Kišobran** se slomio od vjetra.	The **umbrella** broke because of the wind.
229	Kajkavsko **narječje** se govori u Zagorju.	The Kajkavian **dialect group** is spoken in the Zagorje region.
230	Moja baka ima dobro **pamćenje**.	My grandmother has good **memory**.
231	Uvijek postoji i druga **mogućnost**.	There is always another **possibility**.
232	Došao sam profesoru na **razgovor**.	I came for a **conversation** with the professor.
233	Njezina **negativnost** je poražavajuća.	Her **negativity** is amazing.
234	Za ovaj posao je potrebno prekomjerno **naprezanje**.	This job requires extraordinary **exertion**.
235	Pileća **prsa** su bijelo meso.	Chicken **breast** is white meat.
236	**Prsti** su joj jako dugi.	Her **fingers** are very long.
237	Grčka je nekad bila europsko kulturno **središte**.	Greece used to be the **hub** of European culture.
238	Danas će padati **kiša** do pet sati.	**Rain** will be falling today until five o'clock.
239	**Maratonac** trči kroz šumu.	The **marathon runner** is running through the forest.
240	**Raditi** se mora i treba.	One should and must **work**.
241	Ona ima veliko **srce**.	She has a big **heart**.
242	Našli smo **put** koji vodi u šumu.	We found a **path** that leads to the forest.
243	Jedva čekam da počne **srpanj**.	I can hardly wait for **July** to start.
244	Pirova **pobjeda** se skupo plaća.	A Pyrrhic **victory** comes with a high price.
245	Došao je **pas** i počeo je lajati.	The **dog** came and started barking.
246	**Kupus** je jako ukusan.	**Cabbage** is very tasty.
247	Lisičarke su **vrsta** gljiva.	Chanterelles are a **kind** of mushroom.
248	Moja omiljena igra je **košarka**.	My favorite game is **basketball**.
249	**Besprijekornost** ovog proizvoda je nesumnjiva.	The **impeccability** of this product is undoubted.
250	Sutra će nebo biti vedro.	The sky will be clear tomorrow.
251	Gledao sam zanimljivi film sa sestrom.	I watched an interesting film with my sister.
252	Ove godine se više ne bere **borovnica**.	This year there will be no more picking of **blueberries**.

253	On je pošten **nadzornik**.	He is an honest **supervisor**.
254	**Vrba** stoji usred trga.	The **willow** stands in the center of the square.
255	Zbog posla sam morao ići u **Đurđevac**.	I had to go to **Đurđevac** because of work.
256	**Genijalnost** je rijetka pojava.	**Ingenuity** is a rare phenomenon.
257	U kući je **domaćin** spremao ručak.	The **host** was making some lunch in the house.
258	Njegova **darovitost** nema granica.	His **giftedness** is unlimited.
259	U Hrvatskoj su Slovaci česta **narodnost**.	Slovaks are a frequent **"Narodnost"** in Croatia.
260	**Bunar** se nalazi na kraju sela.	The **well** is located at the end of the village.
261	Danas se rodila **djevojčica**.	A **girl** was born today.
262	Ovo pitanje ima veliku **relevantnost**.	This question is of great **relevance**.
263	Njegovo **pamćenje** je kratkoročno.	His **memory** is very short.
264	Veliki **brod** plovi morem.	The big **ship** is sailing at sea.
265	**Sunarodnjak** mu je došao u goste.	The **compatriot** came over to visit him.
266	**Pobjeda** mu je uvijek mnogo značila.	**Victory** always meant much to him.
267	Jako sam sretan kad pada **kiša**.	I'm very happy when **rain** falls.
268	Ne sviđa mi se njegova **prenapornost**.	I don't like his **excessive arduousness.**
269	Hrvatska **šahovnica** je poznata širom svijeta.	The Croatian **šahovnica** (coat of arms) is known throughout the world.
270	U zraku se pojavila **turbulentnost**.	Some **turbulence** appeared in the air.
271	Majka jedva čeka da joj dođe **sin**.	The mother can hardly wait for her **son** to come.
272	Moj stric je **vatrogasac**.	My uncle is a **firefighter**.
273	On uvijek drugim ljudima soli **pamet**.	He always salts other people's **brains**. (He always lectures everybody.)
274	Učiteljica je rekla đaku da zatvori **prozor**.	The teacher told the student to close the **window**.
275	Kupio sam brašno u trgovini.	I bought flour in the store.
276	Danas idemo u berbu.	Today we are going to harvest.
277	Za našu **budućnost** se mora boriti.	We need to fight for our **future**.
278	Sutra se islpaćuje **dnevnica** za subotu.	The **daily wage** for Saturday is being paid tomorrow.
279	Mahnula mi je **rukom** za pozdrav.	She waved goodbye to me with her **hand**.
280	Novi **nadzornik** je još gori od starog.	The new **supervisor** is even worse than the old one.
281	**Nadimak** sam dobio već u školi.	I got my **nickname** back in school.

282	Političko **središte** Hrvatske je Zagreb.	The political **hub** of Croatia is in Zagreb.
283	Po velikom dvorištu trči naš **pas**.	Our **dog** is running in the big yard.
284	Čuo sam za njegovu **genijalnost**.	I heard about his **ingenuity**.
285	Narod i **narodnost** su različite stvari.	Nationality and **"Narodnost"** are different things.
286	Njegova **bestidnost** je neograničena.	His **shamelessness** is unbounded.
287	**Dim** ulazi u kuću kroz prozor.	The **smoke** is getting into the house through the window.
288	On je otišao u kiosk po **duhan**.	He went to the kiosk for some **tobacco**.
289	Dijete je za nagradu dobilo **medenjak**.	The child got some **gingerbread** as a reward.
290	**Smirenost** je pozitivna osobina.	**Composure** is a positive attribute.
291	**Meso** kuham uglavnom sa povrćem.	I usually cook **meat** with vegetables.
292	Njegova **skrušenost** iznenađuje.	His **contrition** is surprising.
293	Pivski **trbuh** imaju pivopije.	Beer drinkers have beer **bellies**.
294	Vlakovi će ovom **prugom** jako brzo voziti.	The trains are going to drive really fast on this **railway track**.
295	**Evanđelje** je dio Svetog pisma.	The **Gospel** is a part of the Holy Bible.
296	U sobi na stolu stoji **čaša**.	There´s a **cup** on the table in the room.
297	**Godina** se dijeli na dvanaest mjeseci.	A **year** is divided into twelve months.
298	Vidio sam crni **dim** na planini.	I saw black **smoke** on the mountain.
299	**Hrđa** se stvara na željezu.	**Rust** forms on iron.
300	Split se nalazi na obali Jadrana.	Split is located on the shore of the Adriatic sea.
301	Ne pijem kavu sa mlijekom.	I don't drink coffee with milk.
302	Tamnokosi **Dalmatinac** gleda more.	The dark-haired **Dalmatian** is looking at the sea.
303	**Kompetentnost** je uvijek tražena.	**Competence** is always needed.
304	**Prozor** u kuhinji je prljav.	The **window** in the kitchen is dirty.
305	Čuveni **književnik** je napisao novu knjigu.	The famed **writer** has written a new book.
306	U akumulatoru je sumporna **kiselina**.	There's sulphuric **acid** in the car battery.
307	**Prsa** dolaze u svim veličinama.	**Breasts** come in all sizes.
308	**Knjigovodstvo** može biti i obiteljski obrt.	**Bookkeeping** can be a family business.
309	**Narječje** se sastoji od nekoliko dijalekata.	A **dialect group** is composed of several dialects.

310	**Sredina** kruha je uvijek mekana.	The **middle part** of the bread is always soft.
311	Lijepo nas je ugostio **domaćin**.	We were received very well by the **host**.
312	Probudilo me je **pjevanje** ptica.	The **singing** of the birds woke me up.
313	Tvoja **genijalnost** je očita.	Your **ingenuity** is obvious.
314	Zeleno **brdo** kraj šume je lijepo.	The green **hill** near the forest is beautiful.
315	Moralna **sigurnost** je jako bitna.	Moral **safety** is very important.
316	**Čudotvorac** je spasio dječaka.	The **wonder-worker** saved the boy.
317	Ženka srndaća je **srna**.	A female roebuck is called **roe deer** (srna).
318	**Tišina** se uvukla u našu ulicu.	**Silence** crept into our street.
319	U ovom je poslu **tolerantnost** jako bitna.	**Tolerance** is very important for this job.
320	**Konobar** je otišao po piće.	The **waiter** went for some drinks.
321	Njegov djed je bio **partizan** u ratu.	His grandfather was a **partisan** during the war.
322	Novi igrač će klubu pružiti **sigurnost**.	The new player will bring the team some **security**.
323	Njezino **rješenje** mi nije jasno.	Her **decision** isn't clear to me.
324	Na ogradu se uhvatila **hrđa**.	The fence was covered by **rust**.
325	Moj tata peče kruh.	My father is baking bread.
326	Moja sestra je vidjela lisicu u šumi.	My sister saw a fox in the forest.
327	Nepoznati **čudotvorac** je otišao.	The unknown **wonder-worker** has left.
328	Kulen je najfinija **kobasica**.	Kulen is the best kind of **sausage**.
329	**Tolerantnost** je ljudska vrlina.	**Tolerance** is a human virtue.
330	Nogomet i **košarka** se igraju sa loptom.	Football and **basketball** are played with a ball.
331	Očekivana **turbulentnost** će biti velika.	The expected **turbulence** will be big.
332	Ovaj posao zahtjeva veliku **smirenost**.	This job requires much **composure**.
333	**Prenapornost** je loša osobina.	**Excessive arduousness** is a bad quality.
334	**Tamburaš** je počeo pjevati.	The **tamburaš** (folk musician) started singing.
335	Mladi **kemičar** piše znanstveni rad.	The young **chemist** is writing a scientific paper.
336	Ta visoka žena je moja **supruga**.	That tall woman is my **wife**.
337	**Relevantnost** ovog zakona je očita.	The **relevance** of this law is clear.
338	Ostala mi je **hrpa** robe za peglanje.	I have a **pile** of clothes to iron.
339	Najbolja je svježa **tjestenina**.	Fresh **pasta** is the best.
340	On je dotaknuo kvaku **rukom**.	He touched the doorknob with his **hand**.

341	**Sin** i kći su otišli zajedno u školu.	My **son** and daughter went to school together.
342	**Partizan** drži pušku u ruci.	The **partisan** is holding a rifle in his hand.
343	Krleža je poznati hrvatski **književnik**.	Krleža is a famous Croatian **writer**.
344	On je prešao dugački **put**.	He went through a long **path**.
345	Popeli smo se na **brdo**.	We climbed up the **hill**.
346	Ispala mu je **gotovina** na pod.	Some of his **cash** fell on the floor.
347	Tužna **vrba** raste uz potok.	The weeping **willow** is growing next to the creek.
348	**Narednik** je čin u hrvatskoj vojsci.	**Staff sergeant** is a rank in the Croatian army.
349	Ona jako voli **sunčanje** na moru.	She really loves **sunbathing** on the sea.
350	U džepu mi je kovanica od pet kuna.	I have a 5 Kuna coin in my pocket.
351	Oni vole jesti grah.	They love eating beans.
352	Tražena **produktivnost** je dostignuta.	The demanded **productivity** has been achieved.
353	**Književnik** je dobio nagradu.	The **writer** received a prize.
354	Istočno **područje** Slavonije je na Dunavu.	The eastern **region** of Slavonia is on the Danube.
355	**Mogućnost** sukoba je neizbježna.	The **possibility** of a conflict is unavoidable.
356	U našem selu se gradi nova **crkva**.	A new **church** is being built in our village.
357	Ona vodi **dnevnik** već nekoliko godina.	She's been writing a **diary** for several years.
358	Susjedova **borovnica** je najslađa.	The neighbor's **blueberries** are the sweetest.
359	Čuo sam kako je **brat** ušao u kuću.	I heard how my **brother** entered the house.
360	U našu školu je stigao novi **nastavnik**.	A new **teacher** came to our school.
361	**Darovitost** je sinonim za talent.	**Giftedness** is a synonym for talent.
362	Veliki i zeleni **hrast** ima puno lišća.	The big and green **oak** has many leaves.
363	**Pitanje** nezaposlenih još nije rješeno.	The **question** of the unemployed is still unanswered.
364	**Parada** prolazi u centru grada.	The **parade** goes through the center of town.
365	Sutra beremo **kupus** kod susjeda.	Tomorrow we're going to pick **cabbage** at the neighbor's.
366	**Hrčak** skače po kavezu.	The **hamster** is jumping around the cage.
367	Ta grobna **tišina** na poslu mi smeta.	That awful **silence** at work bothers me.
368	Iznenadila me je njegova **bestidnost**.	I was surprised by his **shamelessness**.
369	Proučavam **relevantnost** ovog problema.	I am studying the **relevance** of this problem.

370	Moj ujak ima veliki **trbuh**.	My uncle has a big **belly**.
371	Danas čitam **Evanđelje** po Luki.	Today I am reading the **Gospel** of Luke.
372	Bacanje novčića u **bunar** donosi sreću.	Throwing coins into the **well** brings good fortune.
373	Ugrizao me je **komarac**.	A **mosquito** bit me.
374	Moja tvrtka je povećala **produktivnost**.	My company has increased **productivity**.
375	Ona ne voli mineralnu vodu.	She doesn't like mineral water.
376	Prekjučer sam sreo svog starog prijatelja.	I met my old friend the day before yesterday.
377	**Bestidnost** je ružna osobina.	**Shamelessness** is a bad quality.
378	**Pamet** je jedna od najvažnijih vrlina.	**Wisdom** is one of the most important virtues.
379	Stigao je slavni **čudotvorac**.	The famous **wonder-worker** has arrived.
380	Drveni **peradarnik** je otvoren.	The wooden **chicken coop** is open.
381	Naš novi **nastavnik** je mlad.	Our new **teacher** is young.
382	Moja mlađa **sestra** studira pravo.	My younger **sister** is studying law.
383	Nisam još dobio odgovor na svoje **pitanje**.	I still haven't received an answer to my **question**.
384	Danas je u **rudnik** stigao novi direktor.	The new manager arrived at the **mine** today.
385	Ja sutra moram **raditi**.	I have **to work** tomorrow.
386	**Kobasica** visi na tavanu.	The **sausage** is hanging in the attic.
387	**Dnevnica** se isplaćuje za službeno putovanje.	A **daily wage** is paid for a business trip.
388	Sljedeća **godina** će biti prijestupna.	The next **year** will be a leap year.
389	Moj otac radi kao **predavač** na fakultetu.	My father works as a **lecturer** at the university.
390	Plavokosa **djevojčica** dolazi kod bake.	The blond **girl** is coming to her grandmother.
391	Otišao sam na **more** da se odmorim.	I went to the **sea** to rest.
392	Stol u uredu je drven.	The table in the office is wooden.

APPENDIX C – PRAAT SCRIPT

The following is the Praat script used to extract acoustic measurements in the production experiment.

```
clearinfo
directory$ =""
Create Strings as file list... soundlist 'directory$'*.wav
Create Strings as file list... gridlist 'directory$'*.TextGrid
numberOfFiles = Get number of strings
thistier = 2

filedelete results.txt
fileappend results.txt Speaker 'tab$' Label 'tab$' Start[s] 'tab$' Duration[ms] 'tab$' f0-0%
'tab$' f0-10% 'tab$' f0-20% 'tab$' f0-30% 'tab$' f0-40% 'tab$' f0-50% 'tab$' f0-60% 'tab$' f0-
70% 'tab$' f0-80% 'tab$' f0-90% 'tab$' f0-100% 'tab$' Min 'tab$' Min% 'tab$' Max 'tab$'
Max% 'tab$' 'newline$'

for filenumber from 1 to numberOfFiles

  select Strings soundlist
  soundfileName$ = Get string... filenumber
  select Strings gridlist
  gridfileName$ = Get string... filenumber
  Read from file... 'directory$''soundfileName$'
  Read from file... 'directory$''gridfileName$'
  name$ = selected$ ("TextGrid")
  speakershort$ = left$ (name$, 7)
  select TextGrid 'name$'
  numbersounds = Get number of intervals... 'thistier'
  counter = 0

  select Sound 'name$'

    do ("To Pitch (ac)...", 0, 50, 15, "yes", 0.03, 0.2, 0.01, 0.35, 0.3, 250)

  for intervalnumber from 1 to numbersounds

    select TextGrid 'name$'
    label$ = Get label of interval... 'thistier' 'intervalnumber'
        if label$ <> ""
        counter += 1

    start = Get starting point... 'thistier' 'intervalnumber'
    end = Get end point... 'thistier' 'intervalnumber'
    dur = ( end - start )
    duration = ( end - start ) * 1000
    center = ( start + end ) / 2
    snd10 = ( end - start ) / 10
```

```
	snd20 = ( end - start ) / 5
	ten = ( start + snd10 )
	twenty = ( start + snd20 )
	thirty = ( center - snd20 )
	fourty = ( center - snd10 )
	sixty = ( center + snd10 )
	seventy = ( center + snd20 )
	eighty = ( end - snd20 )
	ninety = ( end - snd10 )

	select Pitch 'name$'

	f0_start = do ("Get value at time...", start, "Hertz (logarithmic)", "Nearest")
	f0_ten = do ("Get value at time...", ten, "Hertz (logarithmic)", "Nearest")
	f0_twenty = do ("Get value at time...", twenty, "Hertz (logarithmic)", "Nearest")
	f0_thirty = do ("Get value at time...", thirty, "Hertz (logarithmic)", "Nearest")
	f0_fourty = do ("Get value at time...", fourty, "Hertz (logarithmic)", "Nearest")
	f0_fifty = do ("Get value at time...", center, "Hertz (logarithmic)", "Nearest")
	f0_sixty = do ("Get value at time...", sixty, "Hertz (logarithmic)", "Nearest")
	f0_seventy = do ("Get value at time...", seventy, "Hertz (logarithmic)", "Nearest")
	f0_eighty = do ("Get value at time...", eighty, "Hertz (logarithmic)", "Nearest")
	f0_ninety = do ("Get value at time...", ninety, "Hertz (logarithmic)", "Nearest")
	f0_hund = do ("Get value at time...", end, "Hertz (logarithmic)", "Nearest")

	min = do ("Get minimum...", start, end, "Hertz (logarithmic)", "Parabolic")
	locmin = do ("Get time of minimum...", start, end, "Hertz (logarithmic)", "Parabolic")
	minnorm = ( locmin - start ) / dur * 100
	max = do ("Get maximum...", start, end, "Hertz (logarithmic)", "Parabolic")
	locmax = do ("Get time of maximum...", start, end, "Hertz (logarithmic)", "Parabolic")
	maxnorm = ( locmax - start ) / dur * 100

	fileappend results.txt 'speakershort$' 'tab$' 'label$' 'tab$' 'start:2' 'tab$' 'duration:3' 'tab$'
'f0_start:3' 'tab$' 'f0_ten:3' 'tab$' 'f0_twenty:3' 'tab$' 'f0_thirty:3' 'tab$' 'f0_fourty:3' 'tab$'
'f0_fifty:3' 'tab$' 'f0_sixty:3' 'tab$' 'f0_seventy:3' 'tab$' 'f0_eighty:3' 'tab$' 'f0_ninety:3' 'tab$'
'f0_hund:3' 'tab$' 'min:3' 'tab$' 'minnorm:1' 'tab$' 'max:3' 'tab$' 'maxnorm:1' 'tab$' 'newline$'

endif
endfor

select TextGrid 'name$'
plus Sound 'name$'
plus Pitch 'name$'
Remove

endfor

select Strings soundlist
plus Strings gridlist
Remove
```

APPENDIX D – TABLES AND FIGURES

Table D.1. Mean values of *f0-0%* to *f0-100%* in initial monosyllabic nuclei in Hz

Accent	f0-0%	f0-10%	f0-20%	f0-30%	f0-40%	f0-50%	f0-60%	f0-70%	f0-80%	f0-90%	f0-100%
LF	141.29	142.22	145.45	148.33	150.44	152.11	153	153.17	152.36	150.87	150.06
SF	133.13	135.19	137.43	139.97	142.38	144.70	145.96	147.14	147.27	146.25	145.23

Table D.2. Mean values of *f0-0%* to *f0-100%* in medial monosyllabic nuclei in Hz

Accent	f0-0%	f0-10%	f0-20%	f0-30%	f0-40%	f0-50%	f0-60%	f0-70%	f0-80%	f0-90%	f0-100%
LF	135.49	136.86	137.79	138.26	138.41	138.07	136.83	137.23	135.29	133.14	132.74
SF	130.78	130.48	131.40	131.93	132.26	132.19	131.58	131.14	130.22	129.07	125.57

Table D.3 Mean values of *f0-0%* to *f0-100%* in final monosyllabic nuclei in Hz

Accent	f0-0%	f0-10%	f0-20%	f0-30%	f0-40%	f0-50%	f0-60%	f0-70%	f0-80%	f0-90%	f0-100%
LF	98.81	97.59	95.84	95.03	89.12	86.07	82.90	81.99	81.58	84.00	85.63
SF	99.28	97.66	95.88	95.16	93.17	91.62	89.52	89.86	88.45	91.08	90.85

Table D.4. Mean values of *f0-0%* to *f0-100%* in accented (above) and posttonal syllables (below) in initial syllabic /r̩/ words in Hz

Acc. Syll.	f0-0%	f0-10%	f0-20%	f0-30%	f0-40%	f0-50%	f0-60%	f0-70%	f0-80%	f0-90%	f0-100%
LF	138.30	138.07	139.21	139.86	141.46	145.45	149.44	151.19	152.97	153.91	153.43
LR	127.54	124.55	125.77	126.98	129.91	134.85	136.87	139.81	141.40	143.48	142.94
SF	136.01	135.07	135.63	137.17	139.84	142.79	148.44	148.98	149.53	149.39	148.36
SR	143.31	141.99	141.35	137.34	138.24	143.64	146.30	147.46	148.06	147.94	147.55
Post. Syll.											
LF	136.65	134.87	132.22	129.78	127.49	124.31	122.74	120.52	119.38	117.92	114.78
LR	142.91	142.61	145.06	143.20	143.00	141.55	138.26	137.43	135.86	133.17	131.04
SF	141.66	138.16	136.03	135.08	133.31	131.90	130.19	128.82	128.95	127.07	126.95
SR	156.09	154.04	153.60	149.70	149.49	149.06	147.83	145.85	141.64	140.28	136.87

Table D.5. Mean values of *f0-0%* to *f0-100%* in accented and posttonal syllables in medial syllabic /r̩/ words

Acc. Syll.	f0-0%	f0-10%	f0-20%	f0-30%	f0-40%	f0-50%	f0-60%	f0-70%	f0-80%	f0-90%	f0-100%
LF	135.6	135.59	134.4	136.87	138.3	139.13	140.33	140.44	140.22	140.04	139.37
LR	127.3	127.29	127.37	127.79	129.15	131.33	132.05	133.78	134.5	134.78	136.90
SF	143.4	142.83	143.35	143.49	145.23	146.55	148.43	148.78	147.98	148.19	146.38
SR	138.6	135.26	133.61	135.1	135.74	137.13	138.05	138.52	137.75	137.16	137.4
Post. Syll.											
LF	123.14	121.03	119.24	117.46	116.19	114.71	113.18	112.12	110.25	109.21	108.33
LR	139.19	136.97	134.68	132.94	131.43	129.97	128.09	126.5	126.05	123.21	123.9
SF	128.09	127.38	125.38	124.2	121.84	120.34	119.26	118.84	117.48	114.35	113.59
SR	136.87	135.6	133.97	132.86	132.28	130.12	127.27	125.46	125.54	124.65	124.6

Table D.6. Mean values of *f0-0%* to *f0-100%* in accented and posttonal syllables in final syllabic /ṛ/ words

Acc. Syll.	f0-0%	f0-10%	f0-20%	f0-30%	f0-40%	f0-50%	f0-60%	f0-70%	f0-80%	f0-90%	f0-100%
LF	108.4	108.71	105.94	99.35	97.24	97.36	95.58	93.35	92	88.18	86.06
LR	108.3	106.71	106.62	105.59	98.85	96.62	96.43	95.57	94.74	94.03	94.54
SF	110.3	108.22	106.81	105.86	105.08	104.33	102.15	100.18	98.6	96.3	94.95
SR	109.8	105.25	102.85	101.97	102.74	101.11	101.4	98.877	97.67	97.15	96.77
Post. Syll.											
LF	75.81	75.1	73.33	73.1	73.24	72.07	71.65	69.37	73.83	75.18	
LR	91.59	88.53	87.02	85.69	86.93	87.59	88.09	90.44	90.66	91.89	84.64
SF	78.83	76.28	77.45	76.54	74.97	74.75	77.49	77.48	77.89		
SR	91.91	92.96	91.67	91.09	89.76	89.01	86.26	86.47	85.38	83.56	81.24

Table D.7. Mean values of *f0-0%* to *f0-100%* in accented and posttonal syllables in initial bisyllabic words

Acc. Syll.	f0-0%	f0-10%	f0-20%	f0-30%	f0-40%	f0-50%	f0-60%	f0-70%	f0-80%	f0-90%	f0-100%
LF	133.66	135.09	137.6	139.39	142.53	146.51	150.41	152.43	154.21	154.92	154.29
LR	125.05	123.94	125.62	127.67	130.81	135.19	137.60	140.42	142.01	143.44	143.72
SF	139.36	138.46	139.01	140.59	142.71	144.97	148.35	149.26	149.35	149.18	147.54
SR	135.11	134.82	135.23	134.44	136.26	140.48	143.23	144.59	145.63	145.63	145.46
Post. Syll.											
LF	138.9	136.55	134.68	132.63	130.3	127.48	126.16	124.7	123.13	121.97	120.01
LR	147.66	148.38	149.29	148.79	148.16	146.9	144.69	143.65	142.29	139.95	138.08
SF	141.65	138.68	136.35	135	132.51	131.25	129.16	126.88	126.22	124.32	123.99
SR	157.78	156.3	155.44	152.72	151.94	151.18	149.39	147.22	145.1	143.32	141.55

Table D.8. Mean values of *f0-0%* to *f0-100%* in accented and posttonal syllables in medial bisyllabic words

Acc. Syll.	f0-0%	f0-10%	f0-20%	f0-30%	f0-40%	f0-50%	f0-60%	f0-70%	f0-80%	f0-90%	f0-100%
LF	132.40	133.54	134.30	136.74	138.61	140.18	141.18	141.29	140.73	139.96	138.62
LR	124.59	124.38	124.90	126.14	127.70	129.70	131.00	132.44	133.10	133.33	134.03
SF	140.24	137.73	137.81	137.50	138.68	139.24	140.14	140.43	139.56	139.23	137.96
SR	130.97	129.24	128.96	130.71	131.57	133.29	134.12	134.49	134.44	134.59	135.54
Post. Syll.											
LF	124.41	122.68	121	119.16	118.12	116.54	114.99	114.11	112.71	111.91	111.18
LR	140.31	138.7	137.22	136.19	134.58	132.92	131.5	130.33	129.2	128.02	127.7
SF	123.38	122.26	120.08	119.19	117.07	115.12	114.84	113.79	111.85	109.84	109.11
SR	137.42	135.7	134.27	133.65	132.60	130.89	128.66	127.11	127.09	126.15	125.54

Table D.9. Mean values of *f0-0%* to *f0-100%* in accented and posttonal syllables in final bisyllabic words

Acc. Syll.	f0-0%	f0-10%	f0-20%	f0-30%	f0-40%	f0-50%	f0-60%	f0-70%	f0-80%	f0-90%	f0-100%
LF	106.69	105.09	102.86	98.57	96.06	94.70	92.03	90.34	88.83	86.62	85.11
LR	103.07	101.19	99.46	98.58	95.31	94.54	94.19	93.62	92.96	92.52	92.48
SF	112.02	108.50	104.95	103.26	101.81	100.74	99.02	97.32	96.53	94.55	93.52
SR	106.62	103.45	101.83	100.42	100.98	99.93	100.16	98.42	98.05	97.98	97.42
Post. Syll.											
LF	76.46	75.83	74.88	73.25	74.83	74.02	73.58	71.08	74.48	76.78	81.16
LR	97.80	95.38	92.80	91.36	90.39	89.49	88.00	88.30	86.60	87.34	90.55
SF	79.38	77.75	78.52	78.39	76.58	73.90	75.20	75.80	74.47	68.83	77.08
SR	98.04	97.70	94.85	92.94	91.37	88.26	85.38	83.33	83.40	83.94	82.86

Table D.10. Mean values of *f0-0%* to *f0-100%* in initial 3a words

Acc.	f0-0%	f0-10%	f0-20%	f0-30%	f0-40%	f0-50%	f0-60%	f0-70%	f0-80%	f0-90%	f0-100%
LF	132.03	134.15	136.74	139.58	143.88	147.20	150.28	152.43	154.21	154.61	155.05
LR	114.29	114.72	116.19	118.88	121.86	125.91	129.95	133.89	136.93	139.44	140.13
SF	132.81	133.04	134.72	137.50	140.28	142.68	144.84	146.30	147.68	148.05	148.06
SR	128.32	127.63	127.56	129.54	131.09	133.36	135.46	137.39	138.73	139.43	139.89
Post. 1											
LF	147.47	146.31	144.99	143.2	142.09	140.28	138.65	137.07	135.27	133.49	132.13
LR	155.85	156.53	155.72	155.85	155.51	154.63	153.61	152.89	151.96	150.58	149.22
SF	144.64	143.73	143.18	142.16	140.1	139.02	136.6	134.79	133.35	131.46	129.31
SR	156.03	155.55	154.75	154.36	153.76	152.54	151.24	150.33	149.46	149.17	147.29
Post. 2											
LF	120.27	119.23	118.35	116.84	116.38	115.57	114.76	113.17	112.51	113.03	112.33
LR	126.6	125.13	123.53	121.92	121.23	119.83	118.94	118.23	117.56	116.25	115.35
SF	119.51	117.94	116.14	115.34	114.63	113.79	112.39	111.51	110.43	109.47	109.31
SR	126.86	125.72	124.36	121.17	119.75	118.39	116.37	115.1	113.91	113.82	112.71

Table D.11. Mean and SD values of duration in initial 3a words across four patterns

ASS			ASL			ALS			ALL		
LF	Acc.	97.44 (19.23)	LF	Acc.	81.32 (12.13)	LF	Acc.	108.53 (21.14)	LF	Acc.	104.19 (27.89)
	Post. 1	50.69 (11.97)		Post. 1	52.77 (18.15)		Post. 1	48.89 (12.74)		Post. 1	58.8 (21.41)
	Post. 2	57.33 (12.38)		Post. 2	61.97 (12.74)		Post. 2	64.07 (13.42)		Post. 2	66.58 (17.74)
LR	Acc.	104.42 (13.04)	LR	Acc.	117.08 (20.12)	LR	Acc.	96.07 (30.51)	LR	Acc.	114.96 (14)
	Post. 1	42.55 (12.59)		Post. 1	55.91 (10.06)		Post. 1	69.41 (19.21)		Post. 1	49.13 (12.49)
	Post. 2	44.23 (12.08)		Post. 2	54.88 (12.55)		Post. 2	57.89 (12.69)		Post. 2	44.28 (9.09)
SF	Acc.	77.07 (14.16)	SF	Acc.	76.98 (31.65)	SF	Acc.	83.66 (22.16)	SF	Acc.	71.49 (15.12)
	Post. 1	58.05 (16.03)		Post. 1	51.39 (14.44)		Post. 1	58.31 (16.02)		Post. 1	61.04 (13.39)
	Post. 2	67.81 (11.09)		Post. 2	63.22 (13.24)		Post. 2	68.36 (23.23)		Post. 2	56.41 (14.44)
SR	Acc.	62.16 (22.14)	SR	Acc.	63.36 (7.38)	SR	Acc.	87.16 (21.19)	SR	Acc.	79.65 (21.86)
	Post. 1	44.71 (16.67)		Post. 1	46 (15.13)		Post. 1	52.89 (14.58)		Post. 1	52.48 (13.89)
	Post. 2	59.94 (22.42)		Post. 2	63.78 (18.31)		Post. 2	57.01 (15.74)		Post. 2	55.54 (14.11)

Table D.12. Mean values of *f0-0%* to *f0-100%* in medial 3a words

Acc.	f0-0%	f0-10%	f0-20%	f0-30%	f0-40%	f0-50%	f0-60%	f0-70%	f0-80%	f0-90%	f0-100%
LF	128.97	129.93	130.94	132.44	133.93	135.33	136.33	137.17	137.48	137.23	136.49
LR	115.32	115.05	115.26	116.39	117.98	119.9	122.14	124.52	126.31	127.31	127.11
SF	131.54	131.65	132.52	133.36	134.38	135.03	135.34	135.42	135.3	134.85	133.99
SR	128.25	127.83	128.15	129.36	130.26	131.12	132.2	133.16	133.46	133.8	134.01
Post. 1											
LF	129.72	127.9	126.93	126.24	125.34	124.37	123.02	122.22	120.43	119.85	119.21
LR	139.32	137.95	138.1	137.86	137.25	136.65	135.32	134.69	133.51	131.96	130.74
SF	129.26	127.93	127.52	126.24	124.97	123.61	122.46	121.27	119.19	118.17	116.46
SR	144.61	143.63	143.15	141.58	140.93	139.86	138.46	137.72	136.39	135.25	133.99
Post. 2											
LF	112.77	111.77	111.2	110.17	109.3	108.58	108.04	107.61	106.98	105.31	104.85
LR	117.69	115.71	114.35	112.8	111.74	110.73	109.67	108.74	108.27	107.62	108.13
SF	111.6	110.79	110.26	109.9	108.7	108.12	107.53	106.72	106.14	105.84	105.85
SR	119.52	118.8	117.07	115.98	115.14	114.18	112.8	111.43	110.18	109.2	107.52

Table D.13. Mean and SD values of duration in medial 3a words across four patterns

ASS			ASL			ALS			ALL		
LF	Acc.	99.9 (15.77)	LF	Acc.	77.58 (10.55)	LF	Acc.	106.57 (20.17)	LF	Acc.	101.71 (20.76)
	Post. 1	51.72 (16.8)		Post. 1	49.16 (17.45)		Post. 1	48.08 (9.83)		Post. 1	54.24 (13.93)
	Post. 2	56.34 (16.72)		Post. 2	61.43 (10.96)		Post. 2	67.23 (18.64)		Post. 2	44.94 (15.94)
LR	Acc.	121.52 (17.34)	LR	Acc.	132.45 (15.91)	LR	Acc.	93.2 (27.61)	LR	Acc.	122.61 (13.85)
	Post. 1	41.69 (8.43)		Post. 1	53.38 (11.98)		Post. 1	62.28 (13.34)		Post. 1	47.79 (13)
	Post. 2	46.72 (19.83)		Post. 2	55 (13.77)		Post. 2	58.89 (25.32)		Post. 2	49.99 (11.09)
SF	Acc.	78.59 (8.88)	SF	Acc.	76.95 (29.36)	SF	Acc.	87.13 (23.43)	SF	Acc.	65.54 (22.1)
	Post. 1	58.71 (14.84)		Post. 1	50.29 (13.73)		Post. 1	57.66 (17.34)		Post. 1	57.83 (14.91)
	Post. 2	66.92 (15.58)		Post. 2	51.99 (13.58)		Post. 2	49.83 (14.74)		Post. 2	53.92 (13.1)
SR	Acc.	67.32 (20.09)	SR	Acc.	70.29 (10.54)	SR	Acc.	80.1 (14.43)	SR	Acc.	79.5 (17.18)
	Post. 1	47.84 (10.39)		Post. 1	46.8 (14.19)		Post. 1	47.01 (15.08)		Post. 1	52.01 (10.89)
	Post. 2	59.18 (20.02)		Post. 2	57.33 (16.67)		Post. 2	42.59 (11.21)		Post. 2	58.03 (16.67)

Table D.14. Mean values of *f0-0%* to *f0-100%* in final 3a words. Values written in bold were excluded from the analysis

Acc.	f0-0%	f0-10%	f0-20%	f0-30%	f0-40%	f0-50%	f0-60%	f0-70%	f0-80%	f0-90%	f0-100%
LF	112.89	109.02	107.54	106.38	104.68	102.98	101.02	100.50	98.35	96.91	95.64
LR	101.89	98.40	97.35	95.10	94.59	93.93	93.82	94.19	94.22	94.27	93.49
SF	108.84	106.78	106.27	105.15	104.37	103.52	102.35	101.12	99.83	98.63	96.99
SR	108.72	105.22	103.34	101.38	100.70	100.71	100.11	99.70	99.17	98.11	98.66
Post. 1											
LF	88.99	86.91	86.08	83.90	83.12	82.66	82.52	82.12	81.73	81.49	82.31
LR	94.38	92.47	91.54	90.49	89.81	89.49	88.27	87.49	86.74	86.09	85.47
SF	87.20	85.60	85.15	84.37	83.62	83.04	81.80	82.19	80.81	80.54	81.09
SR	99.33	97.25	95.01	94.07	93.35	93.17	92.40	92.06	91.48	91.91	90.73
Post. 2											
LF	81.69	82.06	81.08	78.45	78.82	79.66	77.86	**78.18**	**80.09**	**78.99**	**83.91**
LR	77.89	78.38	76.33	76.22	78.93	76.53	71.77	**76.20**	**75.41**	**78.61**	**78.60**
SF	77.65	76.11	75.89	77.19	77.37	76.57	78.34	**78.50**	**78.13**	**81.04**	**87.92**
SR	80.70	79.74	78.11	77.85	75.45	76.53	76.52	**74.58**	**70.58**	**72.00**	**75.98**

Table D.15. Mean and SD values of duration in final 3a words across four patterns

ASS			ASL			ALS			ALL		
LF	Acc.	119.4 (23.79)	LF	Acc.	93.96 (17.86)	LF	Acc.	109.2 (30.1)	LF	Acc.	122.95 (27.21)
	Post. 1	54.71 (15.66)		Post. 1	58.53 (11.87)		Post. 1	62.81 (13.64)		Post. 1	60.55 (18.72)
	Post. 2	70.64 (20.3)		Post. 2	64.27 (16.15)		Post. 2	81.52 (18.6)		Post. 2	63.58 (17.41)
LR	Acc.	137.58 (25)	LR	Acc.	143.87 (19.5)	LR	Acc.	119.64 (24.73)	LR	Acc.	137.5 (15.27)
	Post. 1	49.29 (11.25)		Post. 1	56.56 (10.36)		Post. 1	79.72 (14.81)		Post. 1	61.59 (13.85)
	Post. 2	68.23 (18.49)		Post. 2	58.24 (16.61)		Post. 2	74.2 (20.38)		Post. 2	51.48 (13.99)
SF	Acc.	92.64 (16.15)	SF	Acc.	85.85 (34.12)	SF	Acc.	101.44 (30.38)	SF	Acc.	74.55 (22.45)
	Post. 1	75.27 (23.25)		Post. 1	61.53 (19.33)		Post. 1	59.63 (22.94)		Post. 1	69.52 (16.8)
	Post. 2	88.91 (25.33)		Post. 2	66.54 (16.4)		Post. 2	80.26 (18.27)		Post. 2	60.98 (13.15)
SR	Acc.	72.53 (34.96)	SR	Acc.	82.23 (13.72)	SR	Acc.	100.09 (18.77)	SR	Acc.	86.98 (17.05)
	Post. 1	50.49 (12.29)		Post. 1	52.41 (18.45)		Post. 1	63.43 (16.42)		Post. 1	59.78 (20.01)
	Post. 2	86.46 (30.97)		Post. 2	74.49 (13.16)		Post. 2	79.18 (18.84)		Post. 2	65.29 (20.13)

Table D.16. Mean values of *f0-0%* to *f0-100%* in initial 3b words

Pre. 1	f0-0%	f0-10%	f0-20%	f0-30%	f0-40%	f0-50%	f0-60%	f0-70%	f0-80%	f0-90%	f0-100%
LR	110.79	109.00	108.39	108.31	108.00	107.08	107.15	106.99	106.50	105.81	105.97
SR	111.89	111.16	110.15	109.27	108.76	108.30	108.27	107.41	106.94	106.52	105.91
Acc.											
LR	122.49	122.65	124.67	127.10	130.01	133.88	137.11	140.51	143.41	145.53	146.53
SR	129.27	130.28	131.30	133.44	135.19	137.98	139.60	141.88	143.23	144.78	145.37
Post. 1											
LR	157.64	156.82	155.24	154.22	152.38	150.71	149.82	147.2	145.94	142.95	141.71
SR	156.01	156.31	155.97	155.48	154.5	153.07	152.49	150.55	148.9	146.25	144.77

Table D.17. Mean values of *f0-0%* to *f0-100%* in medial 3b words

Pre. 1	f0-0%	f0-10%	f0-20%	f0-30%	f0-40%	f0-50%	f0-60%	f0-70%	f0-80%	f0-90%	f0-100%
LR	114.08	112.54	112.36	111.46	110.80	110.62	110.04	109.45	109.19	107.95	107.91
SR	114.92	111.77	110.86	110.43	109.66	109.60	109.07	108.28	107.89	107.14	106.51
Acc.											
LR	118.26	117.62	118.02	119.69	121.19	123.41	126.07	128.19	130.39	131.77	132.37
SR	121.66	122.11	122.61	123.96	125.30	126.84	128.35	129.82	130.64	131.32	131.55
Post. 1											
LR	139.50	138.42	136.95	134.97	133.60	131.66	129.34	128.57	126.35	124.99	123.95
SR	136.10	135.76	135.00	133.93	133.10	131.82	129.90	128.83	127.04	125.42	124.08

Table D.18. Mean values of *f0-0%* to *f0-100%* in final 3b words

Pre. 1	f0-0%	f0-10%	f0-20%	f0-30%	f0-40%	f0-50%	f0-60%	f0-70%	f0-80%	f0-90%	f0-100%
LR	109.07	107.10	106.36	103.82	103.50	102.82	101.63	101.39	100.87	100.44	99.86
SR	108.16	106.06	104.31	103.33	102.42	101.73	101.12	100.58	99.61	98.53	97.81
Acc.											
LR	101.09	99.06	97.70	97.36	95.83	94.86	94.54	94.35	93.93	93.11	92.70
SR	98.63	98.13	97.65	96.78	95.95	95.41	94.38	94.25	94.35	93.35	92.68
Post. 1											
LR	92.47	92.32	92.20	91.29	91.39	92.02	91.57	90.37	91.16	92.35	93.39
SR	91.88	90.16	88.87	87.04	86.90	86.58	86.84	85.61	84.82	84.80	86.91

Table D.19. Mean values of *f0-0%* to *f0-100%* in initial 4a words

Pre. 1	f0-0%	f0-10%	f0-20%	f0-30%	f0-40%	f0-50%	f0-60%	f0-70%	f0-80%	f0-90%	f0-100%
LR	115.09	114.52	114.40	114.07	113.64	113.09	113.04	112.86	112.07	111.83	111.78
SR	109.22	107.95	107.02	106.33	106.43	106.40	106.17	106.43	106.37	106.37	106.61
Acc.											
LR	121.80	122.77	123.45	124.54	127.46	130.58	133.89	136.82	139.77	141.21	142.29
SR	117.49	118.68	120.23	122.25	125.03	128.51	131.68	135.12	137.62	139.39	140.61
Post. 1											
LR	155.41	154.98	154.54	154.45	153.77	152.58	151.74	150.53	149.73	148.02	146.78
SR	155.15	155.38	154.93	154.36	153.28	152.44	150.51	149.76	148.84	145.92	144.88
Post. 2											
LR	127.81	125.81	123.84	121.38	119.31	118.73	117.13	115.78	114.78	113.65	112.81
SR	126.48	123.94	122.11	120.64	119.31	118.29	116.84	115.12	114.32	113.42	112.48

Table D.20. Mean and SD values of duration in initial 4a words across four patterns

PASS			PASL			PALS			PALL		
LR	Pre. 1	47.9 (11.85)	LR	Pre. 1	50.42 (15.31)	LR	Pre. 1	46.83 (9.2)	LR	Pre. 1	63.62 (15.67)
	Acc.	101.84 (20.85)		Acc.	113.53 (18.01)		Acc.	93.32 (18.69)		Acc.	110.38 (20.58)
	Post. 1	43.69 (11.82)		Post. 1	56.06 (16.36)		Post. 1	55.96 (7.26)		Post. 1	41.93 (9.51)
	Post. 2	41.64 (14.72)		Post. 2	70.98 (12.37)		Post. 2	61.62 (15.59)		Post. 2	63.88 (16.89)
SR	Pre. 1	50.23 (16.29)	SR	Pre. 1	58.99 (10.11)	SR	Pre. 1	52.33 (12.08)	SR	Pre. 1	62.13 (16.3)
	Acc.	96.28 (21.57)		Acc.	83.09 (16.15)		Acc.	100.76 (23.49)		Acc.	102.2 (16.41)
	Post. 1	36.85 (10.49)		Post. 1	39.83 (11.37)		Post. 1	64.38 (14.89)		Post. 1	72.11 (15.78)
	Post. 2	54.78 (8.45)		Post. 2	55.83 (8.95)		Post. 2	74.48 (22.02)		Post. 2	51.4 (13.84)

Table D.21. Mean values of *f0-0%* to *f0-100%* in medial 4a words

Pre. 1	f0-0%	f0-10%	f0-20%	f0-30%	f0-40%	f0-50%	f0-60%	f0-70%	f0-80%	f0-90%	f0-100%
LR	117.33	116.51	116.00	115.70	115.04	114.94	114.11	113.71	113.07	112.66	112.39
SR	112.70	111.05	110.33	110.04	109.41	109.15	108.73	108.20	107.62	107.01	106.93
Acc.											
LR	118.66	118.11	118.75	120.08	121.77	124.15	126.36	128.55	130.34	131.66	132.24
SR	114.11	114.58	114.95	116.39	117.92	120.16	122.38	124.12	125.87	126.90	127.21
Post. 1											
LR	144.72	143.71	142.67	142.31	140.99	140.32	139.44	138.20	137.05	136.16	134.97
SR	140.00	139.61	139.17	138.61	137.51	135.68	134.58	133.49	132.40	131.49	130.38
Post. 2											
LR	119.95	118.62	117.15	115.04	114.49	112.96	111.77	111.19	109.98	108.81	107.92
SR	117.13	115.48	113.89	112.80	111.80	111.05	110.10	109.90	109.09	107.99	108.49

Table D.22. Mean and SD values of duration in medial 4a words across four patterns

PASS			PASL			PALS			PALL		
LR	Pre. 1	49.79 (16.7)	LR	Pre. 1	46.33 (15.33)	LR	Pre. 1	49.52 (7.44)	LR	Pre. 1	60.21 (16.93)
	Acc.	107.8 (18.85)		Acc.	112.41 (19.55)		Acc.	89.35 (22.03)		Acc.	113.07 (16.28)
	Post. 1	41.13 (11.21)		Post. 1	53.13 (11.43)		Post. 1	60.03 (13.01)		Post. 1	44.55 (13.5)
	Post. 2	62.88 (14.1)		Post. 2	65.62 (14.03)		Post. 2	71.19 (13.13)		Post. 2	58.81 (11.53)
SR	Pre. 1	47.83 (20.31)	SR	Pre. 1	49.92 (11.37)	SR	Pre. 1	58.21 (10.65)	SR	Pre. 1	58.14 (12.03)
	Acc.	92.41 (18.42)		Acc.	84.04 (15.97)		Acc.	58.34 (21.16)		Acc.	100.87 (16.05)
	Post. 1	32.87 (8.94)		Post. 1	38.78 (11.35)		Post. 1	93.97 (17.33)		Post. 1	75.59 (13.74)
	Post. 2	60.69 (24.84)		Post. 2	46.6 (10.15)		Post. 2	62.03 (9.67)		Post. 2	58.51 (12)

Table D.22. Mean values of *f0-0%* to *f0-100%* in final 4a words

Pre. 1	f0-0%	f0-10%	f0-20%	f0-30%	f0-40%	f0-50%	f0-60%	f0-70%	f0-80%	f0-90%	f0-100%
LR	111.22	110.39	109.22	108.54	108.06	107.33	106.82	106.16	105.40	104.66	104.38
SR	109.64	107.94	106.64	104.52	103.87	103.52	102.97	102.72	102.12	101.43	100.76
Acc.											
LR	103.91	100.69	99.77	98.96	98.84	98.48	98.41	98.56	98.60	98.02	96.83
SR	102.53	101.67	100.83	99.89	99.35	98.94	98.87	98.80	98.60	98.25	98.92
Post. 1											
LR	98.81	97.49	96.19	95.47	94.72	93.81	93.03	92.40	91.96	91.39	91.11
SR	98.43	97.67	96.59	95.26	93.71	93.24	90.82	88.73	87.93	88.22	87.33
Post. 2											
LR	83.67	83.56	83.95	84.14	83.58	83.31	84.40	83.82	83.14	83.75	86.40
SR	77.08	77.06	75.45	73.92	72.70	71.34	71.86	72.43	72.64	72.32	70.94

Table D.24. Mean and SD values of duration in final 4a words across four patterns

PASS			PASL			PALS			PALL		
LR	Pre. 1	54.74 (16.01)	LR	Pre. 1	41.56 (12.57)	LR	Pre. 1	55.61 (12.51)	LR	Pre. 1	54.65 (11.62)
	Acc.	136.52 (18.01)		Acc.	121.18 (19.8)		Acc.	122.18 (22.36)		Acc.	120.91 (15.49)
	Post. 1	46.68 (13.51)		Post. 1	56.12 (12.97)		Post. 1	75.89 (12.82)		Post. 1	50.17 (9.15)
	Post. 2	71.41 (24.94)		Post. 2	69.04 (16.06)		Post. 2	80.93 (21.63)		Post. 2	59.91 (11.51)
SR	Pre. 1	59.48 (19.19)	SR	Pre. 1	53.33 (12.96)	SR	Pre. 1	57.09 (18.98)	SR	Pre. 1	65.05 (11.7)
	Acc.	87.82 (19.84)		Acc.	90.48 (17.85)		Acc.	107.45 (20.29)		Acc.	114.05 (14.11)
	Post. 1	33.65 (20.92)		Post. 1	39.98 (13.24)		Post. 1	83.96 (17.02)		Post. 1	92.78 (18.37)
	Post. 2	72.51 (18.1)		Post. 2	64.17 (16.17)		Post. 2	84.51 (20.21)		Post. 2	57.88 (15.06)

Table D.25. Mean values of *f0-0%* to *f0-100%* in initial 4b words

Pre. 2	f0-0%	f0-10%	f0-20%	f0-30%	f0-40%	f0-50%	f0-60%	f0-70%	f0-80%	f0-90%	f0-100%
LR	109.75	108.62	108.09	107.17	107.25	107.07	107.00	106.63	105.64	105.05	105.11
SR	116.51	113.00	113.12	112.51	111.84	111.66	110.83	110.09	109.23	109.54	109.90
LF	119.16	114.88	114.17	110.86	110.19	110.02	110.01	109.22	109.31	109.04	108.60
Pre. 1											
LR	110.84	110.82	110.57	110.38	109.97	109.56	109	108.4	107.72	107.62	107.38
SR	117.61	117.21	117.26	116.87	116.52	115.81	115.02	114.54	114.09	113.58	113.36
LF	113.86	114.06	114.09	113.94	113.35	112.98	112.84	112.23	112.09	111.94	112.15
Acc.											
LR	125.61	126.06	126.91	128.8	131.51	133.72	136.79	139.15	141.83	143.75	144.67
SR	123.91	127.27	130.3	132.25	134.55	137.78	140.56	143.14	144.92	146.11	146.85
LF	130.69	132.55	135.45	138.64	143.18	147.17	149.85	153.29	155.76	156.92	157.14
Post. 1											
LR	152.5	151.23	150.09	149.12	147.55	147.31	145.68	143.59	142.54	141.51	140.25
SR	152.46	151.3	150.58	148.73	147.5	146.77	145.05	141.81	141.1	138.86	139.51
LF	130.54	129.25	126.35	125.12	123.81	121.52	119.85	118.35	116.63	115.37	113.31

Table D.26. Mean and SD values of duration in initial 4b words across patterns

Pattern	Accent	Syll. Type	Mean
PPAS	LR	Pre. 2	50.49 (15.38)
		Pre. 1	45.87 (10.13)
		Acc.	93.98 (24.9)
		Post. 1	53.4 (15.31)
	SR	Pre. 2	54.79 (17.05)
		Pre. 1	53.32 (13.43)
		Acc.	78.16 (18.23)
		Post. 1	65.23 (19.34)
PPAL	LR	Pre. 2	49.54 (10.26)
		Pre. 1	50.34 (13.97)
		Acc.	98.55 (23.38)
		Post. 1	55.25 (12.68)
	LF	Pre. 2	49.89 (13.67)
		Pre. 1	50.81 (13.57)
		Acc.	96.22 (15.37)
		Post. 1	53.32 (13.49)

Table D.27. Mean values of *f0-0%* to *f0-100%* in medial 4b words

Pre. 2	f0-0%	f0-10%	f0-20%	f0-30%	f0-40%	f0-50%	f0-60%	f0-70%	f0-80%	f0-90%	f0-100%
LR	114.10	113.63	112.90	112.29	111.15	110.51	110.24	109.53	108.72	108.07	107.53
SR	112.06	112.10	111.85	111.42	112.00	111.41	110.80	109.38	108.22	107.20	106.42
LF	121.46	120.1	118.29	115.19	114.46	113.56	113.69	112.74	112.12	111.56	110.9
Pre. 1											
LR	110.28	109.84	109.77	109.57	108.38	107.87	107.41	106.95	106.42	105.84	105.86
SR	114.98	113.79	112.31	111.83	111.60	111.00	110.67	109.85	109.28	108.95	108.66
LF	112.16	112.18	111.71	111.38	110.91	110.81	110.38	110.17	109.96	109.91	109.54
Acc.											
LR	118.19	118.56	119.00	119.77	120.92	122.51	124.37	126.25	127.84	128.94	129.18
SR	116.65	118.64	120.05	121.78	123.05	124.17	126.12	126.94	127.95	128.12	128.24
LF	122.61	125.38	127.09	129.58	131.37	133.97	136.72	138.54	139.93	139.76	139.24
Post. 1											
LR	135.87	135.09	134.66	133.57	133.00	132.16	130.62	129.93	128.41	127.73	126.71
SR	132.06	130.59	129.17	128.24	126.91	125.49	122.92	121.52	119.11	116.42	115.25
LF	120.95	117.47	115.98	115.62	113.86	113.36	113.19	112.13	111.16	112.38	113.69

Table D.28. Mean and SD values of duration in medial 4b words across patterns

Pattern	Accent	Syll. Type	Mean
PPAS	LR	Pre. 2	54.61 (14.26)
		Pre. 1	47.01 (12.04)
		Acc.	97.54 (30.65)
		Post. 1	55.05 (15.52)
	SR	Pre. 2	46.95 (18.08)
		Pre. 1	50.05 (14.55)
		Acc.	74.16 (16.32)
		Post. 1	69.84 (16.97)
PPAL	LR	Pre. 2	51.27 (10.19)
		Pre. 1	49.41 (15.41)
		Acc.	100.31 (24.41)
		Post. 1	51.41 (11.93)
	LF	Pre. 2	52.58 (11.01)
		Pre. 1	52.67 (13.39)
		Acc.	100.3 (17.23)
		Post. 1	53.98 (11.99)

Table D.29. Mean values of *f0-0%* to *f0-100%* in final 4b words

Pre. 2	f0-0%	f0-10%	f0-20%	f0-30%	f0-40%	f0-50%	f0-60%	f0-70%	f0-80%	f0-90%	f0-100%
LR	109.04	108.77	108.25	107.05	106.82	106.12	105.61	105.02	104.33	103.76	104.13
SR	114.06	112.78	110.39	110.14	109.17	108.32	107.73	106.76	106.01	105.70	104.16
LF	115.31	114.32	111.12	110.56	110.21	109.56	108.22	107.76	107.23	106.33	105.59
Pre. 1											
LR	106.01	105.85	105.87	105.11	104.56	103.97	103.22	103.50	103.56	103.01	102.81
SR	111.83	109.20	107.81	106.02	104.98	104.21	102.95	102.49	101.60	100.49	99.73
LF	109.15	108.97	108.69	108.19	107.53	106.69	106.23	105.80	104.54	104.00	103.53
Acc.											
LR	103.30	100.67	98.43	97.01	96.30	95.88	95.73	95.52	95.16	94.78	94.64
SR	99.38	99.11	98.91	98.59	98.33	97.93	97.7	97.67	97.34	96.58	96.43
LF	106.86	105.86	105.25	102.65	101.92	101.28	100.54	99.86	98.83	97.97	96.05
Post. 1											
LR	93.47	92.86	90.7	90.1	90.56	90.89	90.41	90.08	89.86	90.84	90.52
SR	89.85	88.44	87.21	86.12	84.66	85.61	82.71	82.76	82.52	81.13	80.30
LF	83.78	85.59	84.53	83.25	82.84	80.16	81.68	82.99	81.42	82.87	83.88

Table D.30. Mean and SD values of duration in final 4b words across patterns

Pattern	Accent	Syll. Type	Mean
PPAS	LR	Pre. 2	55.66 (19.86)
		Pre. 1	47.38 (12.68)
		Acc.	141.66 (24.99)
		Post. 1	57.89 (17.63)
	SR	Pre. 2	54.58 (18.38)
		Pre. 1	57.74 (17.42)
		Acc.	95.48 (19.41)
		Post. 1	90.33 (23.34)
PPAL	LR	Pre. 2	56.24 (12.2)
		Pre. 1	54.31 (16.11)
		Acc.	135.02 (24.8)
		Post. 1	54.8 (13.22)
	LF	Pre. 2	50.83 (11.58)
		Pre. 1	51.63 (14.03)
		Acc.	99.97 (18.04)
		Post. 1	61.36 (14.46

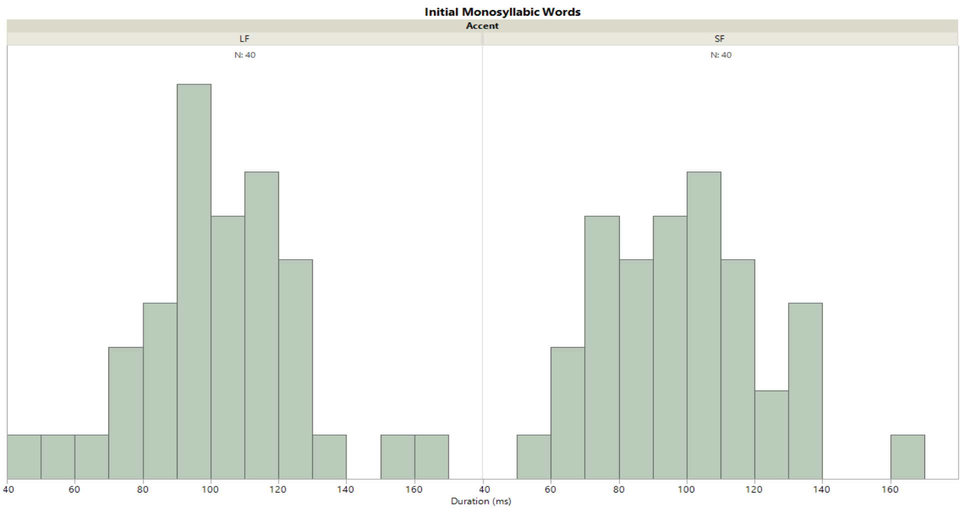

Figure D.1. Distribution histograms of Duration in initial monosyllabic words across the two falling accents. N refers to the number of words measured

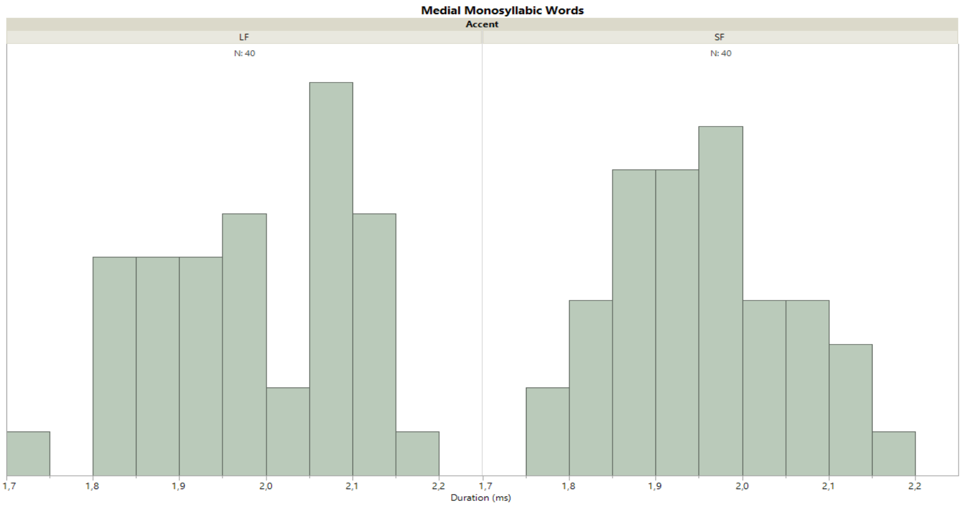

Figure D.2. Distribution histograms of Duration (log-transformed) in medial monosyllabic words across the two falling accents

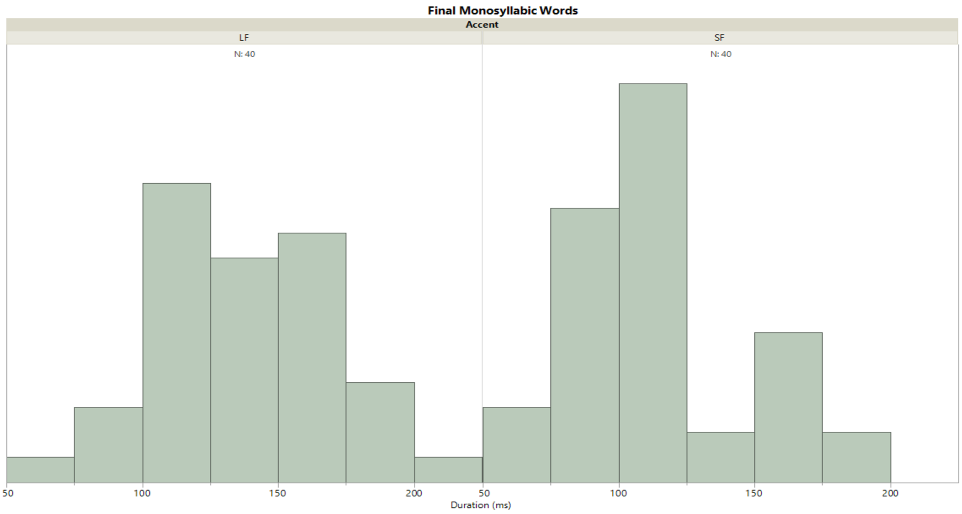

Figure D.3. Distribution histograms of Duration in final monosyllabic words across the two falling accents

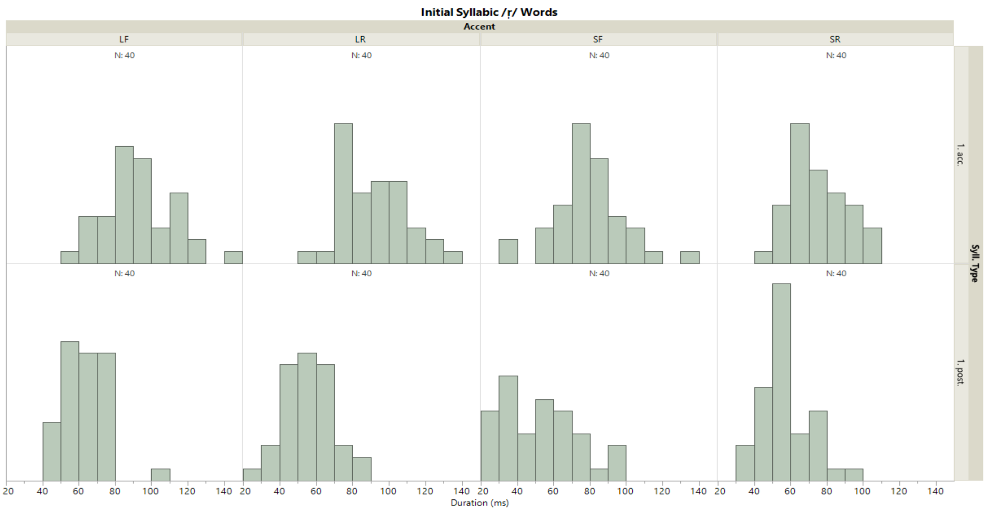

Figure D.4. Distribution histograms of Duration in initial syllabic /r̩/ words across the four accents

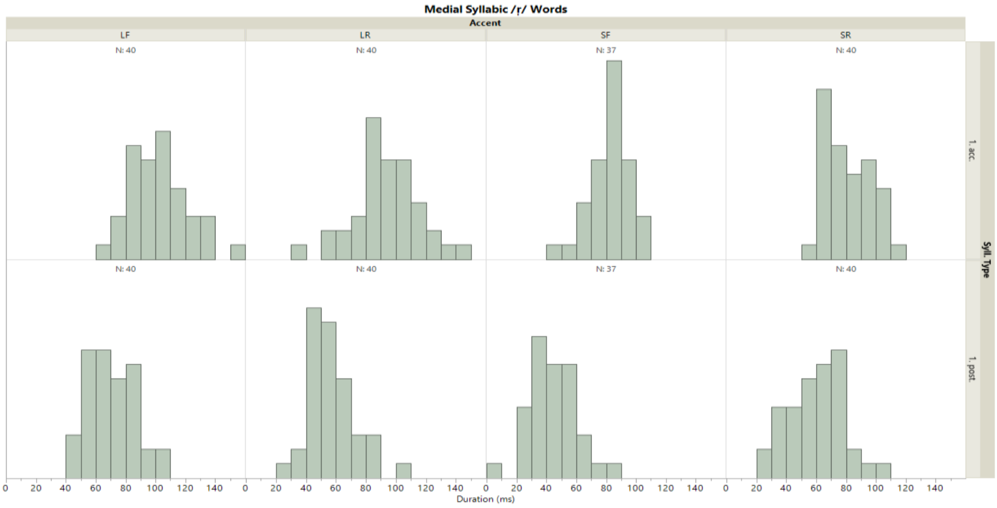

Figure D.5. Distribution histograms of Duration in medial syllabic /ɽ/ words across the four accents

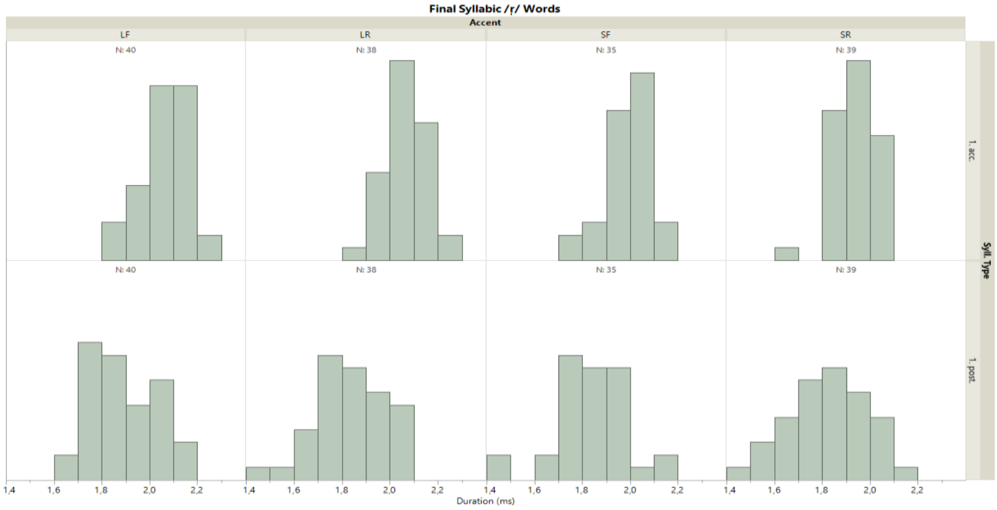

Figure D.6. Distribution histograms of Duration (log-transformed) in final syllabic /ɽ/ words across the four accents

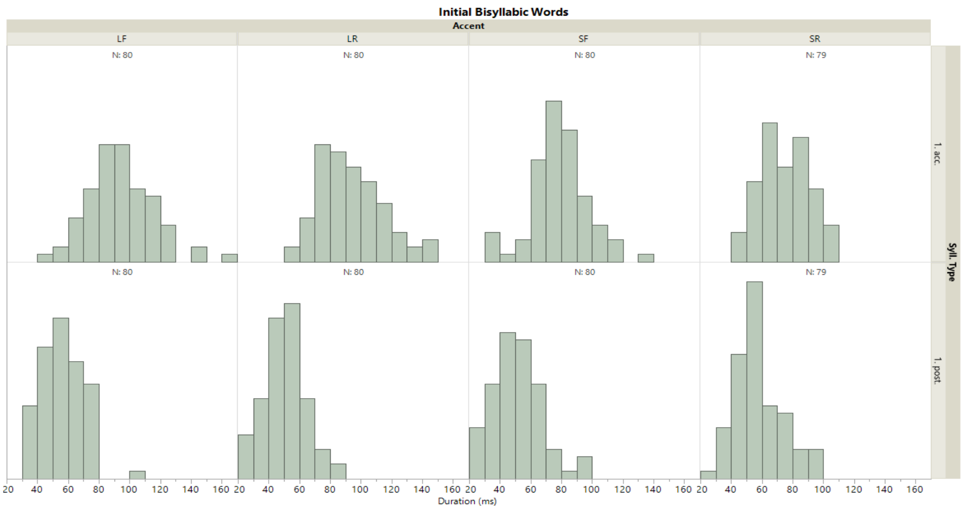

Figure D.7. Distribution histograms of Duration in initial bisyllabic words across the four accents

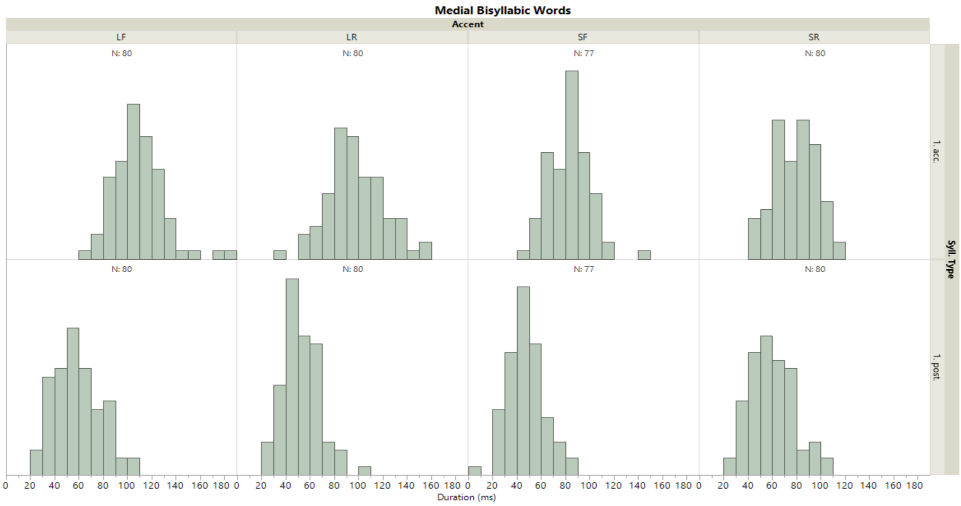

Figure D.8. Distribution histograms of Duration in medial bisyllabic words across the four accents

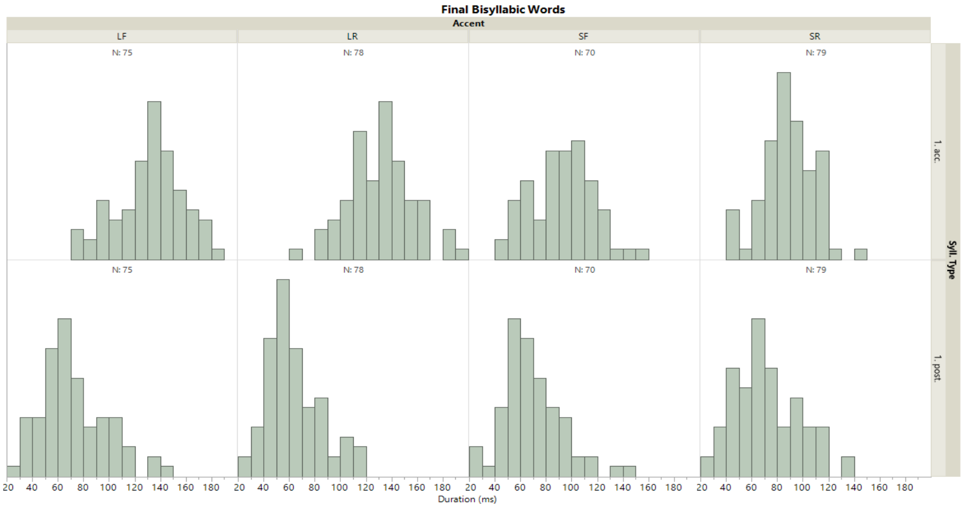

Figure D.9. Distribution histograms of Duration in final bisyllabic words across the four accents

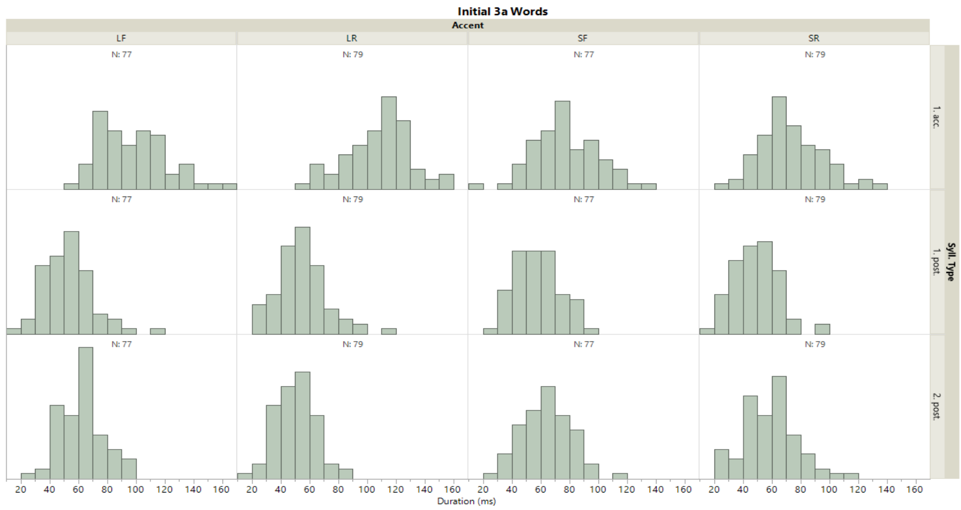

Figure D.10. Distribution histograms of Duration in initial 3a words across the four accents

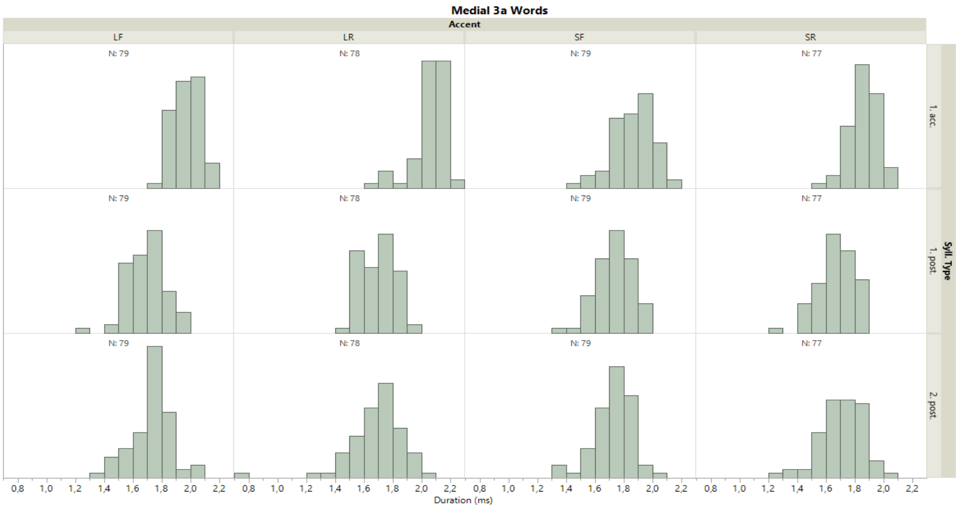

Figure D.11. Distribution histograms of Duration (log-transformed) in medial 3a words across the four accents

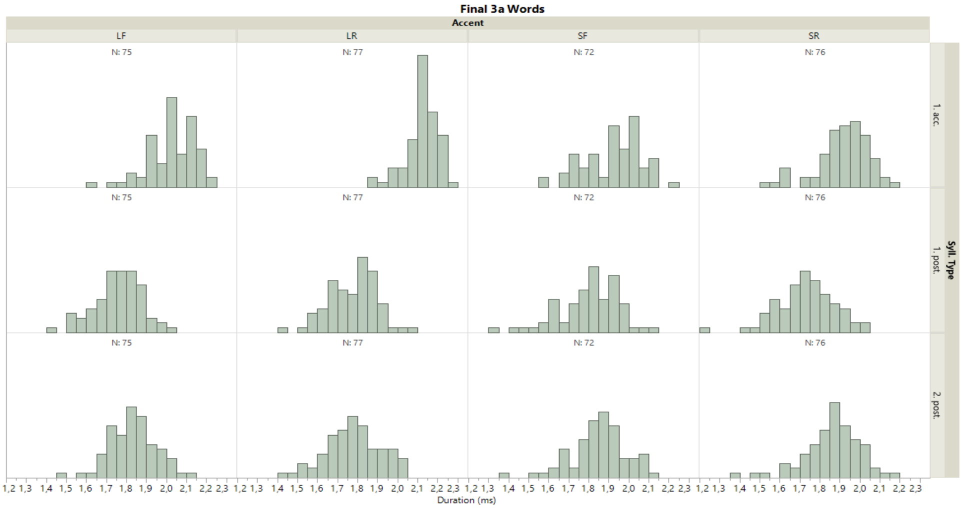

Figure D.12. Distribution histograms of Duration (log-transformed) in final 3a words across the four accents

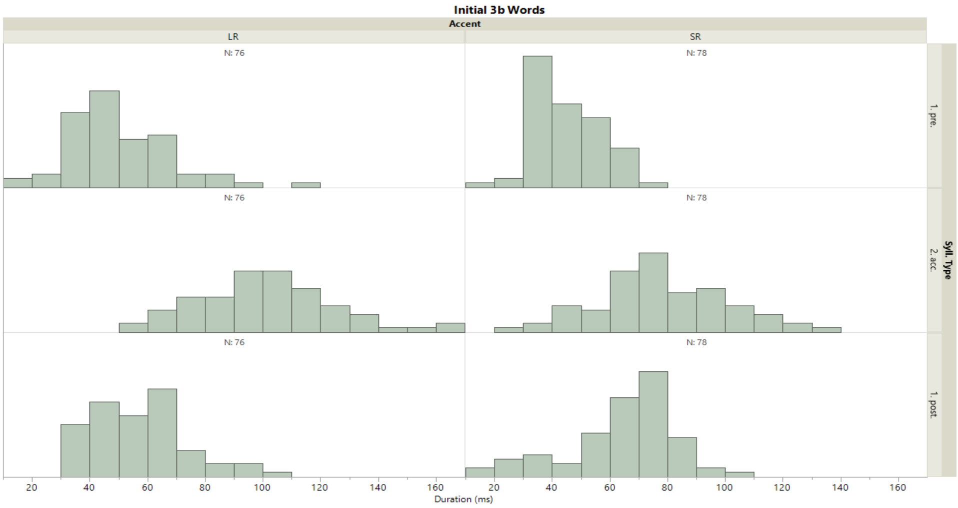

Figure D.13. Distribution histograms of Duration in initial 3b words across the two rising accents

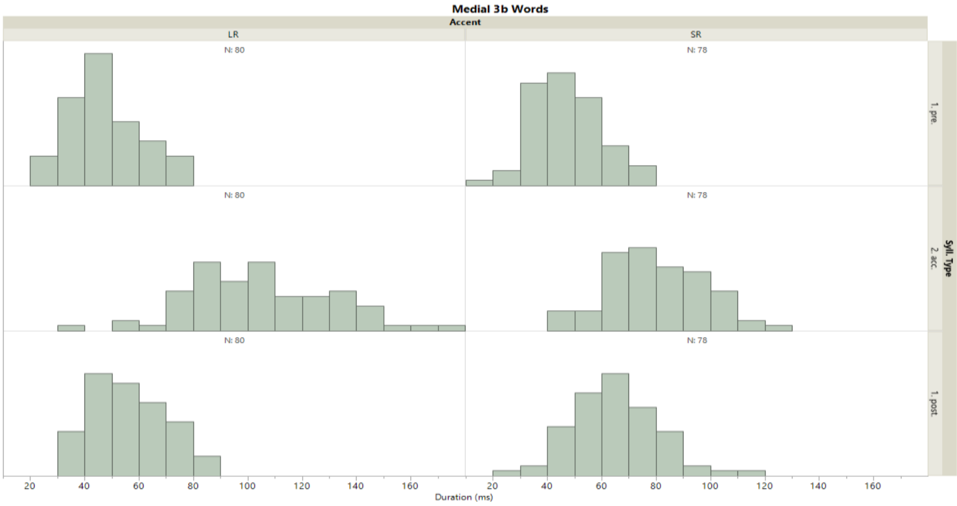

Figure D.14. Distribution histograms of Duration in medial 3b words across the two rising accents

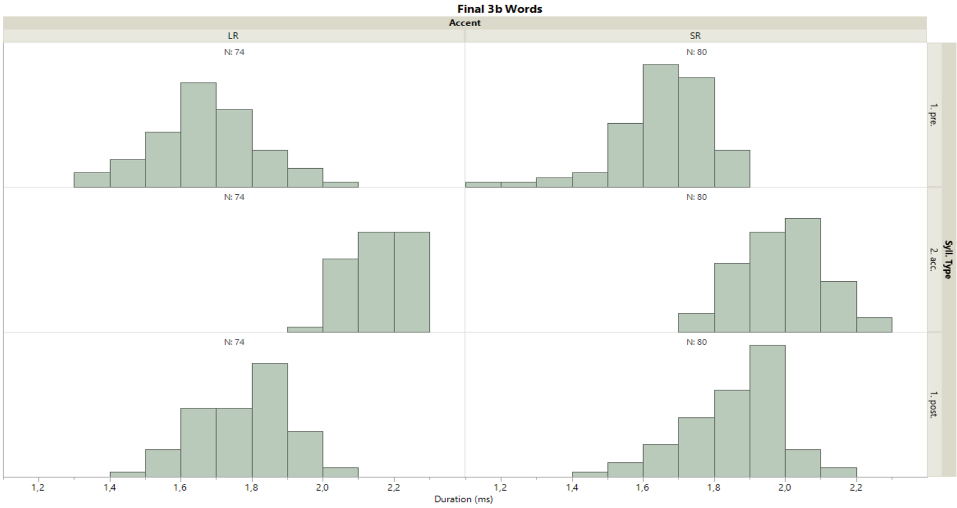

Figure D.15. Distribution histograms of Duration (log-transformed) in final 3b words across the two rising accents

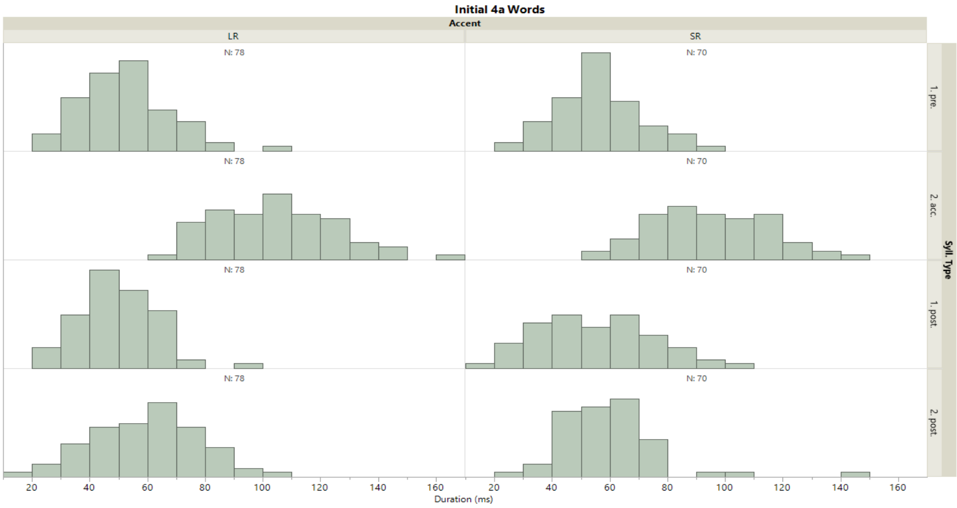

Figure D.16. Distribution histograms of Duration in initial 4a words across the two rising accents

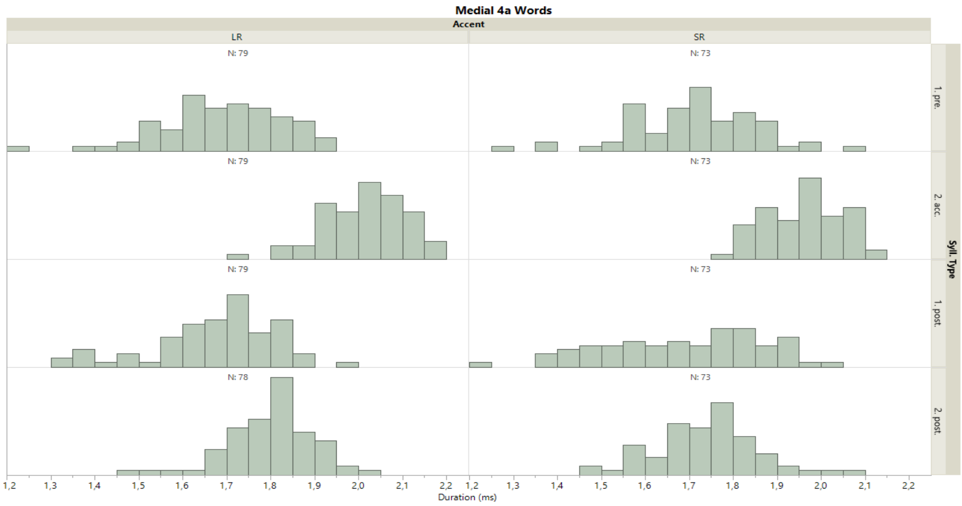

Figure D.17. Distribution histograms of Duration (log-transformed) in medial 4a words across the two rising accents

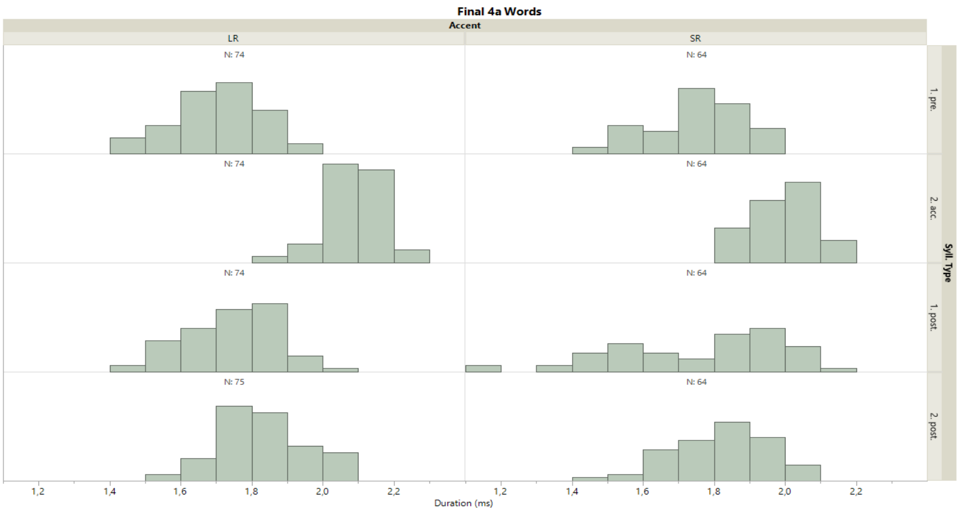

Figure D.18. Distribution histograms of Duration (log-transformed) in final 4a words across the two rising accents

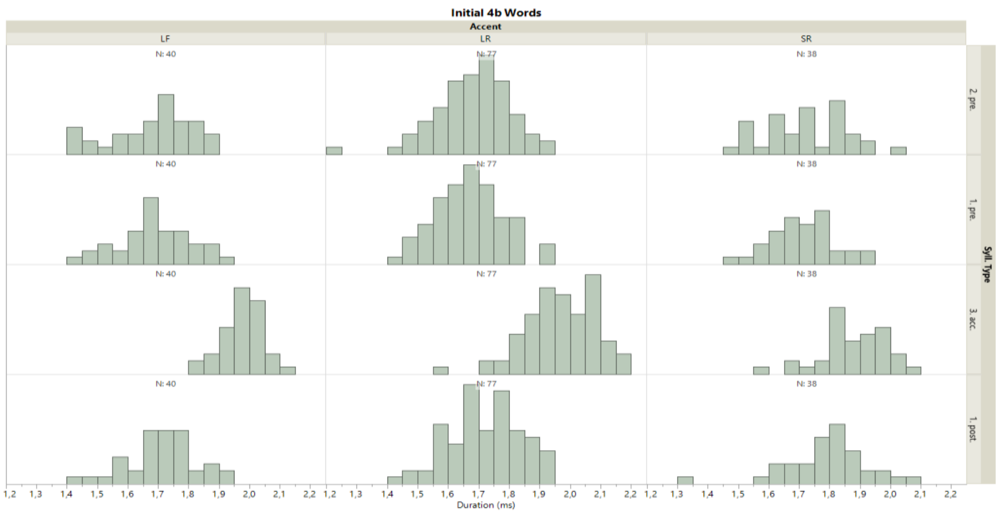

Figure D.19. Distribution histograms of Duration (log-transformed) in initial 4b words across the rising accents and LF

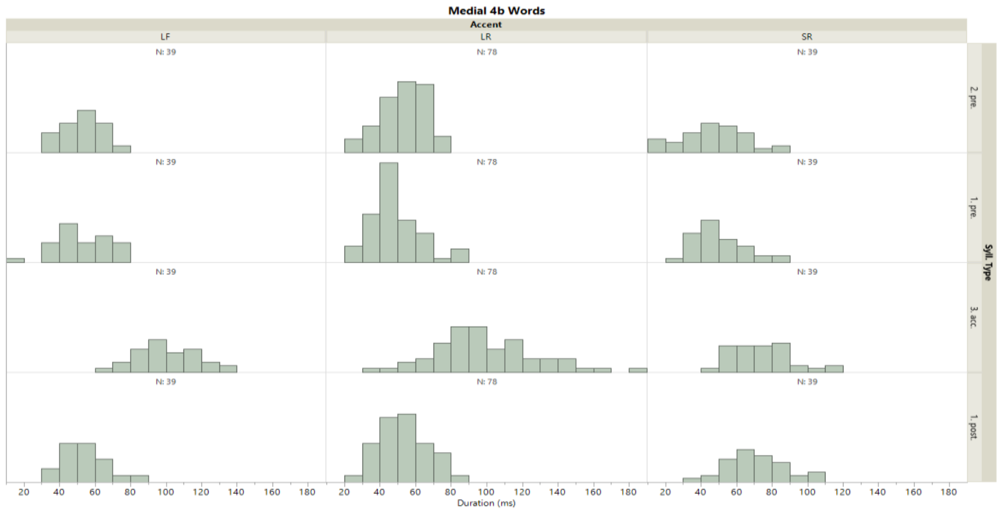

Figure D.20. Distribution histograms of Duration in medial 4b words across the two rising accents and LF

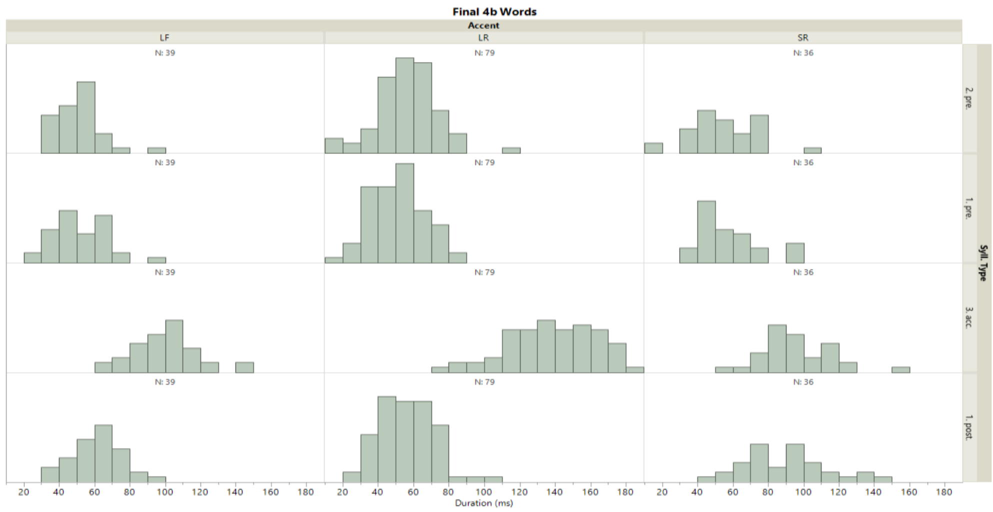

Figure D.21. Distribution histograms of Duration in final 4b words across the two rising accents and LF

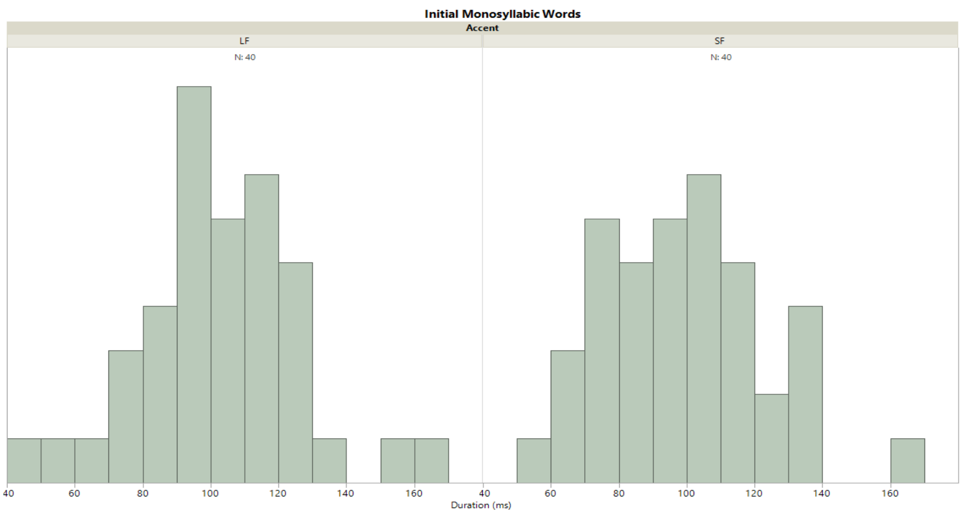

Figure D.22. Distribution histograms of OvMean in initial monosyllabic word across the two falling accents

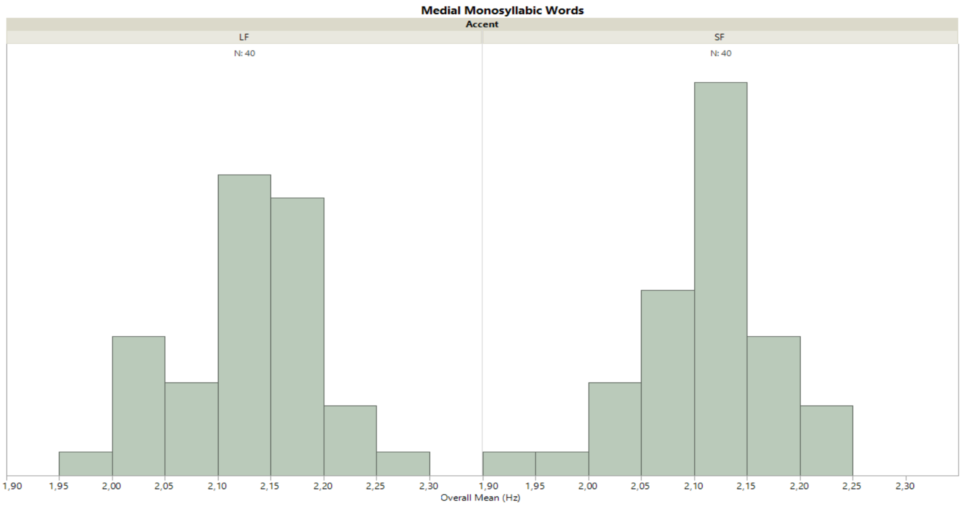

Figure D.23. Distribution histograms of OvMean (log-transformed) in medial monosyllabic word across the two falling accents

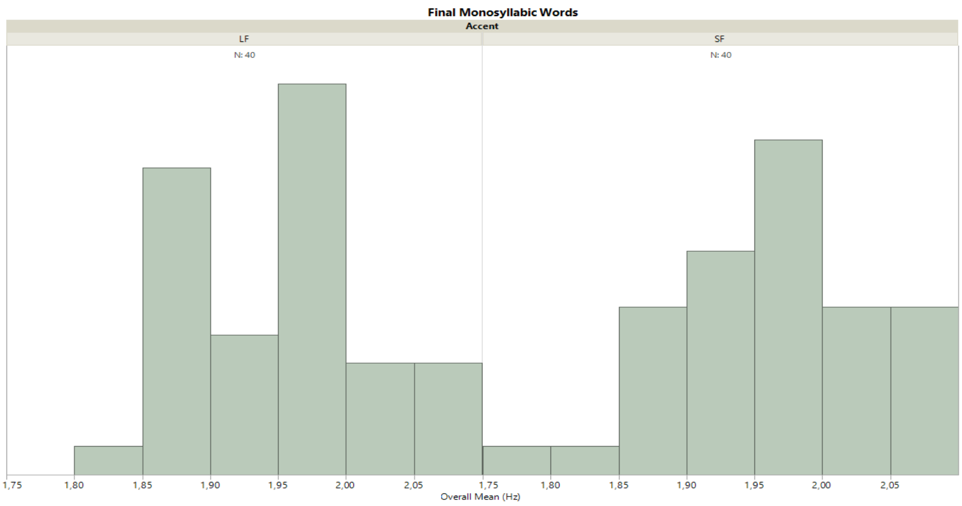

Figure D.24. Distribution histograms of OvMean (log-transformed) in final monosyllabic word across the two falling accents

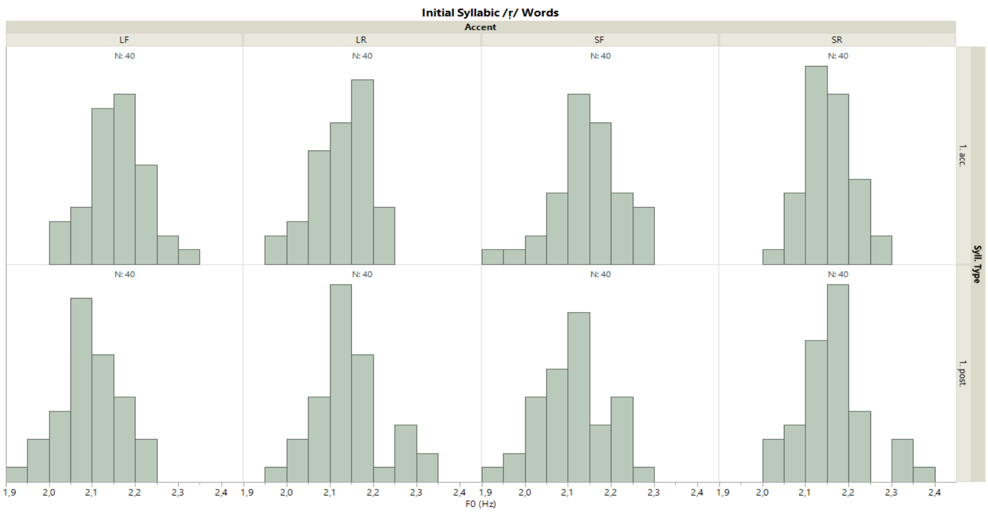

Figure D.25. Distribution histograms of OvMean (log-transformed) in initial syllabic /r̩/ words across the four accents

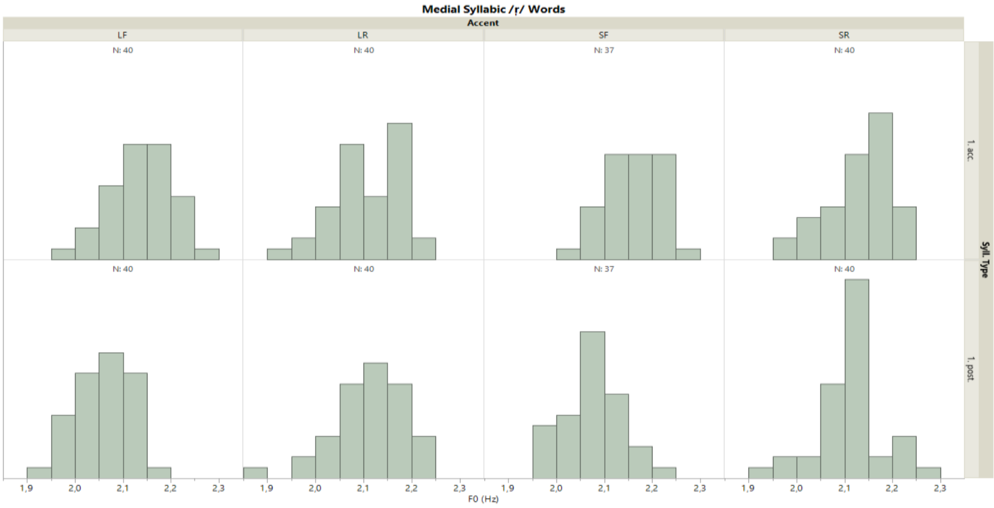

Figure D.26. Distribution histograms of OvMean (log-transformed) in medial syllabic /ṛ/ words across the four accents

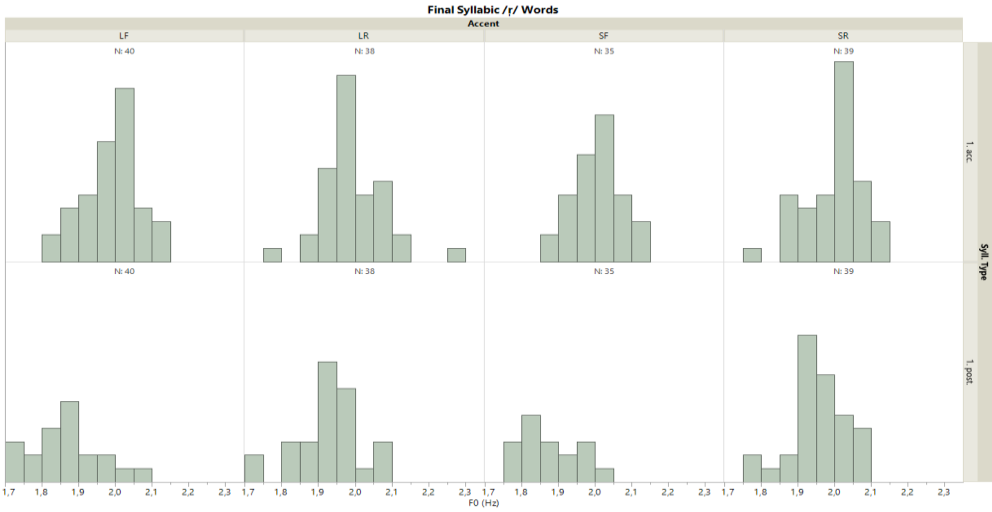

Figure D.27. Distribution histograms of OvMean (log-transformed) in final syllabic /ṛ/ words across the four accents

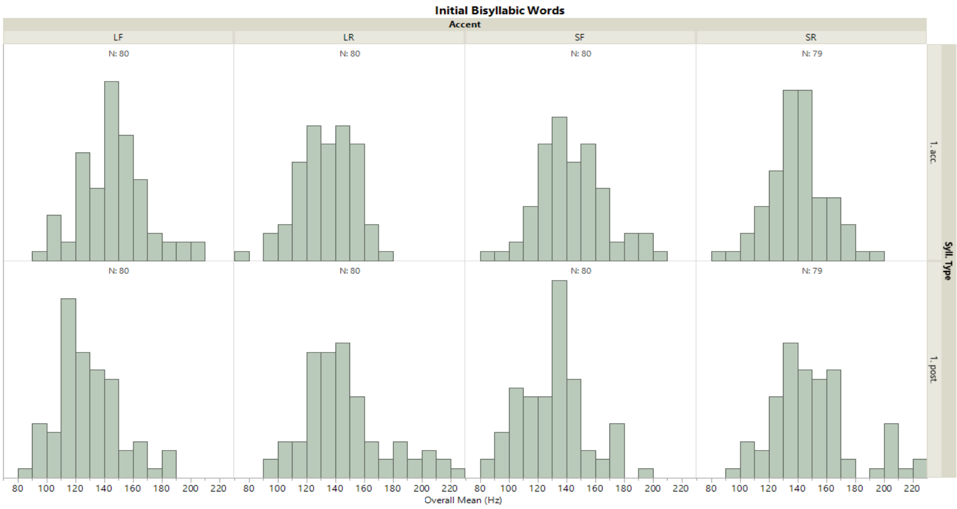

Figure D.28. Distribution histograms of OvMean in initial bisyllabic words across the four accents

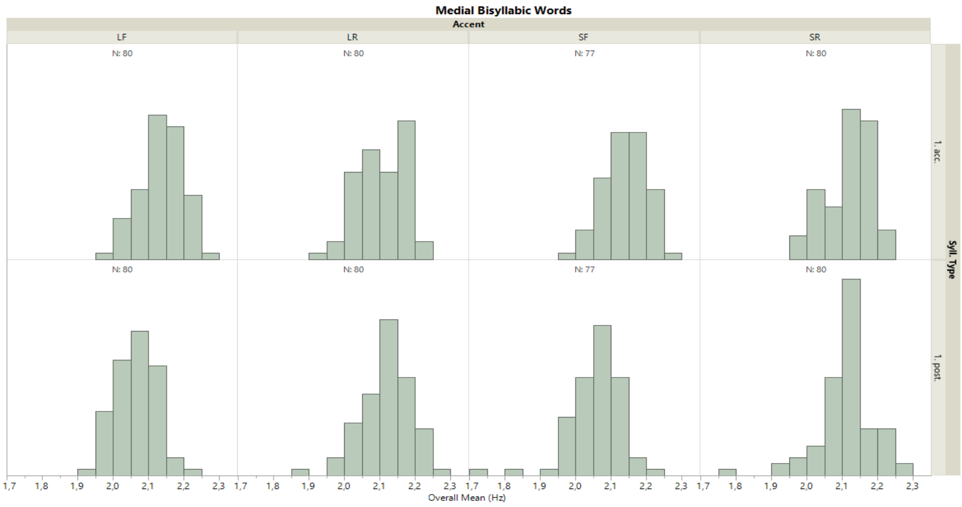

Figure D.29. Distribution histograms of OvMean (log-transformed) in medial bisyllabic words across the four accents

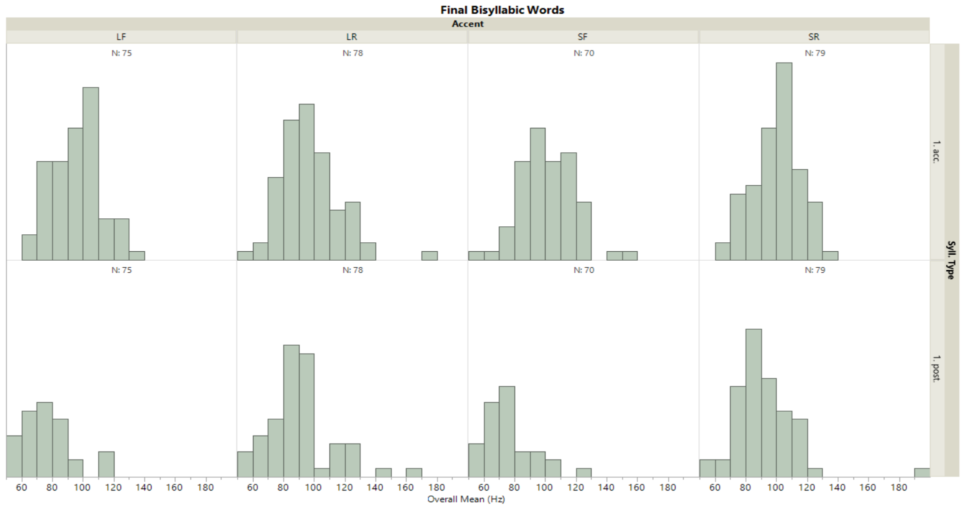

Figure D.30. Distribution histograms of OvMean in final bisyllabic words across the four accents

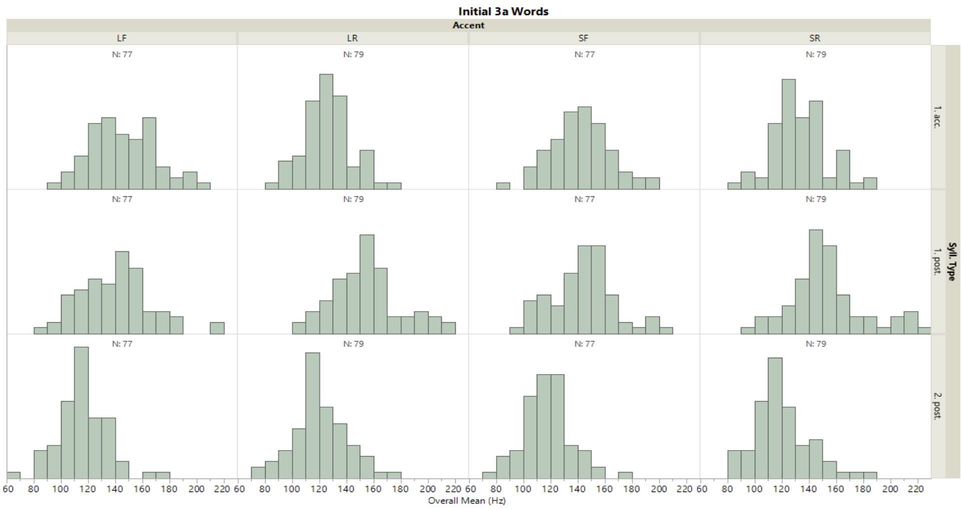

Figure D.31. Distribution histograms of OvMean in initial 3a words across the four accents

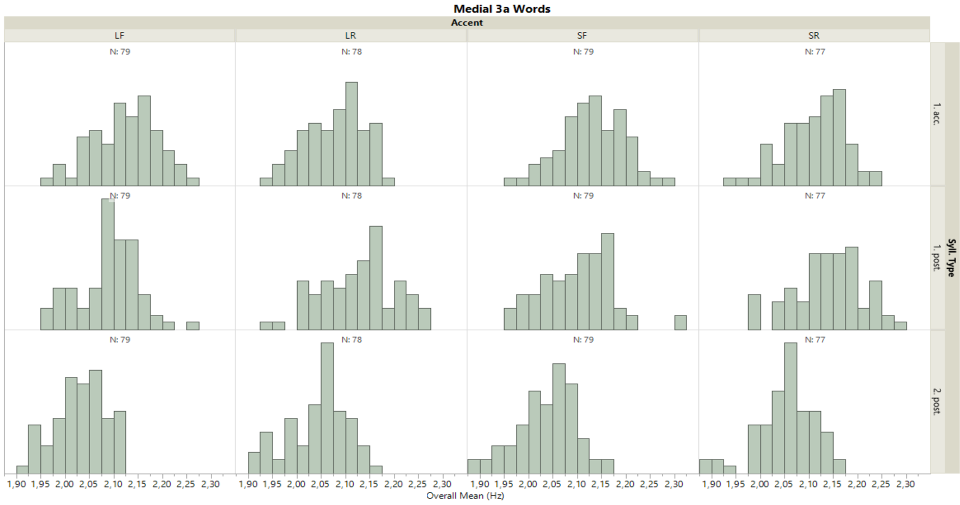

Figure D.32. Distribution histograms of OvMean (log-transformed) in medial 3a words across the four accents

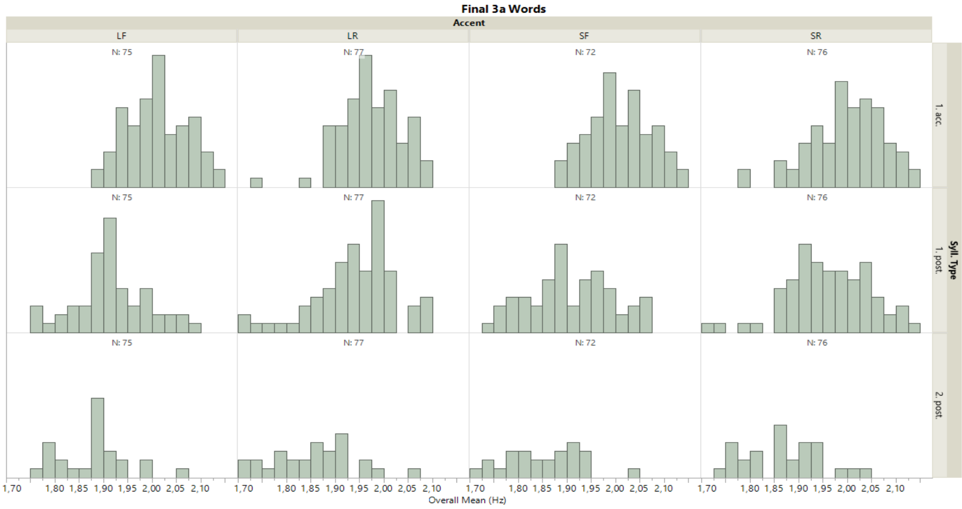

Figure D.33. Distribution histograms of OvMean (log-transformed) in final 3a words across the four accents

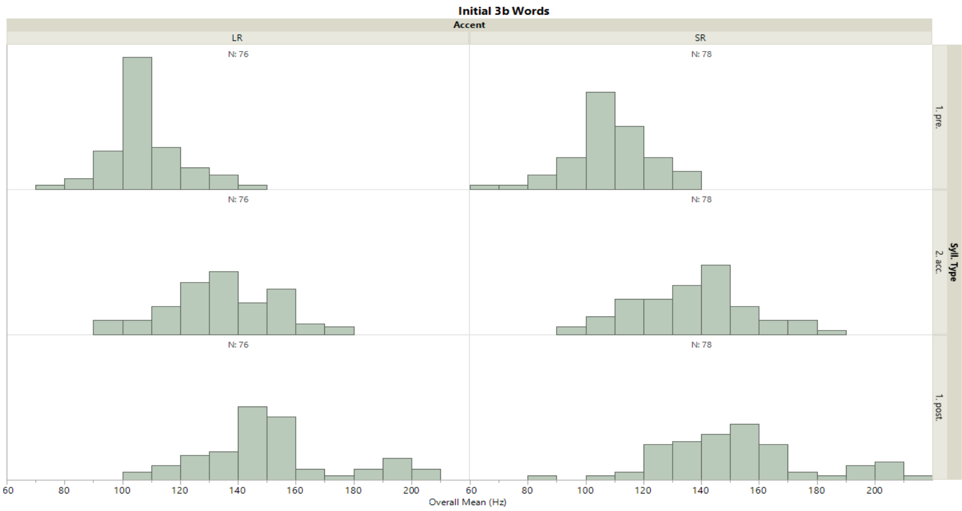

Figure D.34. Distribution histograms of OvMean in initial 3b words across the two rising accents

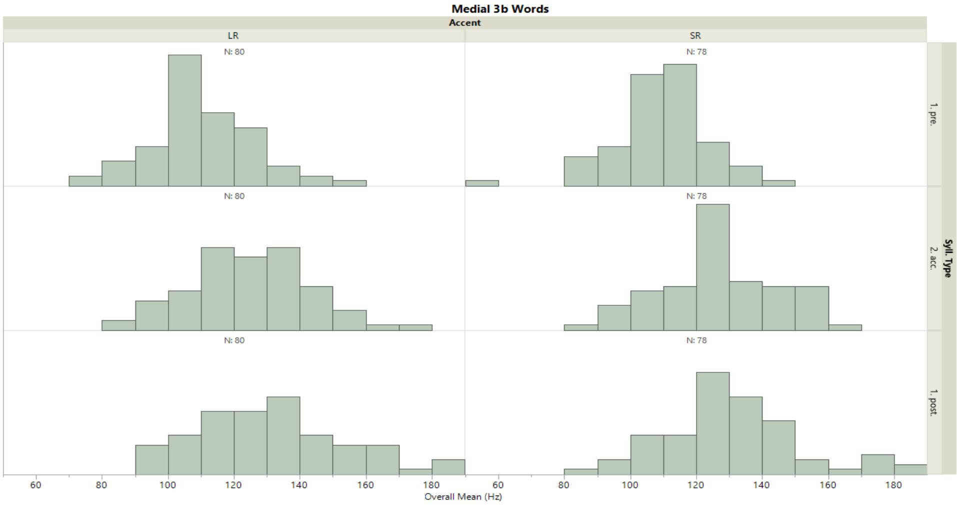

Figure D.35. Distribution histograms of OvMean in medial 3b words across the two rising accents

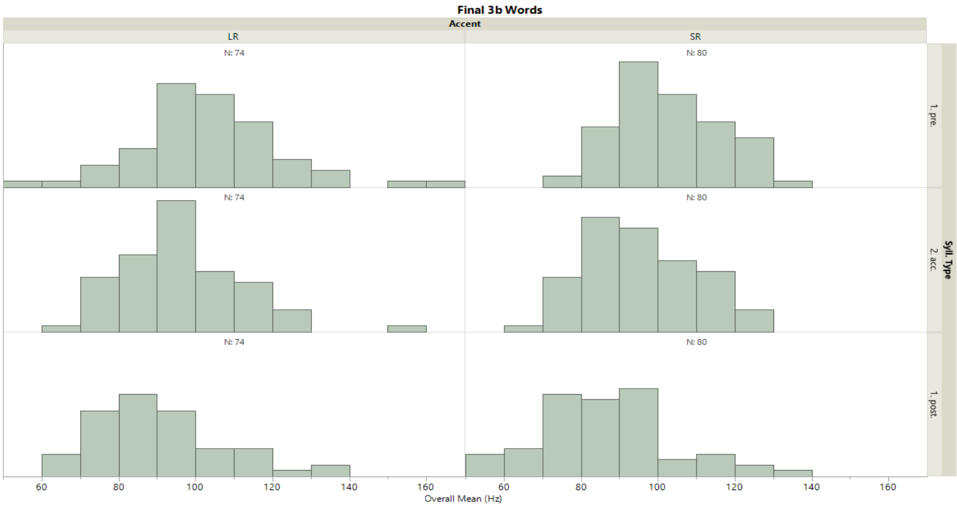

Figure D.36. Distribution histograms of OvMean in final 3b words across the two rising accents

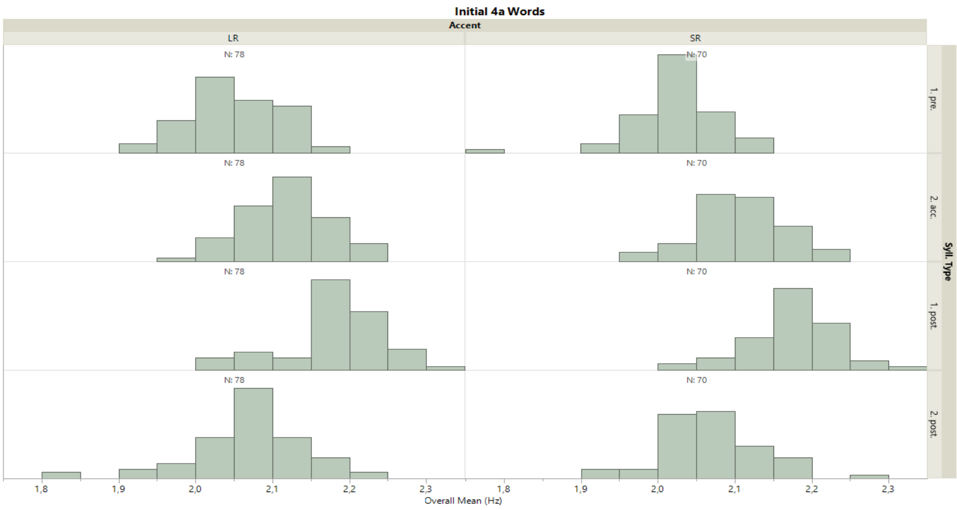

Figure D.37. Distribution histograms of OvMean (log-transformed) in initial 4a words across the two rising accents

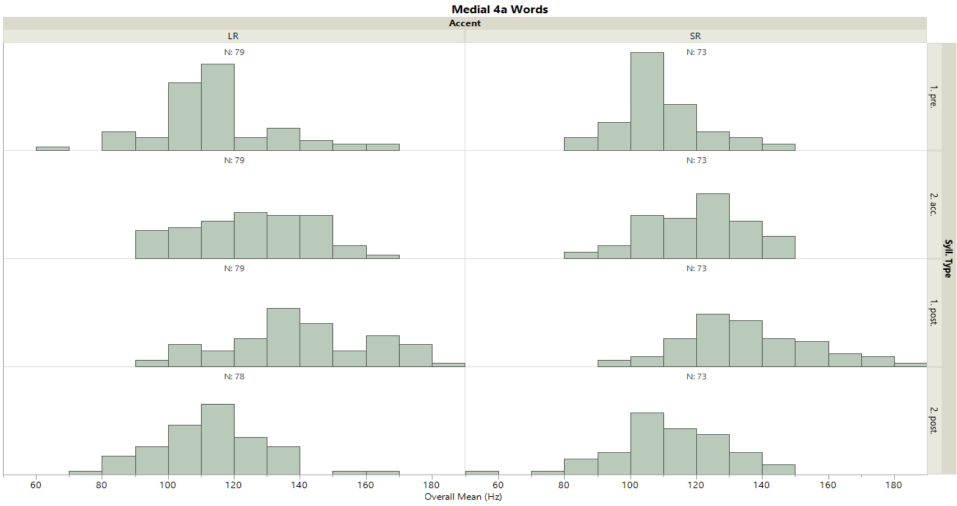

Figure D.38. Distribution histograms of OvMean in medial 4a words across the two rising accents

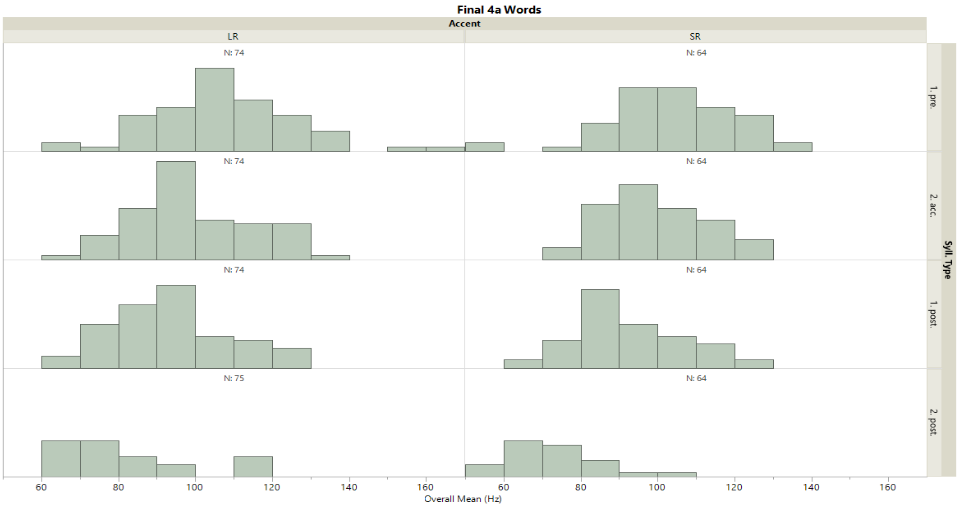

Figure D.39. Distribution histograms of OvMean in final 4a words across the two rising accents

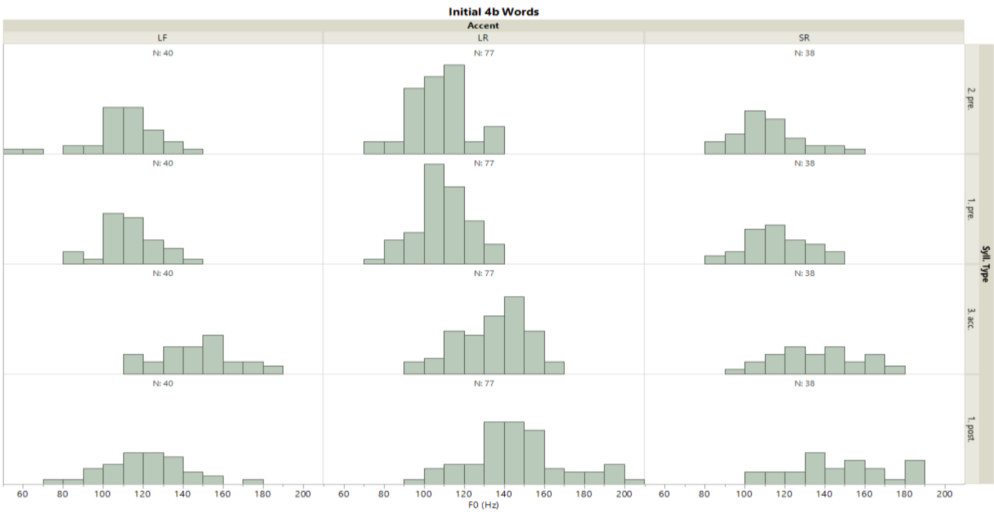

Figure D.40. Distribution histograms of OvMean in initial 4b words across the two rising accents and LF

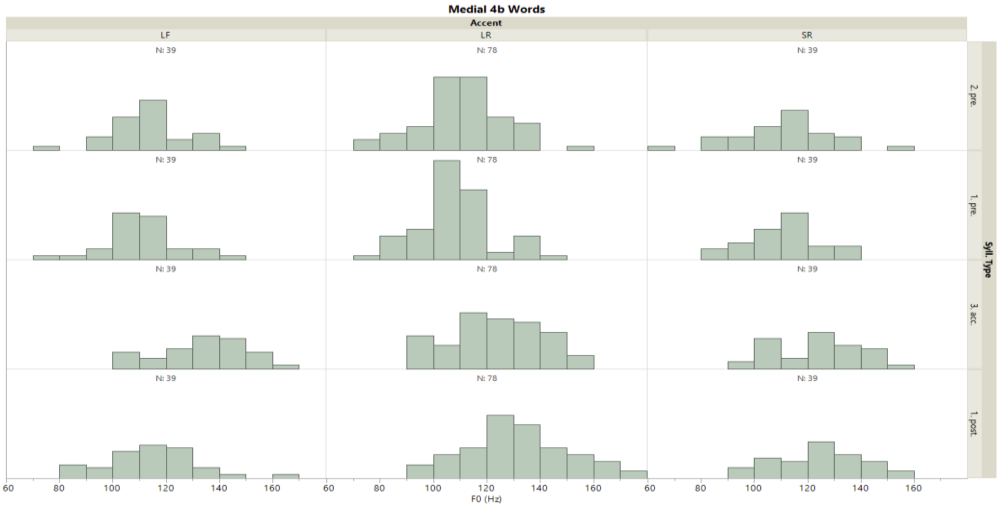

Figure D.41. Distribution histograms of OvMean in medial 4b words across the two rising accents and LF

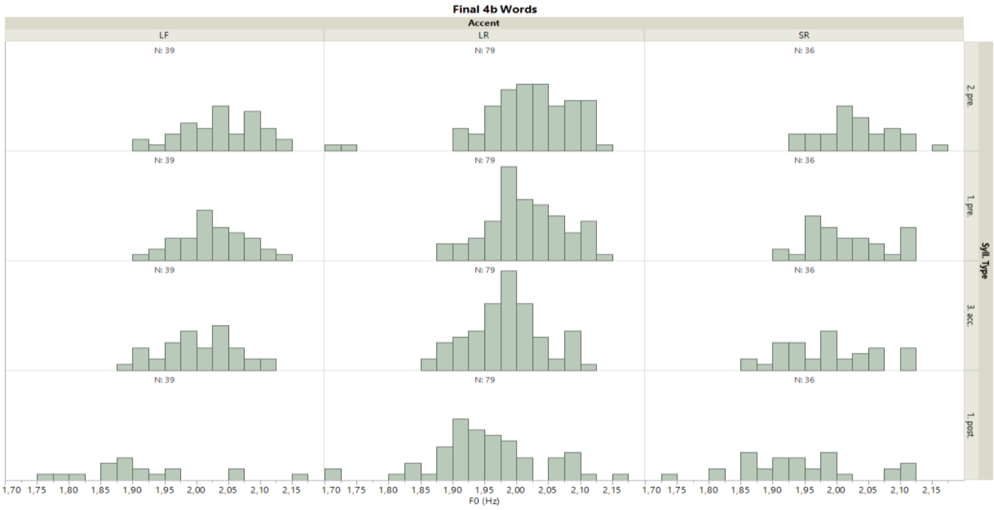

Figure D.42. Distribution histograms of OvMean (log-transformed) in final 4b words across the two rising accents and LF

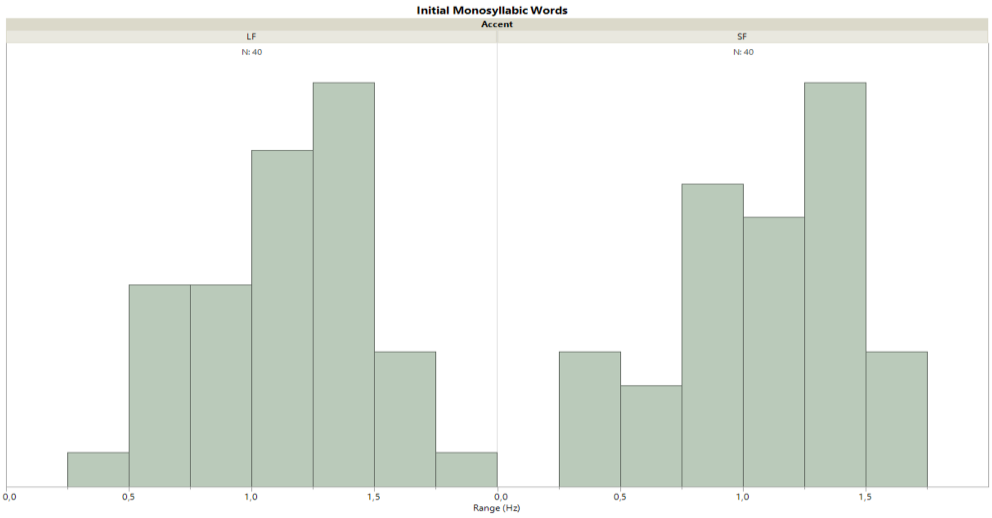

Figure D.43. Distribution histograms of Range (log-transformed) in initial monosyllabic words across the two falling accents

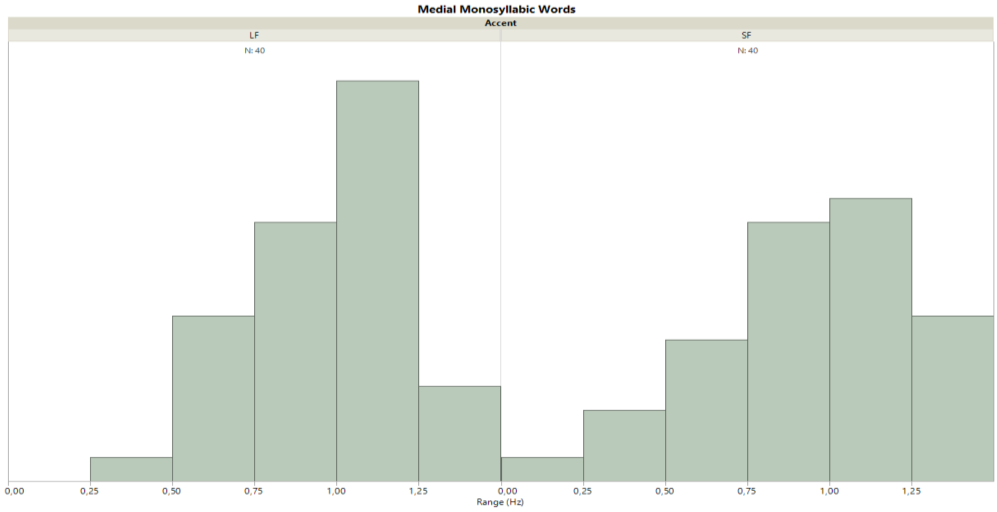

Figure D.44. Distribution histograms of Range (log-transformed) in medial monosyllabic words across the two falling accents

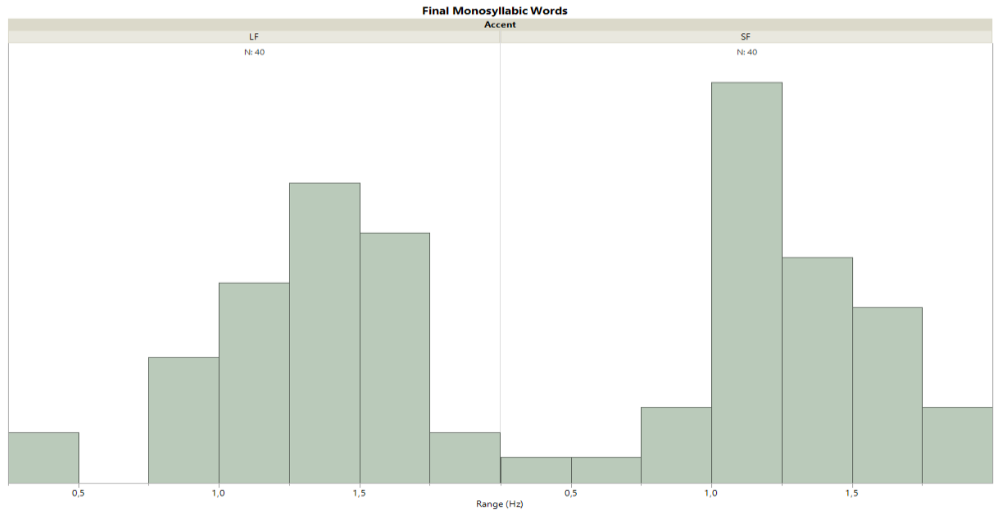

Figure D.45. Distribution histograms of Range (log-transformed) in final monosyllabic words across the two falling accents

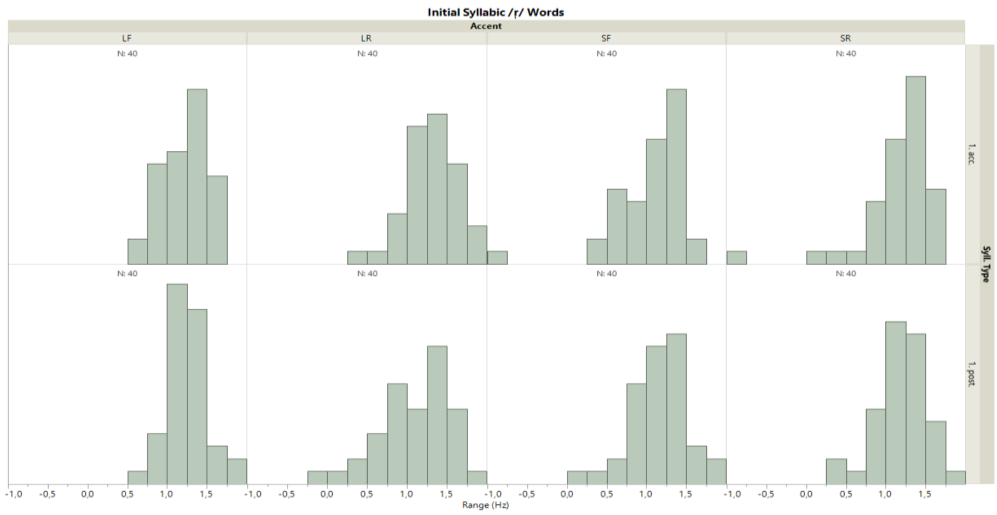

Figure D.46. Distribution histograms of Range (log-transformed) in initial syllabic /r̥/ words across the four accents

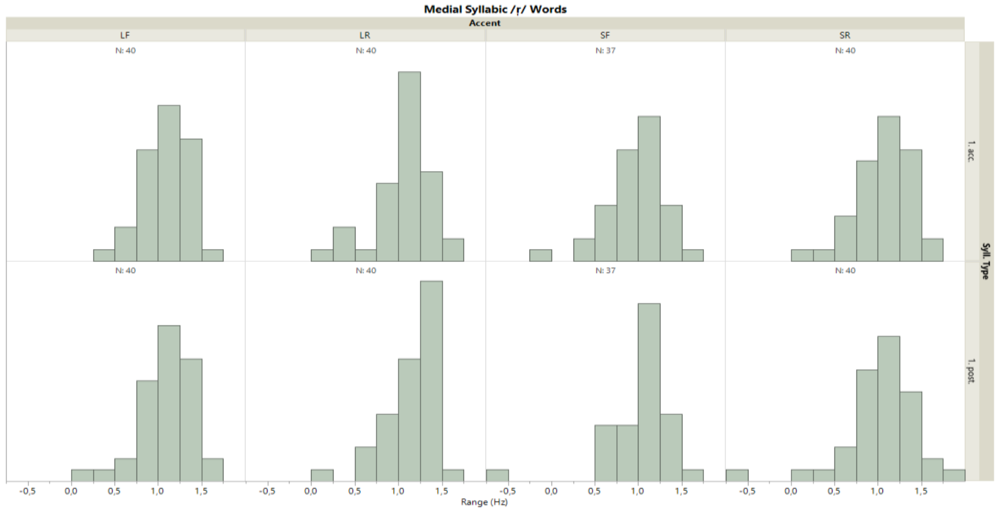

Figure D.47. Distribution histograms of Range (log-transformed) in medial syllabic /ṛ/ words across the four accents

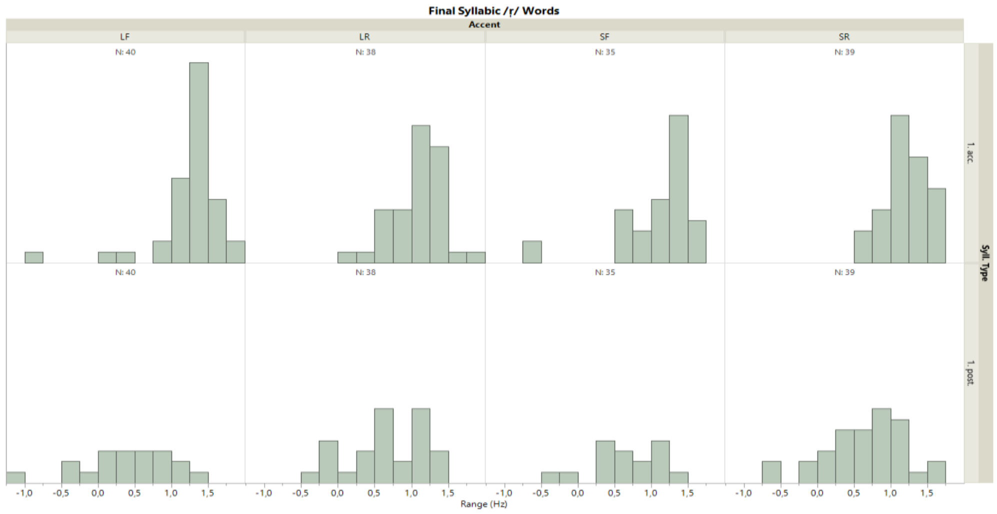

Figure D.48. Distribution histograms of Range (log-transformed) in final syllabic /ṛ/ words across the four accents

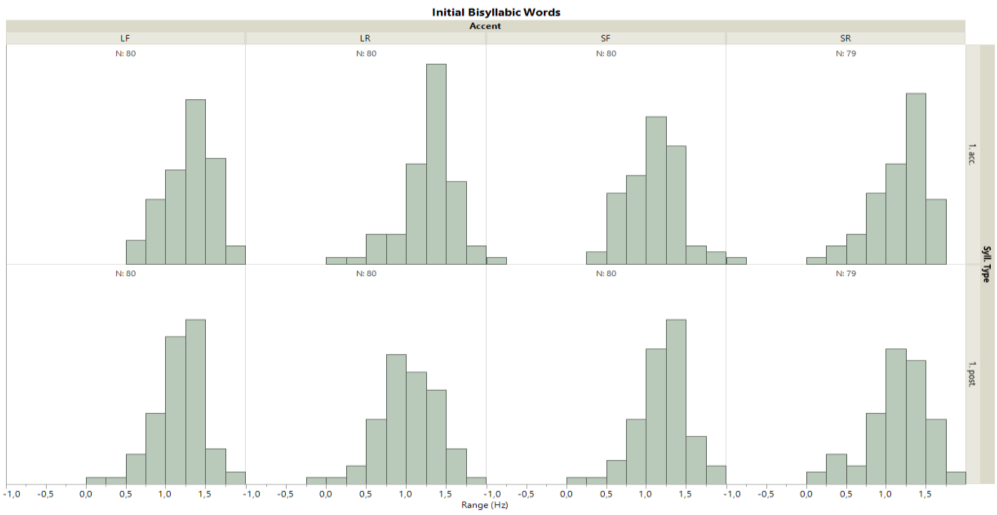

Figure D.49. Distribution histograms of Range (log-transformed) in initial bisyllabic words across the four accents

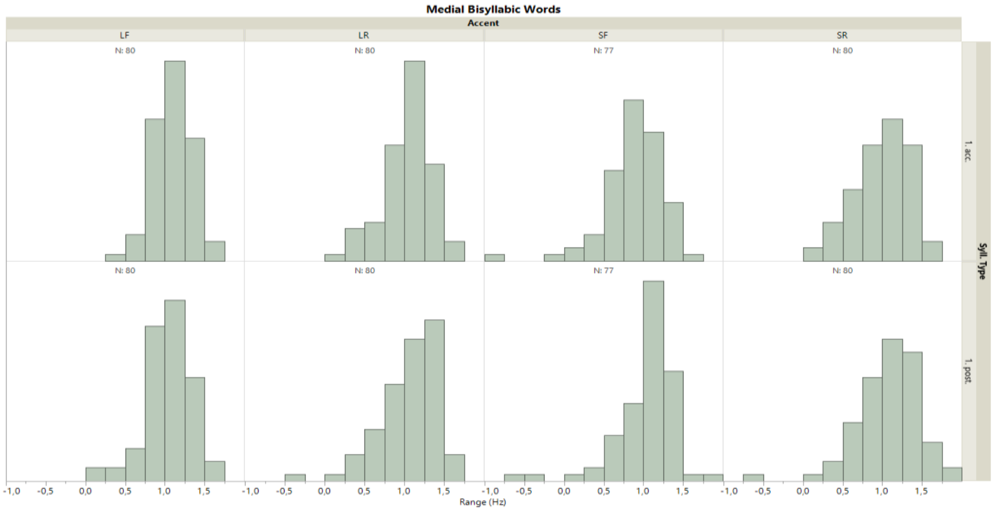

Figure D.50. Distribution histograms of Range (log-transformed) in medial bisyllabic words across the four accents

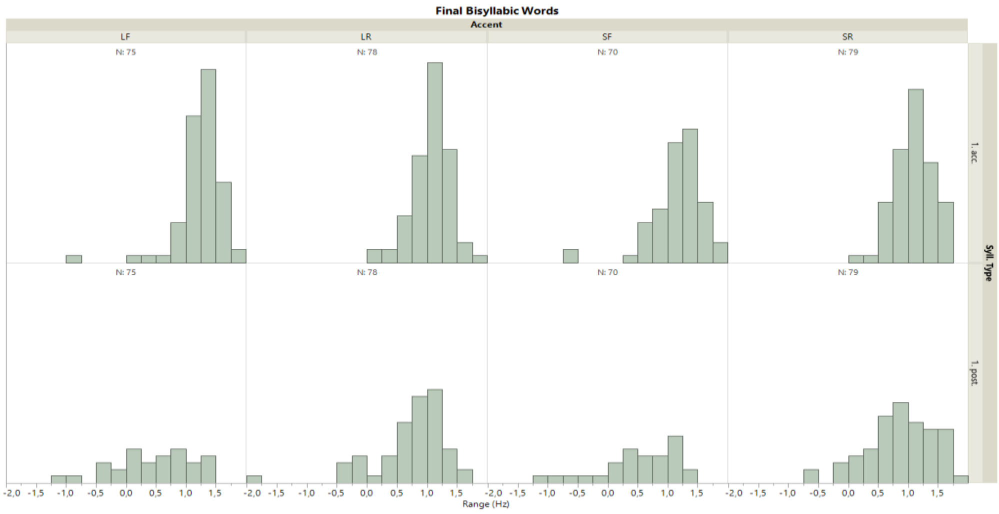

Figure D.51. Distribution histograms of Range (log-transformed) in final bisyllabic words across the four accents

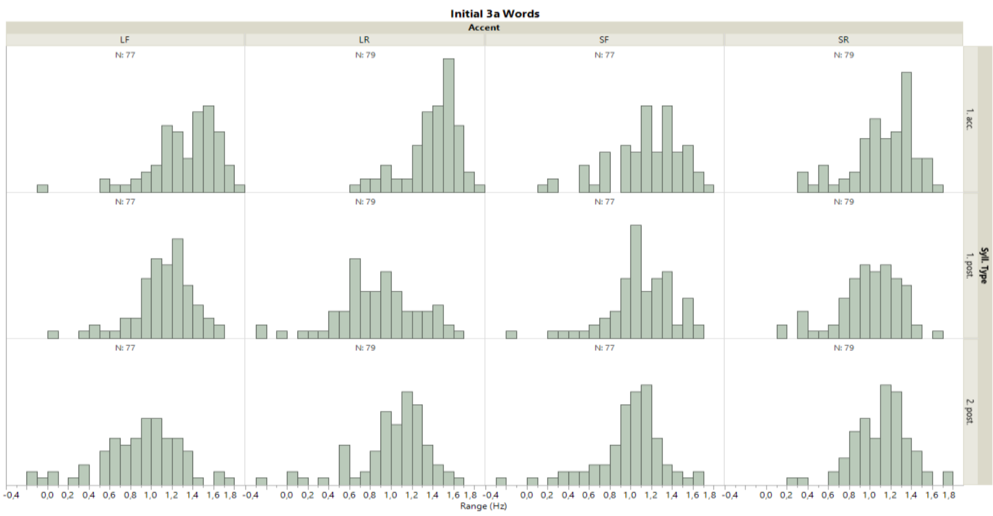

Figure D.52. Distribution histograms of Range (log-transformed) in initial 3a words across the four accents

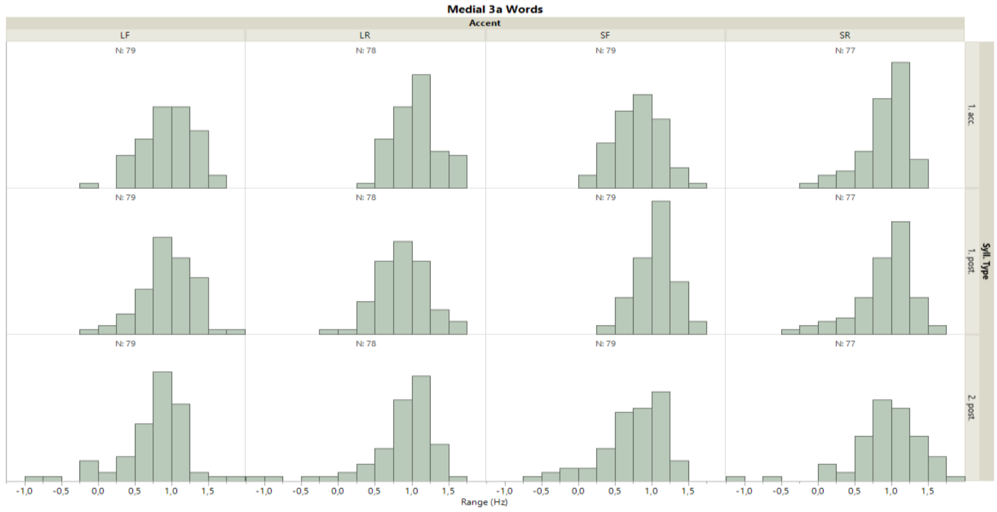

Figure D.53. Distribution histograms of Range (log-transformed) in medial 3a words across the four accents

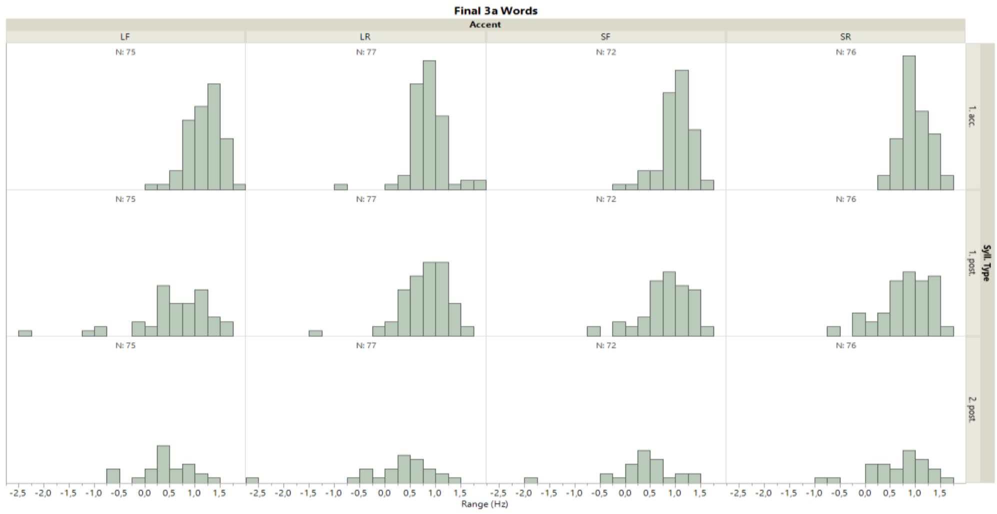

Figure D.54. Distribution histograms of Range (log-transformed) in final 3a words across the four accents

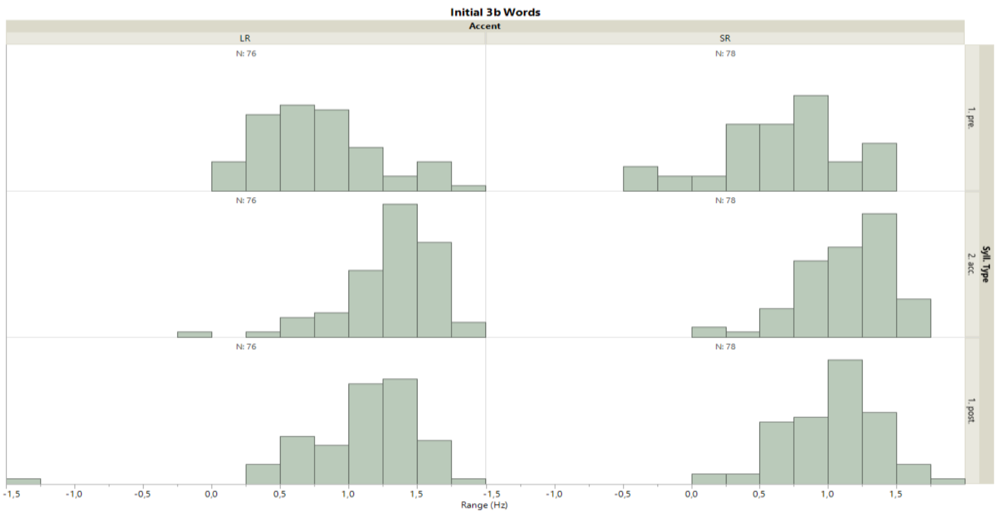

Figure D.55. Distribution histograms of Range (log-transformed) in initial 3b words across the two rising accents

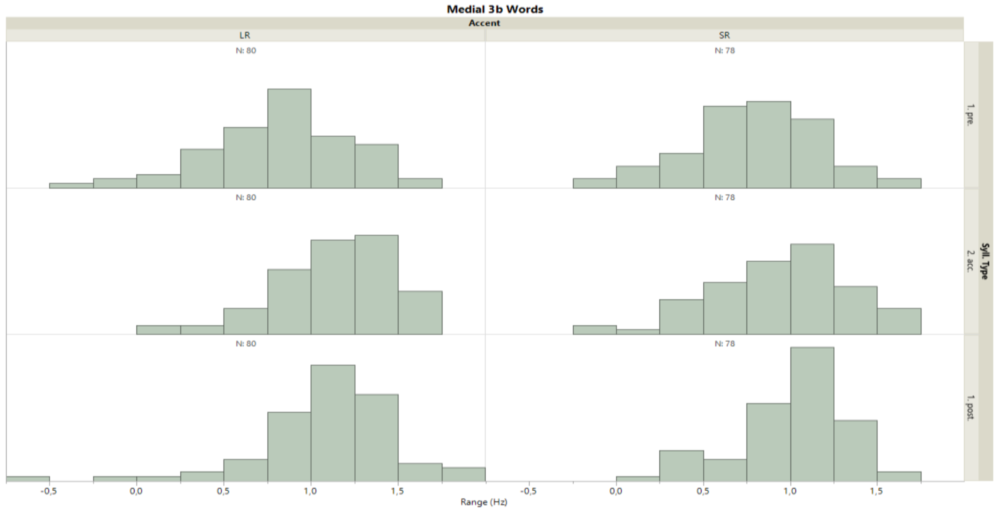

Figure D.56. Distribution histograms of Range (log-transformed) in medial 3b words across the two rising accents

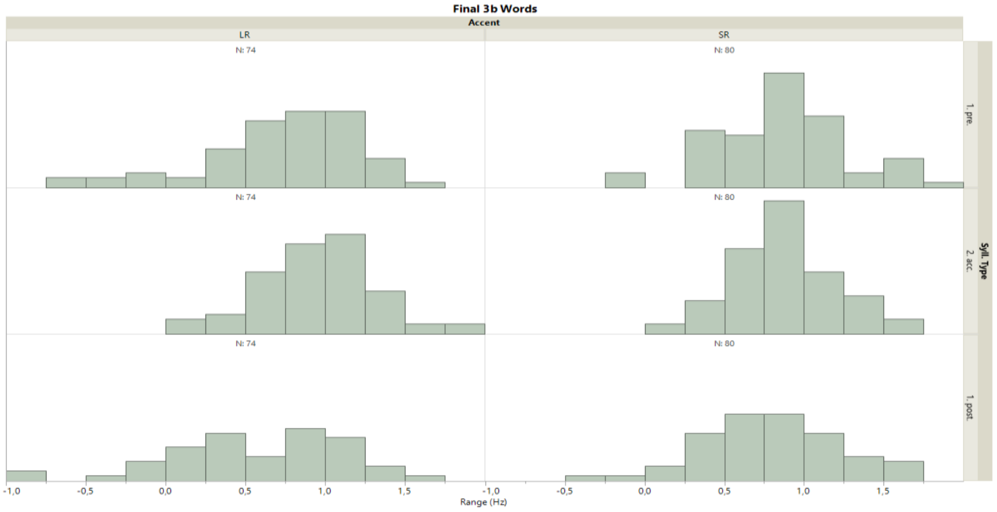

Figure D.57. Distribution histograms of Range (log-transformed) in final 3b words across the two rising accents

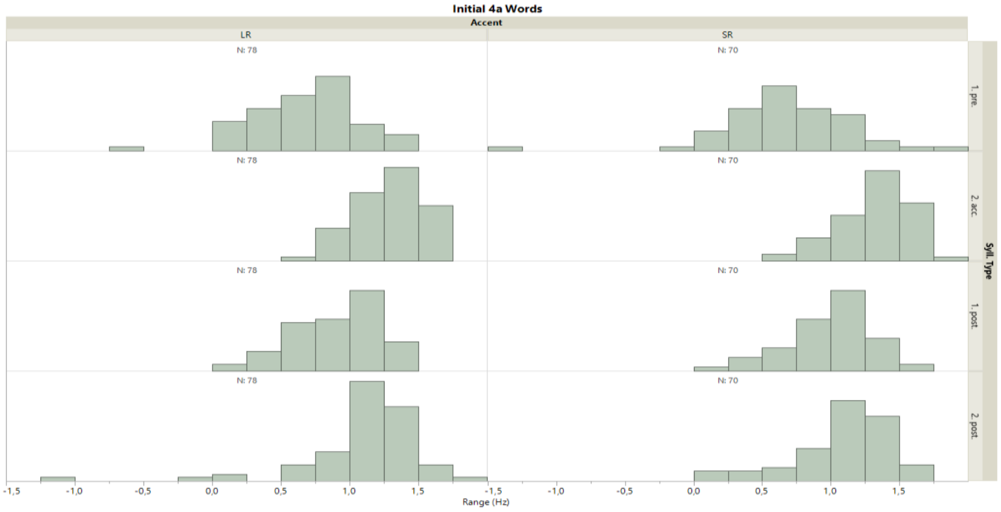

Figure D.58. Distribution histograms of Range (log-transformed) in initial 4a words across the two rising accents

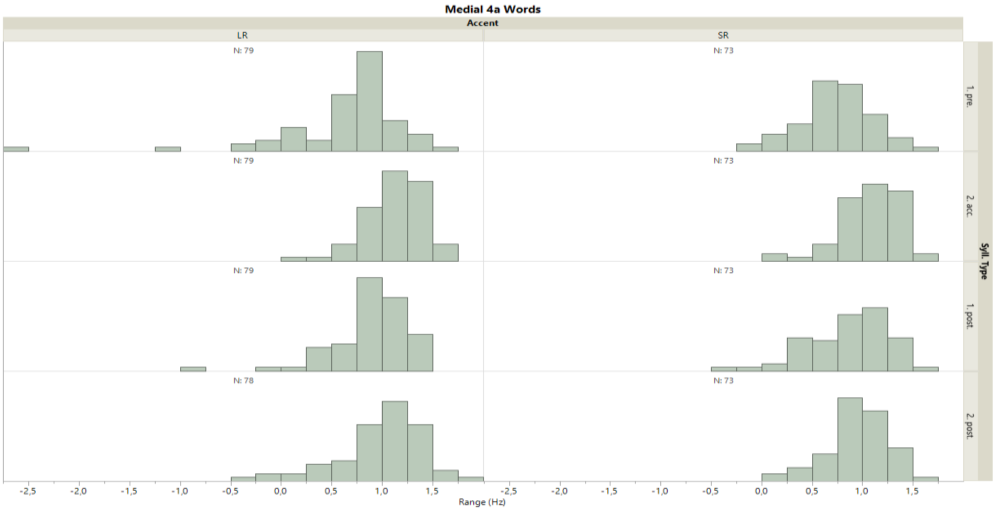

Figure D.59. Distribution histograms of Range (log-transformed) in medial 4a words across the two rising accents

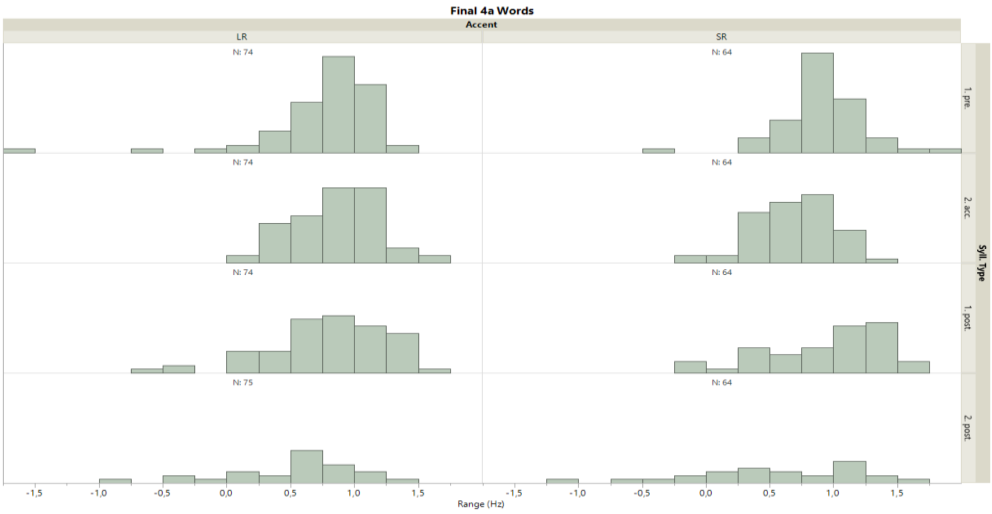

Figure D.60. Distribution histograms of Range (log-transformed) in final 4a words across the two rising accents

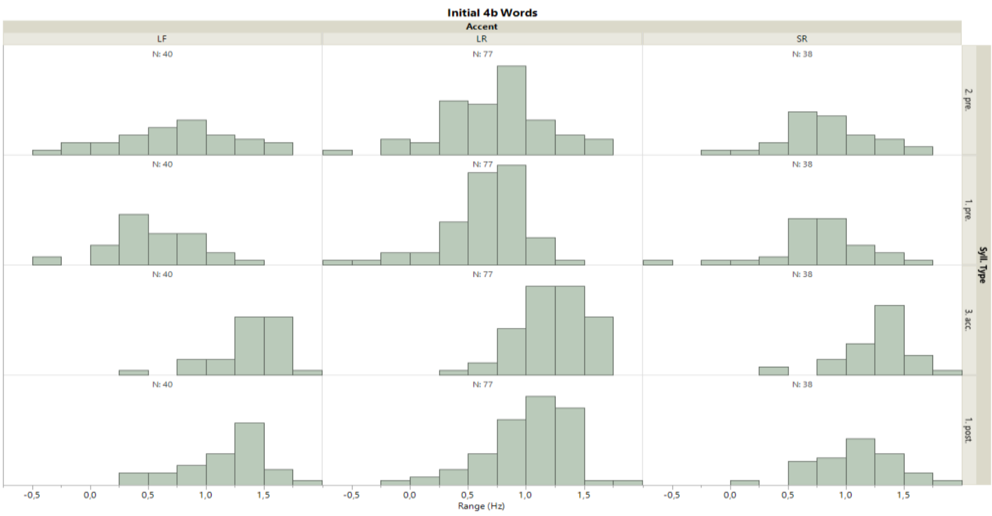

Figure D.61. Distribution histograms of Range (log-transformed) in initial 4b words across the two rising accents and LF

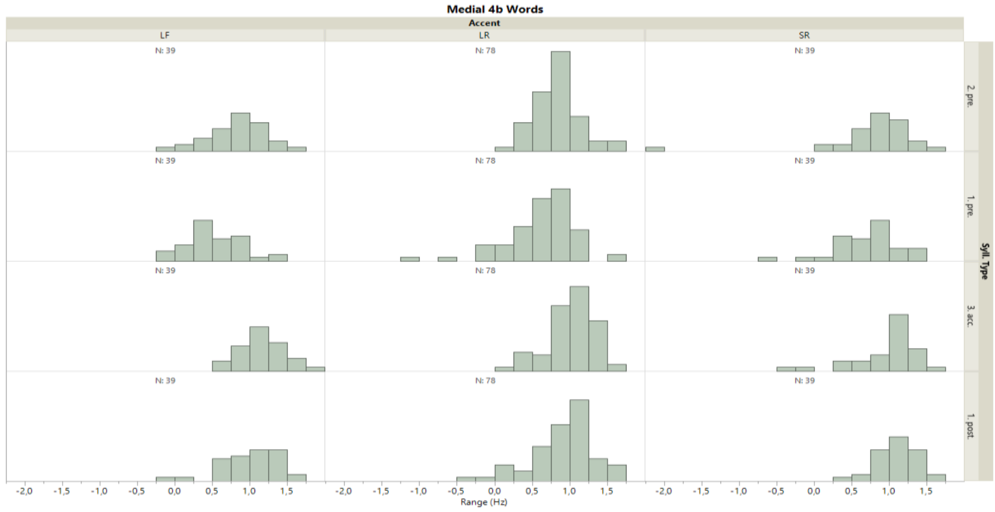

Figure D.62. Distribution histograms of Range (log-transformed) in medial 4b words across the two rising accents and LF

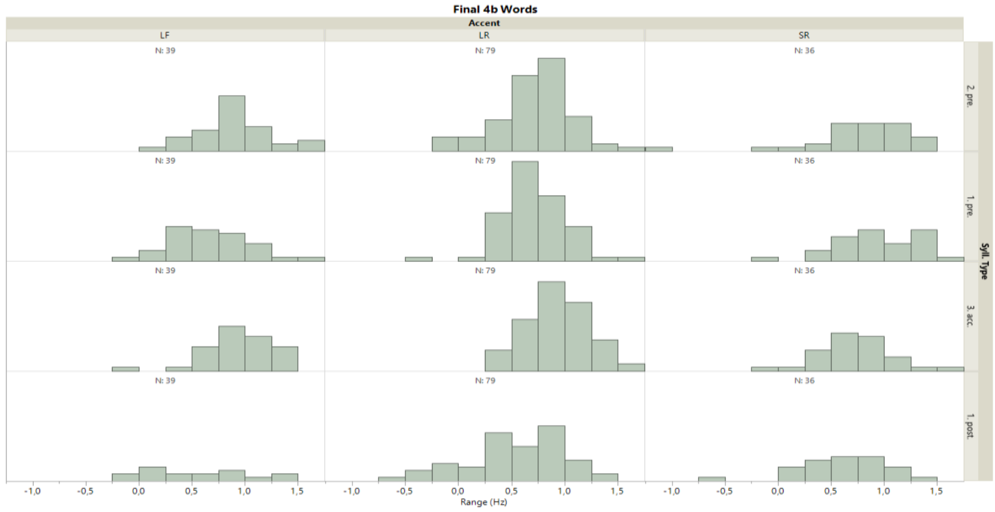

Figure D.63. Distribution histograms of Range (log-transformed) in final 4b words across the two rising accents and LF

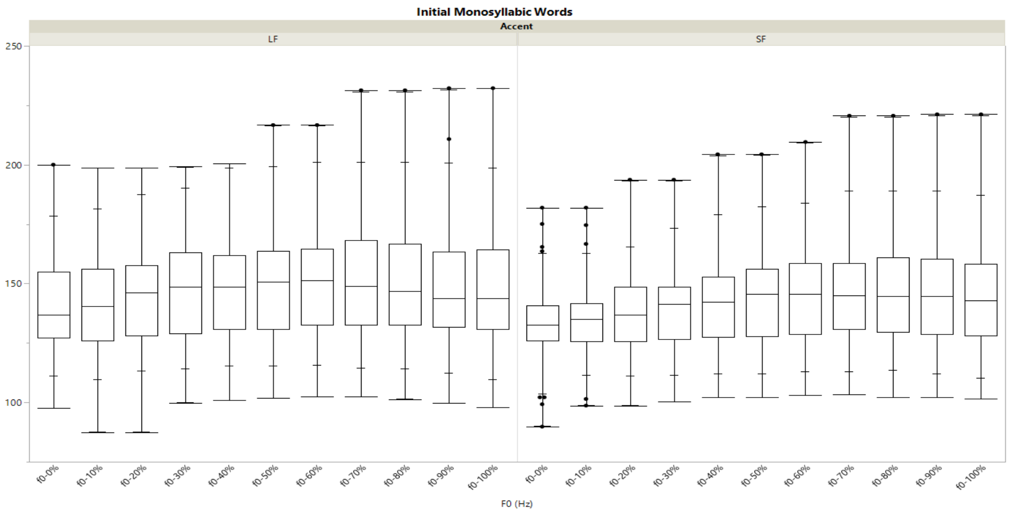

Figure D.64. Quantile boxplots of all F_0 measurement points in initial monosyllabic words across the two falling accents

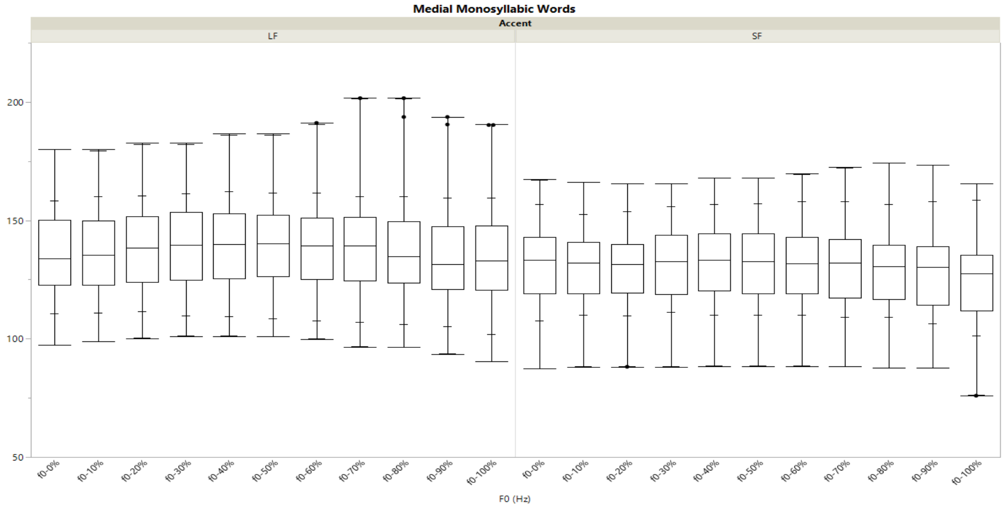

Figure D.65. Quantile boxplots of all F_0 measurement points in medial monosyllabic words across the two falling accents

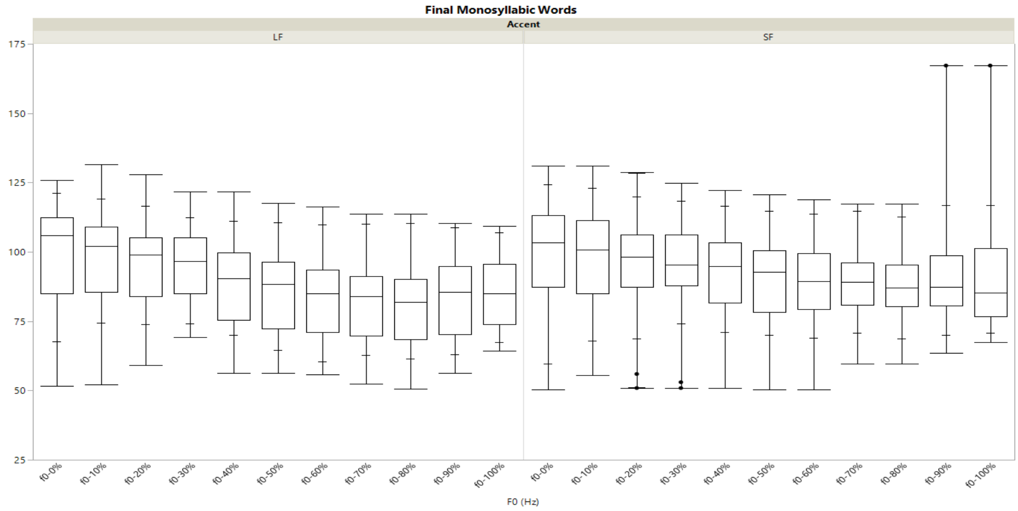

Figure D.66. Quantile boxplots of all F_0 measurement points in final monosyllabic words across the two falling accents

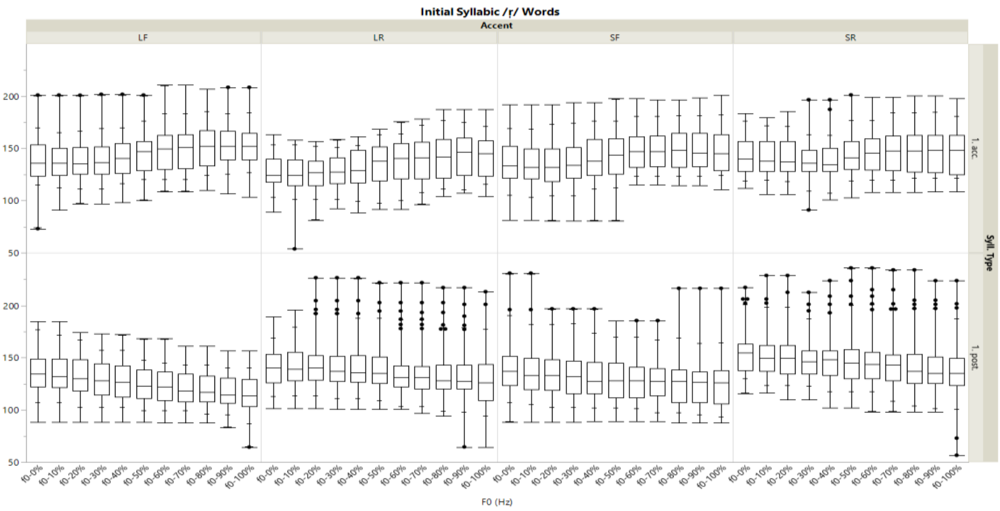

Figure D.67. Quantile boxplots of all F_0 measurement points in initial syllabic /r̥/ words across the four accents

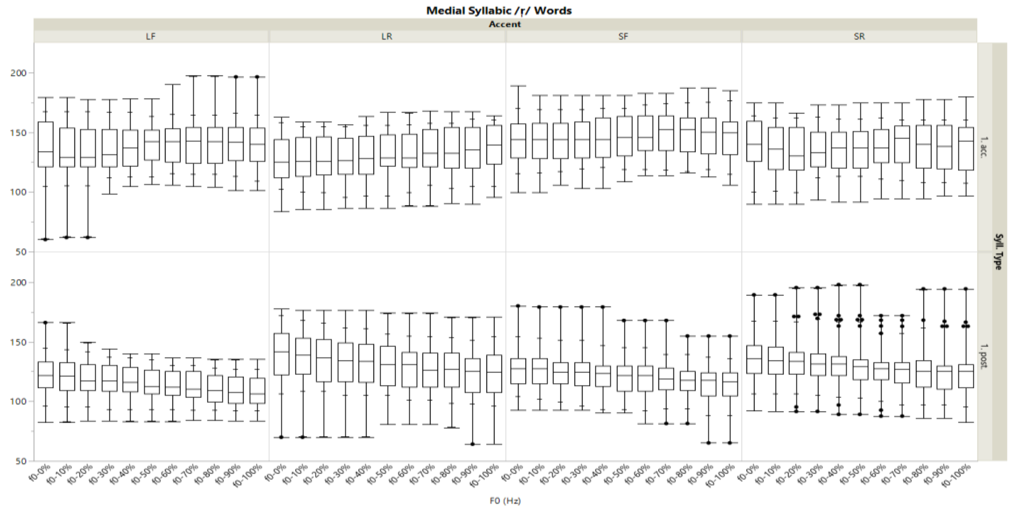

Figure D.68. Quantile boxplots of all F_0 measurement points in medial syllabic /ɽ̩/ words across the four accents

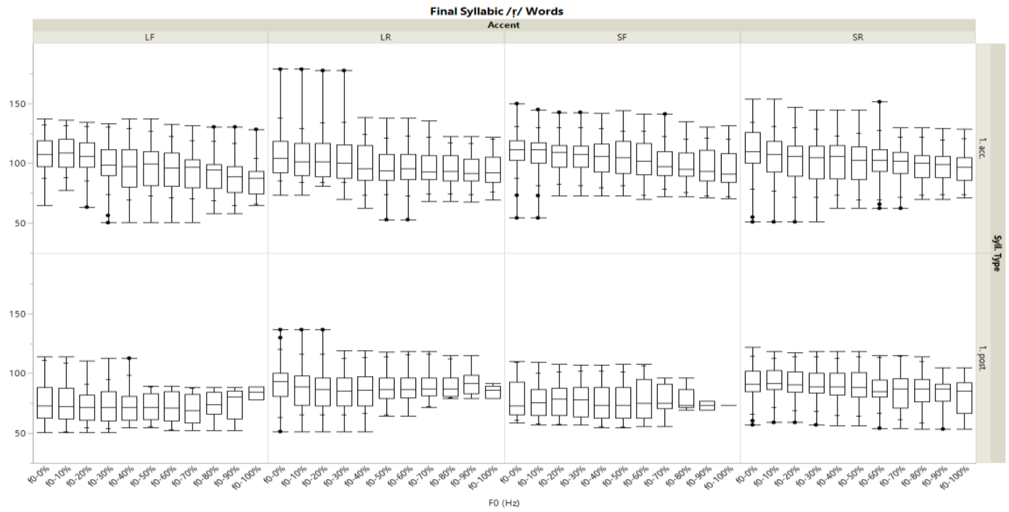

Figure D.69. Quantile boxplots of all F_0 measurement points in final syllabic /ɽ̩/ words across the four accents

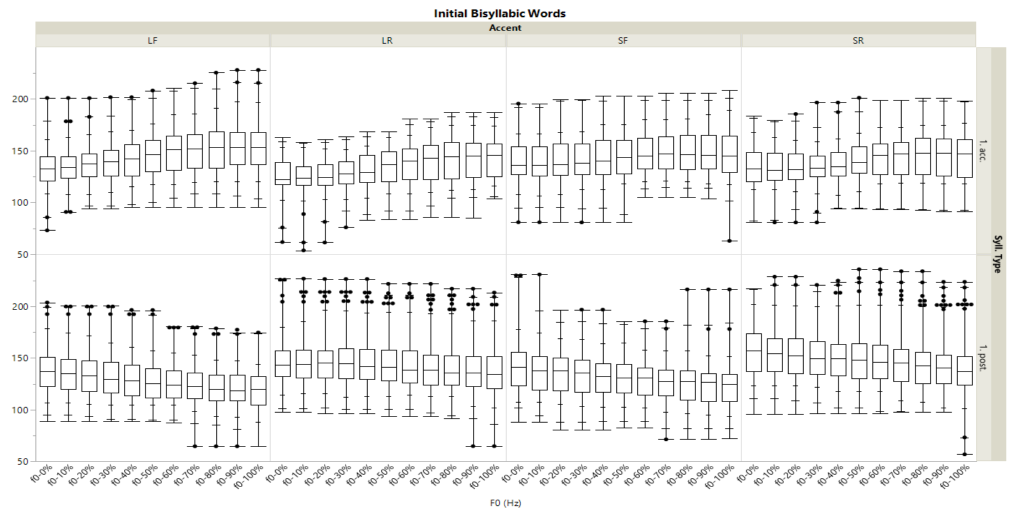

Figure D.70. Quantile boxplots of all F_0 measurement points in initial bisyllabic words across the four accents

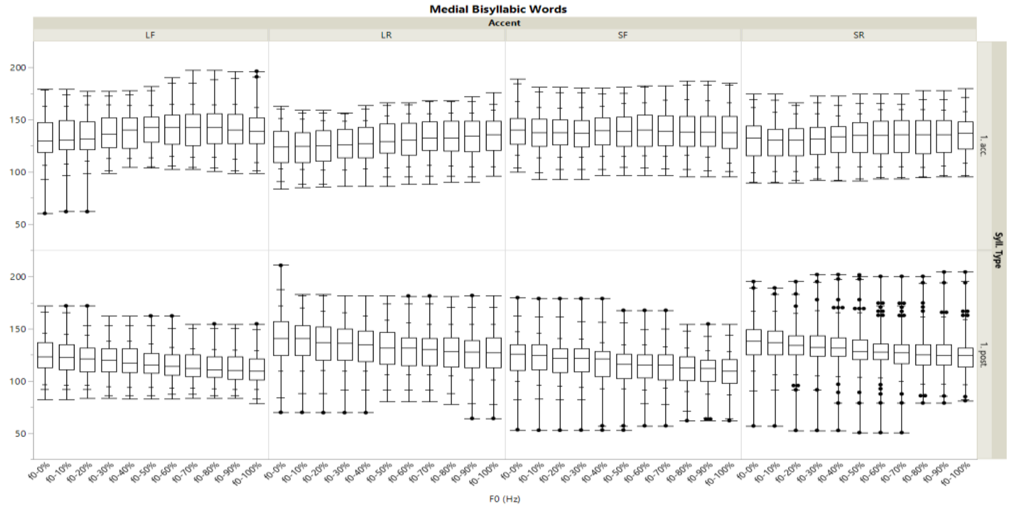

Figure D.71. Quantile boxplots of all F_0 measurement points in medial bisyllabic words across the four accents

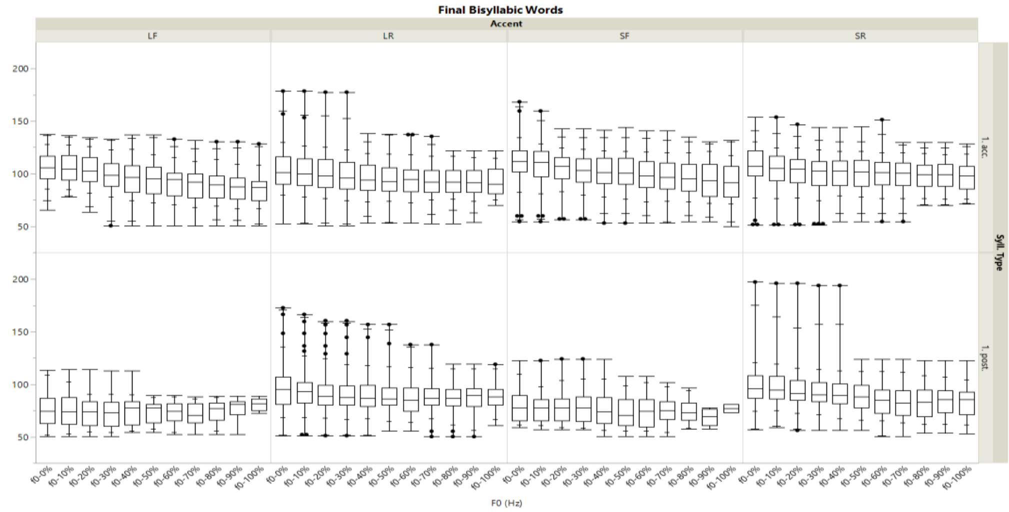

Figure D.72. Quantile boxplots of all F_0 measurement points in final bisyllabic words across the four accents

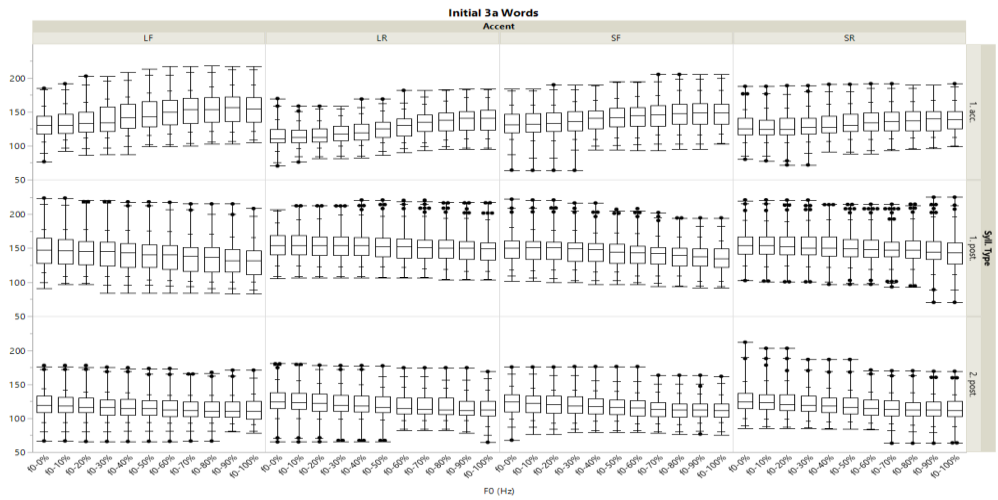

Figure D.73. Quantile boxplots of all F_0 measurement points in initial 3a words across the four accents

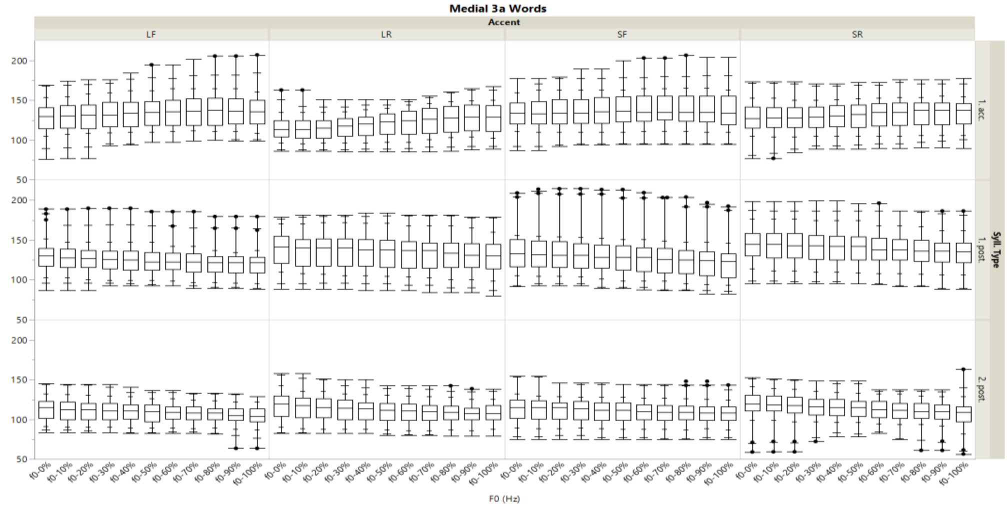

Figure D.74. Quantile boxplots of all F_0 measurement points in medial 3a words across the four accents

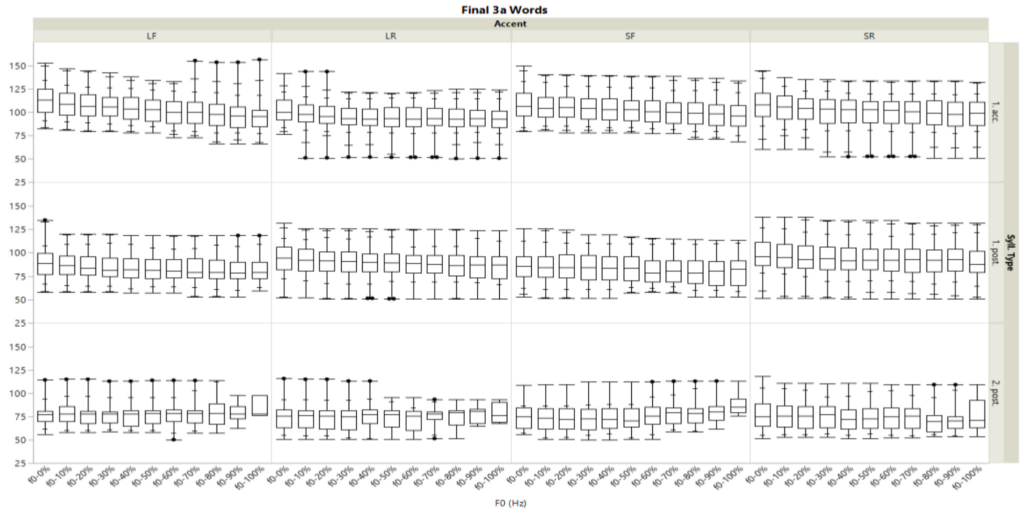

Figure D.75. Quantile boxplots of all F_0 measurement points in final 3a words across the four accents

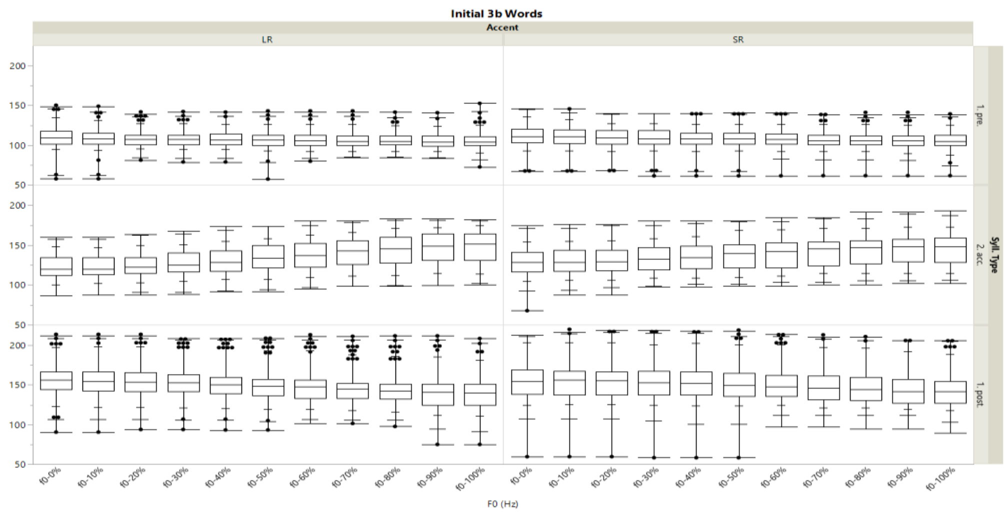

Figure D.76. Quantile boxplots of all F_0 measurement points in initial 3b words across the two rising accents

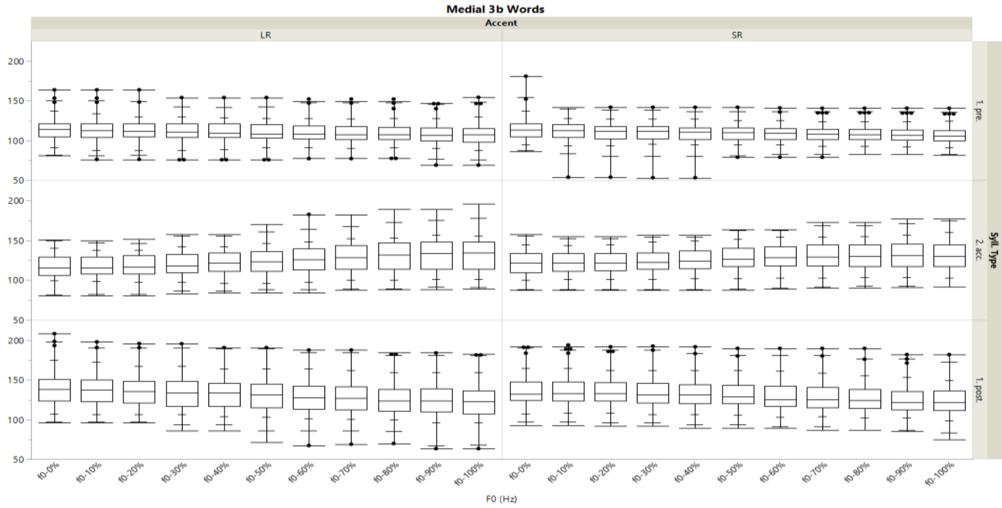

Figure D.77. Quantile boxplots of all F_0 measurement points in medial 3b words across the two rising accents

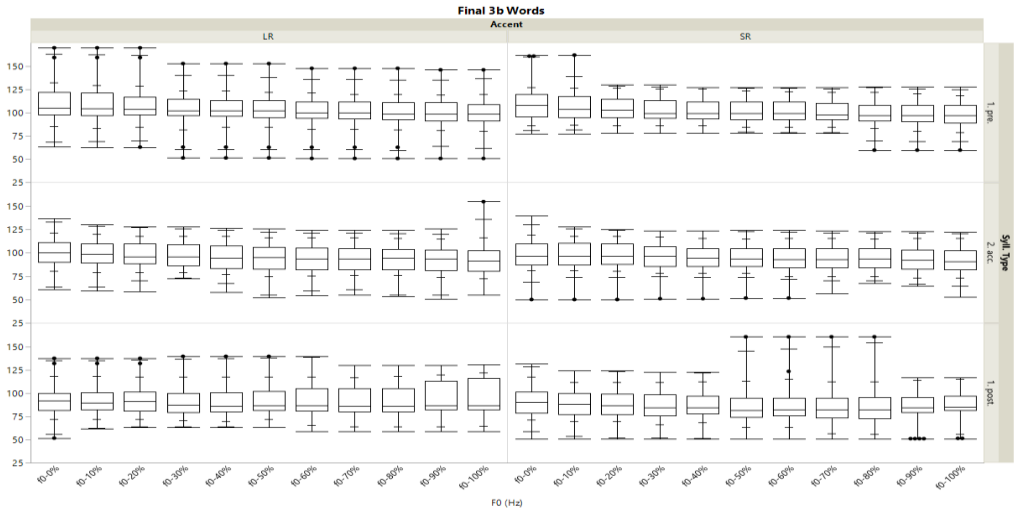

Figure D.78. Quantile boxplots of all F_0 measurement points in final 3b words across the two rising accents

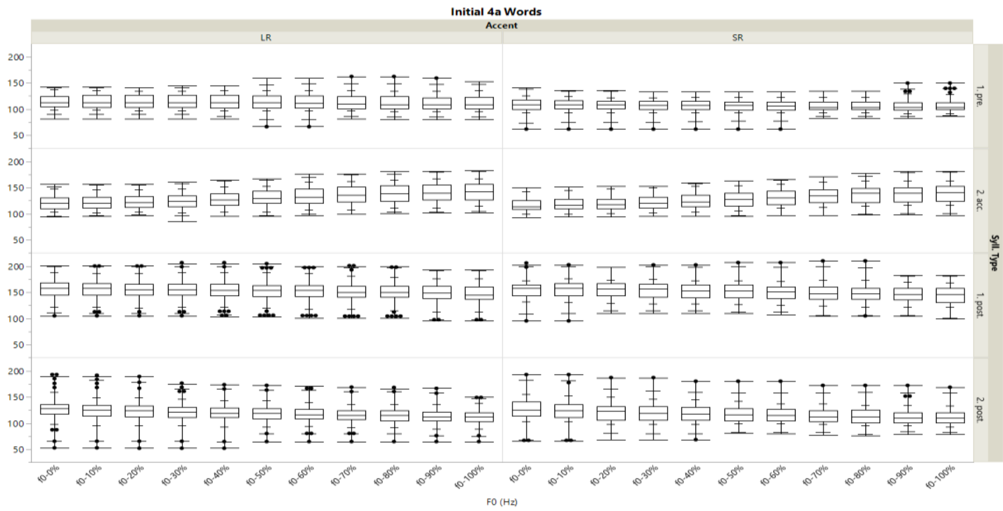

Figure D.79. Quantile boxplots of all F_0 measurement points in initial 4a words across the two rising accents

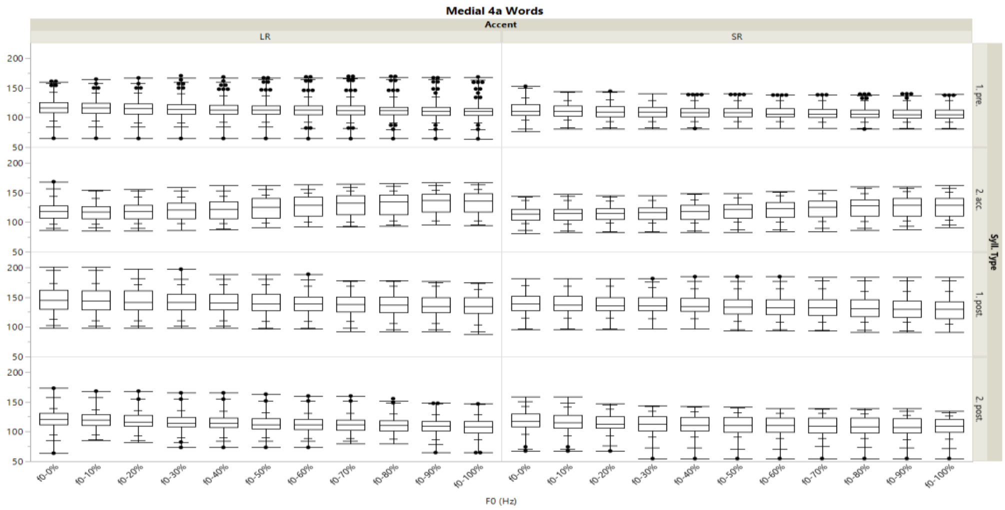

Figure D.80. Quantile boxplots of all F_0 measurement points in medial 4a words across the two rising accents

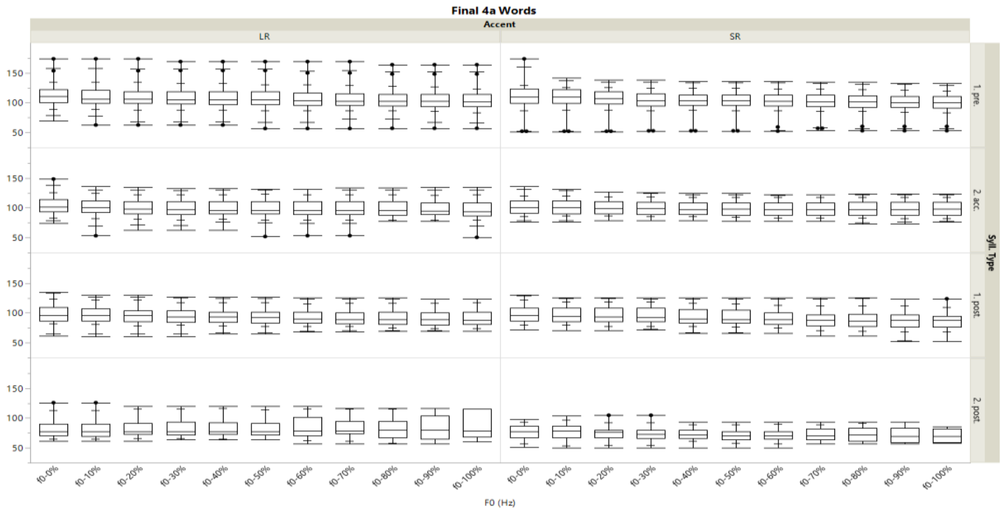

Figure D.81. Quantile boxplots of all F_0 measurement points in final 4a words across the two rising accents

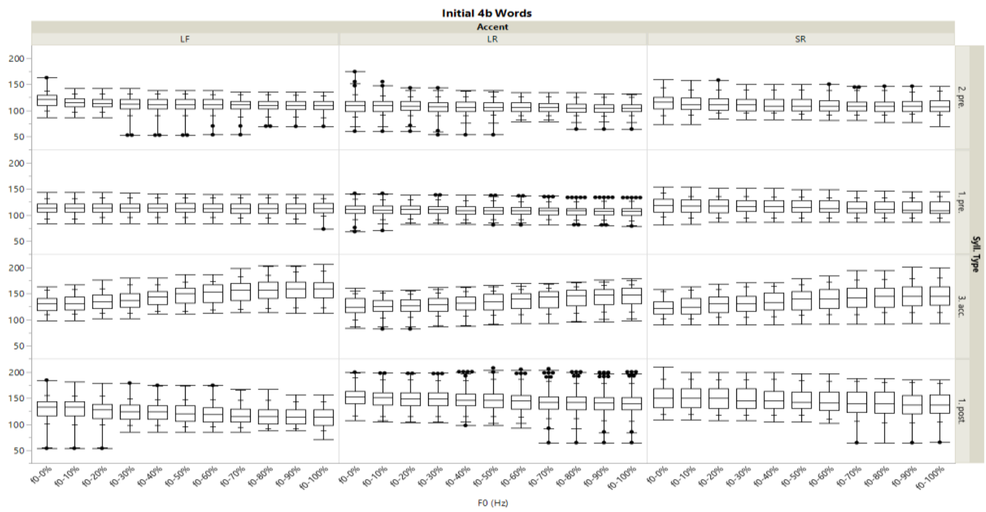

Figure D.82. Quantile boxplots of all F_0 measurement points in initial 4b words across the two rising accents and LF

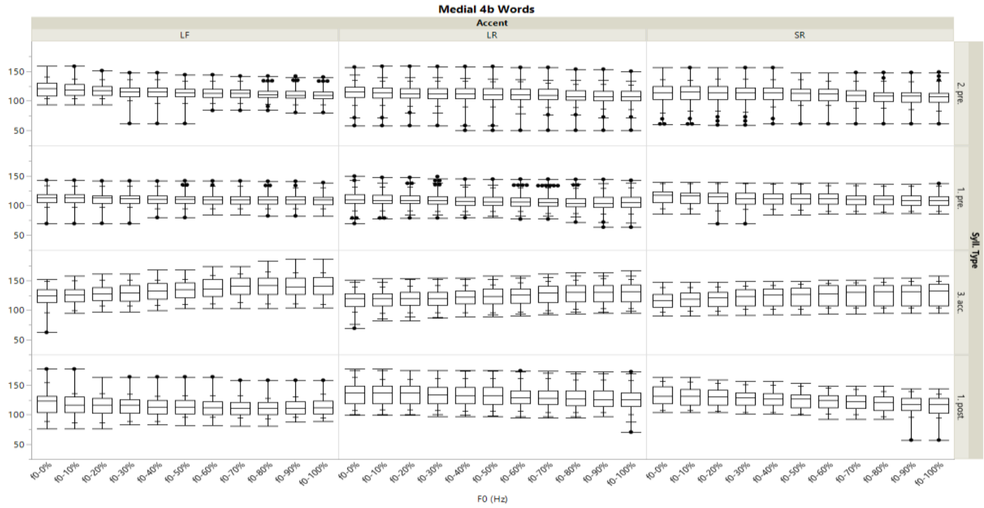

Figure D.83. Quantile boxplots of all F_0 measurement points in medial 4b words across the two rising accents and LF

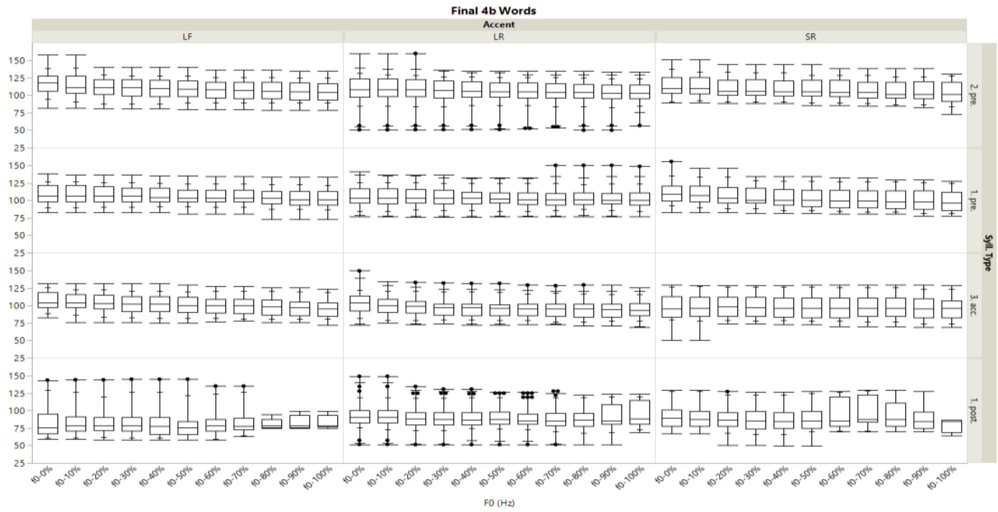

Figure D.84. Quantile boxplots of all F_0 measurement points in final 4b words across the two rising accents and LF

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