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The Phonetics and Phonology of Nyagrong Minyag, an Endangered Language of Western China

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Dedicated to the people of Nyagrong

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Abstract

Nyagrong Minyag (Sino-Tibetan, Tibeto-Burman, Qiangic, Rgyalrongic, Horpic) is an under-documented language spoken by approximately 1,000 ethnically Tibetan people in Xinlong (Nyagrong) County, Ganzi Tibetan Autonomous Prefecture, Sichuan Province, China. The language is endangered not only from common factors such as decreasing intergenerational transmission and shrinking domains of use, but also from the likely relocation of speakers to make way for building hydroelectric dams on the Yalong River. This dissertation is part of a larger project to document and preserve the language in its cultural context, in partnership with members of the language community.

This study aims to describe the sound system of Nyagrong Minyag, with particular attention to phonetic detail. Like other closely related languages, Nyagrong Minyag has a large inventory of sounds. It is comprised of twelve vowels and 42 consonants, which can cluster together in unexpected ways. In addition to auditory and phonemic analysis, this dissertation incorporates articulatory and acoustic data to describe and analyze the sounds in this language.

These methods have revealed several details about this language's system of sounds. First, through static palatography, tongue gestures are shown to distinguish the three places of articulation for affricates and account for variation in some consonant clusters. Second, I find that Nyagrong Minyag's aspirated fricatives are acoustically characterized by a drop in spectral center of gravity through the fricative and a drop in pitch in the vowel that follows. Aspirated fricatives are typologically rare, and these acoustic investigations contribute to the understanding of this phenomenon. Finally, I find phonemic and acoustic evidence for uvular approximation as a secondary articulation on vowels. Compared with plain, non-uvularized vowels, uvularized vowels are characterized by a drop in F2 and an increase in F3-F2, both of which correlate with vowel backness. Like Evans et al. (2016), I argue for the International Phonetic Alphabet to recognize uvular approximation in their catalogue of secondary articulations, and for reports of velarized vowels in other Rgyalrongic languages to be reexamined.

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Chapter 1

Introduction

This dissertation presents a detailed description of the phonetics and phonology of Nyagrong Minyag, an endangered and underdocumented language of western China. Younger generations of speakers are currently shifting toward the use of more prestigious languages: mainly Nyagskad, a local variety of Tibetan, and in some instances, Southwest Mandarin Chinese. This situation is exacerbated by current plans to relocate all speakers out of their villages to make way for hydroelectric dam construction along the nearby river. This work aims to contribute to the documentation of Nyagrong Minyag and endangered languages generally, especially with regard to the often overlooked phonetic details.

In Section 1.1, information is provided about the speakers, language setting and context, as well as its classification. Section 1.2 is a review of previous research on Nyagrong Minyag and closely related languages, as well as some issues related to language identification. In Section 1.3, the language's vitality and particular endangerment factors are discussed. Finally, in Section 1.4, I foreshadow the contributions of this dissertation and provide a road map to the particular topics explored here.

1.1 Background

1.1.1 Geo-political setting

Nyagrong Minyag is spoken by approximately 1,000 people living in the western part of Sichuan Province, long regarded as a frontier zone in China, especially before the annexation of Tibet. Speakers live along the Yalong River in Nyagrong (Xinlong) County, Garze (Ganzi) Tibetan Autonomous Prefecture, Sichuan Province, China (see the map in Figure 1.1). Culturally, this region is part of the Khams Tibetan region, which is one of three greater Tibetan regions (the others are the Amdo and Central/Lhasa regions). All speakers are officially classified as ethnically Tibetan by the Chinese gov-

Figure 1.1. Map highlighting the location of Nyagrong County, Ganzi Prefecture, Sichuan Province, China, adapted from Bzangpo (2012: p. 34)

ernment, and Tibetan culture and religion have greatly influenced the lives and identities of Nyagrong Minyag speakers.

Within the Nyagrong Minyag speech community there are at least two distinct dialect areas. These are roughly based on the townships of Nyagrong County. The Manqing (Manchen) dialect is spoken in the areas closer to the Nyagrong County town and its administrative seat, which also has access to a nearby highway through which outside goods and services are brought in. Because of contact with Tibetan speakers from other areas, the Manqing dialect appears to have taken on many features of local varieties of Tibetan. The Bomei (Bangsmad) dialect is spoken further downriver around the Bomei township, and appears to be the slightly more conservative of the two. An illustration of the dialect areas is shown in the map in Figure 1.2. This dissertation focuses on the Bomei dialect of Nyagrong Minyag, as all of the recordings are from speakers who grew up and live in Bomei township. Reports of a third dialect in Youlaxi (Yangslagshis) have not been confirmed, and may in fact relate to Queyu (Choyo, Zhaba; ISO 639-3: qvy), another language of the Qiangic group of Tibeto-Burman which is also spoken in Youlaxi.

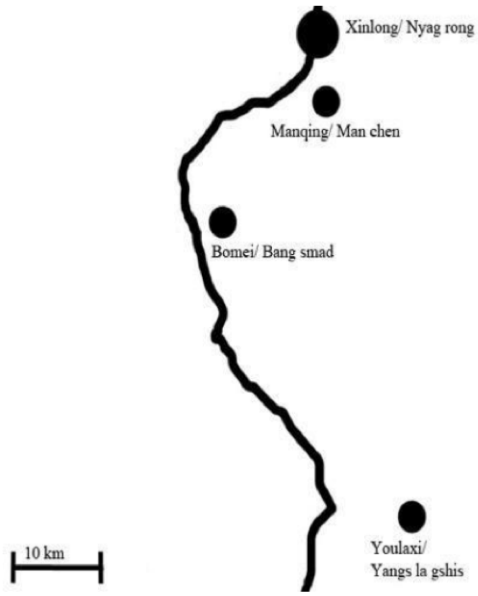


Figure 1.2. Map of Nyagrong Minyag dialects in Nyagrong (Xinlong) County, adapted from Bzangpo (2012)

Nyagrong Minyag is the name used in this dissertation because it includes the autonym of its speakers ("Minyag" or *məna*) and is geographically specific with its inclusion of the county name ("Nyagrong"). The geographical designation is needed so that it is not confused with the similarly named Minyag (Muya), a Qiangic language spoken in and around Kangding, Sichuan. Alternative names exist for this language, including the Chinese translation Xinlong Muya, or Western Horpa (Sun to appear). In the documentation of understudied minority languages, several issues arise with respect to choosing what names to use. Chen & Campbell (2018) give a thorough explanation of these issues, including the desire to use names that are maximally useful to the widest possible audiences, while respecting their needs and preferences. In the choice of the name "Nyagrong Minyag," deference was given to the community and their autonym, while eschewing other alternatives such as "Ergong" because it is pejorative, as well as variations of "Horpa" or "Rgyalrong" because, for these speakers, they are meaningless and carry no significance. (For a parallel example, see Lhundrop's (2017) justification for the use of "rTa'u.") In the context of the larger documentation project from which this research comes, community members were encouraged to take ownership of the documentation efforts, and by extension the language's future maintenance, hence the choice of a name with which speakers are able to identify.

1.1.2 Classification

Nyagrong Minyag is a Tibeto-Burman language, a subgroup of the Sino-Tibetan family (Sino-Tibetan, Tibeto-Burman, Qiangic, Rgyalrongic, Horpic). Considerable knowledge has been assembled about the shared traits of the Rgyalrongic languages (e.g., Sun 2000a,b, Jacques et al. 2017). The Rgyalrongic languages are likely closely related to other Qiangic languages of Sichuan, such as Muya, Queyu and Qiang (Jacques 2017) and are generally understood to be within the Qiangic branch (Matisoff 2003, Sun to appear). The designation Horpic is a newly evolving one, also used by Sun et al. (2017), and it denotes a group of closely related languages in western Sichuan. It comes from the term "Horpa," a designation used by many, including *Ethnologue* (Simons & Fennig 2018) to refer to one language with multiple mutually unintelligible "dialects" (more on this in Section 1.2). Figure 1.3 shows the genetic relationship of Nyagrong Minyag within the Sino-Tibetan language family.

1.1.3 Typological overview

The basic word order in Nyagrong Minyag is Subject-Object-Verb. In noun phrases, adjectives and numerals follow nouns (noun-adjective, noun-numeral), and possessives precede nouns (genitive-noun). Nouns are marked with suffixes to show grammatical relations (subject, object, etc.) and postpositions are used to show other information, such as location and possession. Verbs are marked with both prefixes (e.g., transitive vs. intransitive) and suffixes (e.g., tense-aspect).

1.2 Previous research

In order to consider which previous studies are relevant to this dissertation, considerations about the status of Nyagrong Minyag as a linguistic entity must be discussed. In the existing literature, there is a lack of consensus about whether Nyagrong Minyag should be considered a separate language or rather one variety of a large language-complex known variously as Horpa, Ergong, Stau, Daofu, or Western Rgyalrong. Proponents of the latter include *Ethnologue* (Simons & Fennig 2018), which lists "Nyagrong-Minyag" (also spelled "Nyagrong-Minyak") as one of many dialects of Horpa (ISO 639-3: ero), with the other named dialects sTau (rTau, Daofu, Dawu) and Geshitsa (Geshiza, Geshizha). This designation appears to be based largely on a survey by Shearer & Sun (2002).

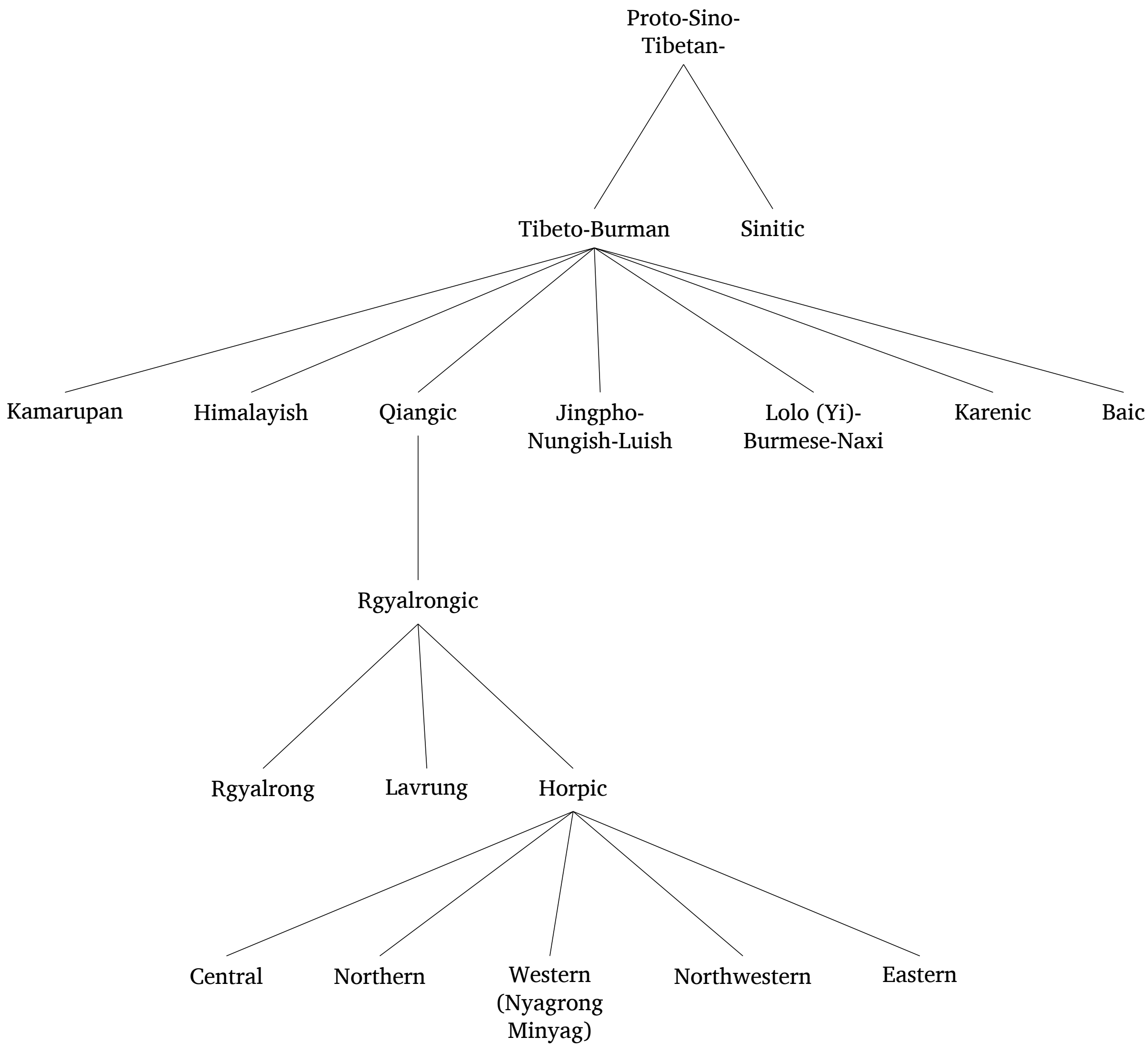


Figure 1.3. Classification of Nyagrong Minyag within the larger Sino-Tibetan family. Adapted from Matisoff (2003) and Sun (2000a, to appear)

The earliest mentions of Horpa come from nineteenth-century western explorers in Asia (Hodgson 1853, Rosthorn 1897). In the modern era, the most influential early work was a large survey of minority languages by Sun Hongkai (1983), who refers to the languages collectively as Ergong. From there, other Chinese scholars give descriptions of Daofu (Huang 1991) and Jiarong (Lin 1993). A grammatical sketch of the Geshitsa variety was provided by Duo'erji (1998).

In-depth work on comparative morphosyntax of Rgyalrongic languages led J. Sun (2000a) to propose three distinct Rgyalrongic languages: Rgyalrong (proper), Lavrung and Horpa-Shangzhai, noting that further differentiation among these may be articulated. More recently, Jacques et al. (2017) provide a sketch of Stau (Horpa, Ergong), a "cluster" of languages with mutually unintelligible varieties, of which they name three major varieties: Stau, Geshizha, and Shangzhai. The data for their sketch is taken largely from the Kongse dialect in Daofu County. With regards to the lower-level classification, they claim that Stau (Horpa) along with Lavrung (which they call "Khroskyabs") represent a subgroup of the Rgyalrongic languages, based upon common vocabulary and verbal morphology which are unlikely to be parallel innovations. These innovations are not shared by other "core" Rgyalrongic languages such as Zbu, Situ, Japhug and Tshobdun.

Now, Horpa has gone from being called a language with several varieties (Sun 2005a, Sun & Tian 2013) to being referred to as a subgroup of languages (Sun & Tian 2016, Tian & Sun 2016). For the latter concept, the term "Horpic" is also applied (Sun et al. 2017). Gates (2013) explores the mutual intelligibility of Horpic languages, which he refers to as the Western Rgyalrongic language cluster, and finds little to no mutual intelligibility among speakers from Xianshui, Geshiza and Niega. Sun (to appear) gives an excellent overview of the Horpa languages and he names five varieties with geographical designations: Central, spoken in Rtau (Daofu), Rongbrag (Danba) and Chuchen (Jinchuan) Counties; Northern, spoken in Dzamthang (Rangtang) County; Western, spoken in Nyagrong (Xinlong) County; Northwestern, spoken in Brag'go (Luhuo) County; and Eastern, spoken in Rongbrag (Danba) County. Sun (to appear) notes that Western Horpa (Nyagrong Minyag) is a tonal language, while many other Horpic languages appear to have lost tones over time. However, in the Bangsmad (Bomei) dialect of Nyagrong Minyag, I do not find convincing evidence for the presence of contrastive phonemic tone.

In fact, all of the above mentioned languages or varieties of Horpa and other Rgyalrongic languages, with the exception of Sun's (to appear) mention of Western Horpa, are relevant because of their relatedness to Nyagrong Minyag, but are not reported to be intelligible to speakers of Nyagrong Minyag. The first direct reports in the existing literature on the language spoken in Nyagrong (Xinlong) County come from Suzuki (2009, 2010, 2012). These reports are all based on the Manqing dialect, whereas this dissertation is on the Bomei dialect. Limited mutual intelligibility is reported even among these dialects, with speakers generally preferring to speak the local variety of Khams Tibetan with others from a neighboring dialect area.

Aspects of the verbal morphosyntax of the Bomei dialect of Nyagrong Minyag, such as tense/aspect and inverse, are explored by Kuo & Chen (2013) and Chen & Van Way (2013). Van Way & Bzangpo (2015) explore the prestige and vitality of Nyagrong Minyag and how its geographical and socio-cultural setting on the Tibetan periphery affects it. No other studies of Nyagrong Minyag offer the in-depth phonetic and phonological treatment that this dissertation provides.

1.3 Language vitality and maintenance

The internal and external forces that are affecting the maintenance of Nyagrong Minyag and contributing to its endangerment are examined by Van Way & Bzangpo (2015); all of the vitality and sociolinguistic information presented there and in this section come from the author's field notes and interviews with speakers. Nyagrong Minyag is at the bottom of a prestige hierarchy which also includes varieties of Tibetan and Chinese. Speakers' shift away from Nyagrong Minyag and toward these other languages is occurring alongside changes in education, technology, language attitudes, and access to the Chinese economy. In addition, relocation as a result of the construction of a hydroelectric dam may have significant consequences for the future of this language.

1.3.1 Socio-cultural context

Nyagrong Minyag is one of many minority languages spoken on the margins of China's Tibetosphere, which includes not just the Tibetan Autonomous Region, but also parts of the neighboring Chinese provinces of Qinghai, Sichuan and Yunnan. This region, which is often referred to as simply "Tibet," is far from being a homogeneous, monolingual entity. There are at least thirty-nine minority languages spoken within China's Tibetosphere, and nearly all of these are threatened or endangered (Roche 2014). In the map in Figure 1.4, we can see that the majority of the linguistic diversity within the Chinese Tibetosphere can be found in the areas that are peripheral to the rest of China.

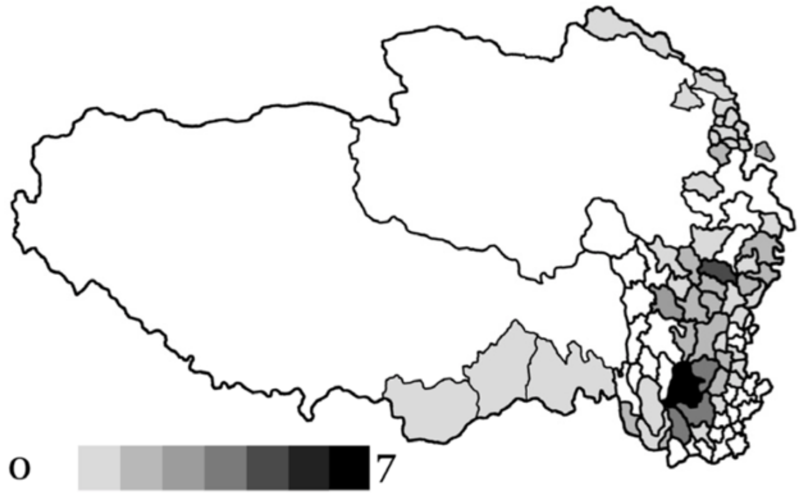


Figure 1.4. Map of the Chinese Tibetosphere showing the number of minority languages spoken per county, adapted from Roche (2014).

Nyagrong Minyag, like many of these minority languages, is at the cultural and political margins of the societies in which it is situated. The Chinese Tibetosphere is traditionally divided into three regions: Lhasa/Central, Khams, and Amdo; Lhasa is regarded as the political and cultural center of Tibet and it is the capital of the Tibetan Autonomous Region; the Khams and Amdo regions, therefore, have a marginal status within the Chinese Tibetosphere. In fact, the Khams and Amdo regions, which are both east of Lhasa, are closer in proximity to majority Han populations, and have long been regarded as "frontier zones" within China. Nyagrong Minyag speakers, who are all classified as ethnically Tibetan and belong to the Khams group, thus find themselves at the periphery both of the Tibetosphere, where non-standard varieties of Tibetan are spoken and distinct indigenous practices and beliefs are observed, and within China, where Tibet itself is often seen as an exotic "other" within the Han-majority People's Republic of China.

1.3.2 Contact and shift

The Nyagrong Minyag language is in a close contact relationship with multiple varieties of Tibetan and Chinese. The cultural and geographical area in which Nyagrong Minyag speakers live is the Khams Region of the Tibetan Plateau. Traditionally, the Tibetan language has been described as having three dialects: Central, Khams, and Amdo. However, much recent research (e.g., Sun 2014) on outlying varieties of Tibetan has encouraged a revision of this traditional view to a more fluid understanding in which there are several "Tibetic" languages, which generally have little to no mutual intelligibility among them. The language in closest contact with Nyagrong Minyag is a highly divergent local Tibetic language of Nyagrong County, called "Nyagskad" by its speakers. All Nyagrong Minyag speakers also speak Nyagskad; there are likely no monolingual Nyagrong Minyag speakers. Today, Nyagrong Minyag-speaking elders can all speak Nyagskad as well, though many remember those who only spoke Nyagrong Minyag. With second-language speakers included, speaker numbers for Nyagskad show positive growth over time, which indicates a shift toward Nyagskad under way.

In Nyagrong County, within many homes and villages, there is also a shift away from Nyagrong Minyag, which is generally being replaced by Nyagskad. This is partly a result of intermarriage between Nyagrong Minyag speakers and non-speakers. The story of the village of Nuqu helps illustrate this. Nuqu is a village in Nyagrong County where, as the story goes, Nyagrong Minyag had been the only language spoken. The village leader, however, took a wife from outside Nuqu, who only spoke Nyagskad and was not able to speak Nyagrong Minyag. The village leader, therefore, ordered everyone in the village to begin speaking Nyagskad so that his wife could communicate with them and feel more comfortable in her new home. Though this story is likely apocryphal, the fact that Nyagrong Minyag speakers tell it shows the extent to which they are conscious of the shift from Nyagrong Minyag to Nyagskad and how rapidly it is taking place.

Other forms of Tibetan are in less contact with Nyagrong Minyag and have very low mutual intelligibility with Nyagskad. Most speakers respond to this situation by using Mandarin Chinese (often Sichuan dialect) to communicate, to the extent that they are able. When a Tibetan from Nyagrong County uses a Tibetic language with another Tibetan, it is often with a high degree of accommodation to their interlocutor's speech, when this is possible due to prior language exposure. Some of this exposure depends upon knowledge of Literary Tibetan or "Yigskad," which can be used in some cases to adapt to an unfamiliar Tibetic language. Most Nyagrong Minyag speakers gain limited exposure to Yigskad through chanting, and some through education. The only Nyagrong Minyag speakers who attain a high level of competence in Yigskad are monks and students with formal training in Tibetan language.

Today, education and trade provide many Nyagrong Minyag speakers with opportunities to learn Chinese. The medium of learning in primary and secondary schools is Chinese (see Section 3.3 for details). Standard Mandarin (or "Putonghua") is the gold-standard of the education system, but many teachers settle for teaching in Sichuan dialect because they feel more comfortable with it. Students, therefore, are exposed to Chinese in school and diligent students often master it as a second language. Beyond schooling, others who use Chinese are usually involved in trade or business with Chinese, and they generally live in or close to the county town where, because of road access, trade is heavier.

1.3.3 Prestige

Nyagskad is higher in prestige than Nyagrong Minyag for most speakers and other residents of Nyagrong County. During formal events, such as wedding speeches, religious celebrations, and other official occasions, Nyagskad has become the preferred medium. Even in the case of a wedding in which all family members present are Nyagrong Minyag speakers, Nyagskad is used to give speeches, a domain in which Nyagrong Minyag was previously used. Nyagskad is also the preferred lingua franca throughout Nyagrong County. When Nyagrong Minyag speakers from different areas within the county communicate, they choose Nyagskad, even though mutual intelligibility in Nyagrong Minyag is often possible. Nyagskad is also supported by the community in an organized way: each year, fifteen days are devoted to learning Nyagskad neologisms. The event is convened by an organization which coins new words and determines which ones will be introduced and learned. Many of the words are for new forms of technology or concepts introduced from outside. Speakers participate in contests, and prizes are awarded to the winners for learning the new words. Through this organized effort, Nyagskad has become more responsive to new domains, such as technology, government, education, etc.

The prestige of Chinese (in its many varieties) is complex. On one hand, many speakers appreciate the increasing number of opportunities available to those who can speak Chinese well. On the other hand, because of speakers' remote, relatively isolated location, opportunities for mastering Chinese outside of school or intensive trade relations are not many. In addition, because of tensions between Tibetans and the Chinese government, many ethnically Tibetan people prioritize solidarity and unity with other Tibetans, and thus mastery of Tibetan language (especially Yigskad) is, for many speakers, more highly valued than Chinese.

Nyagrong Minyag is at the bottom of this prestige ladder that exists in the peripheral regions of the Chinese Tibetosphere, below Tibetic and Chinese languages. Like other minority languages of the area, Nyagrong Minyag is often called "Ghost Language" (Dreskad), a pejorative exonym applied by non-speakers who encounter it. This negative attitude that some non-speakers of Nyagrong Minyag exhibit is also present among some speakers who feel it is backward and not useful in the modern world.

1.3.4 Usage trends

The use of Nyagrong Minyag is declining over time. It is generally being replaced by Nyagskad, the local variety of Tibetan, and, to a lesser extent, varieties of Mandarin Chinese. Young speakers tend to use Nyagskad words or phrases when speaking Nyagrong Minyag, and/or code-switch between the two languages. Among older speakers, mixing with Nyagskad is less common, and they are reported to remember more "original" Minyag words and phrases.

The domains in which Nyagrong Minyag is used are increasingly limited. In formal settings, Nyagskad is considered the more "official" language. This means that speeches at weddings, religious ceremonies, and other formal settings are in Nyagskad. Nyagrong Minyag is used in speakers' homes and in the fields, since most speakers are farmers.

Material culture is another area in which the use of Nyagrong Minyag is declining. Traditional tools for farming, such as ox-driven plows, hoes, irrigation tools, etc., are no longer used and are being replaced by more efficient modern technology. The loss of traditional techniques in the agricultural domain means a loss of language—for example, each component of a traditional plow has a unique Nyagrong Minyag word. The domestic domain is another area in which the adoption of modern material culture is leading to the diminishment of the Nyagrong Minyag lexicon. In the home, most families have, for example, modern ovens made of metal, for which they have borrowed words from Chinese, but in the past, families had traditional ovens made of stone, for which each part has a unique Nyagrong Minyag word. In making barley wine, which is no longer a common practice, a rich vocabulary was once available for the implements and processes, but is now largely forgotten. Younger speakers, who have no experience of these traditional tools and techniques, not only have less experience with the traditions of their ancestors, but also use more loanwords, which are replacing Nyagrong Minyag vocabulary.

Nyagskad is used as a local lingua franca between speakers who might otherwise use their own varieties of Nyagrong Minyag. Speakers from different townships almost always speak Nyagskad when talking with each other, although mutual intelligibility is often possible. To a lesser extent, this is also the case even between people from different villages within the same township. This shows that as transportation is becoming easier with better roads and faster vehicles, Nyagrong Minyag has fallen in prestige and usage, as Nyagskad has risen. As society in this remote part of China becomes more connected, this change in prestige may reflect a desire among speakers to play up their identity as Tibetan (and thus speak the local variety of Tibetan), and play down their identity as speakers of Nyagrong Minyag.

1.3.5 Education

The education system that serves Nyagrong Minyag speakers is undergoing many improvements, and is providing more residents than ever before with quality schooling. However, there is no formal education in Nyagrong Minyag and the educational system does not support the use of Nyagrong Minyag. Because it enhances the usage and prestige of other languages like Nyagskad, Literary Tibetan and Chinese, the system of education does not support the maintenance of Nyagrong Minyag, and in some ways, may be responsible for undermining it.

In the villages where Nyagrong Minyag is spoken, formal education begins at age six or seven with kindergarten. Primary school follows, which can last for six years. Until recently, most primary education took place in the local township, but now many of the township primary schools have closed and parents choose to send their children to the county town for their primary education. Students learn math, science, and history, and they also have language classes for Chinese and English. The main medium of instruction in today's county-level primary schools is Chinese, generally the Sichuan dialect of Mandarin or standard Putonghua. Previously, children who attended primary school in their townships, had little to no exposure to Chinese language before attending middle school. Children who come from Nyagrong Minyag-speaking homes often get their first exposure to Chinese in school, and because it is the main medium of instruction, they are expected to learn it very quickly. Nyagrong Minyag is rarely spoken in schools, and usually only between children from the same village.

Families in Nyagrong County, even from the most rural areas, see increasing value in their children's education. This means that a higher percentage of children are enrolling in schools, and the truancy rates are low and decreasing. Until recently, it was easy to get out of paying a truancy fine by means of personal connections, but now truancy laws are more strictly enforced. Many of today's parents are making greater investments and sacrifices for their children's education by renting a home part of the year in the county town while their children are attending school. However, because road conditions are improving, this is becoming less of a necessity. Today, because of shifting values and better educational opportunities, children from Nyagrong Minyag-speaking households are receiving a better and more standard education, but one which does little to help maintain their traditional language.

In middle school, children attend the Nyagrong County Town school, where they receive education in science, math, history, English, Chinese and some Literary Tibetan. Previous generations of students from outside the county town who attended primary school close to their home villages, had their first formal exposure to Mandarin in the middle-school classroom, where nearly all subjects are taught in Chinese. One exception is the study of Literary Tibetan, where students learn to read and write a standard literary form of the Tibetan language. In these courses, the entryway to learning for most students is Nyagskad, the local variety of Khams Tibetan, and students learn to draw parallels from this language to the standard Literary Tibetan of the classroom. Because all Nyagrong Minyag speakers are classified as ethnically Tibetan and identify strongly with the culture of Tibet, this aspect of their education serves to reinforce the prestigious position of Nyagskad among the spoken languages in Nyagrong County.

There are several high schools which students from Nyagrong may attend, determined by placement from the high-school entrance examination. The high schools are in various places throughout Ganzi Tibetan Autonomous Prefecture, but none are in Nyagrong County. Language instruction varies throughout these schools: in most, all classes are taught with Chinese as the medium of instruction; in some, there are optional Tibetan language classes, while all other classes are taught in Chinese; in one, the high school in Ganzi Town, many subjects such as math, science and history, are taught through the medium of Literary Tibetan. Nyagrong Minyag-speaking students who attend high school usually do so far away from other Nyagrong Minyag speakers, and receive virtually no support for their native-language needs.

The education system for Nyagrong Minyag speakers is improving and serving the needs of more and more children and their families, but at a price. Through its growth and improvement, the system of education is further enhancing the position of more dominant languages like Chinese, Literary Tibetan, and Nyagskad. This is pushing Nyagrong Minyag down on the prestige hierarchy, which puts it in a precarious position for the future.

1.3.6 Dam construction

The growth of China's economy and the modernization and urbanization of Chinese society is causing many changes for the country. Among these changes is a growing demand for energy, especially from domestic sources. To meet these demands, Chinese state-run companies are in a process of building a large number of hydroelectric dams, and many of these are in Sichuan Province and other parts of southwest China. In 2009, as part of a series of dam projects on the Yalong River, residents of Nyagrong County learned of plans to build a dam near their homes. This dam will impede the flow of the Yalong River and completely inundate the homes and lands of virtually all Nyagrong Minyag speakers.

Currently, there is no organized plan to relocate speakers together as a result of the dam construction. If speakers move to different areas and have to assimilate to groups speaking other languages, there is likely to be a disruption in transmission of Nyagrong Minyag to younger generations. Because Nyagrong Minyag is already at the bottom of a prestige hierarchy in Nyagrong County, where Nyagrong Minyag has been spoken for, presumably, centuries, it will likely have even lower prestige when speakers move to other areas. Nyagrong Minyag speakers and their children will be under pressure to assimilate to their new surroundings and learn other languages, such as other minority languages, other Tibetic languages, and/or Chinese.

Of course, alongside the loss of a language, valuable knowledge, history, heritage and identity are also lost. The beautiful mountainous landscape of Nyagrong County has inspired many tales of local legendary people and deities. These stories are an important part of Nyagrong Minyag heritage which may be lost if the language becomes dormant without proper documentation. In times of hardship, residents take consolation in their local deities, such as mountains and rivers. Elders use folktales to teach children about history, morality, and their ancestors' way of life. Without these stories, and their geographical referents, speakers could become separated from their cultural heritage and identity. Likewise, traditional ecological knowledge of, for example, local plants and their medicinal uses could be lost. Without access to the lands where the stories and the plants come from, speakers may be cut off from this aspect of their heritage as well.

1.4 Contributions

This dissertation, and the larger language and cultural documentation projects through which it has been nourished (Van Way & Bzangpo 2018), contribute to the need for documentation and description of understudied and endangered languages. The goals of the larger documentation project include annotated corpora of natural speech, a lexical database of Nyagrong Minyag with glosses in English, Tibetan and Chinese, and community-driven resources such as a writing system and learning materials.

This study, in particular, provides phonetic details and in-depth phonological analyses that shine a light on several of the more complex or unusual phenomena in this language. Phonetically detailed descriptions of endangered languages are not common, but greatly enrich our understanding of the nature of human language (Ladefoged 2003). Specifically, this dissertation explores, through quantitative analysis, at least two typologically rare phenomena: aspirated fricatives and uvularized vowels. The material presented can be used to further refine recurring sound correspondences and thus the classification of Horpic and Rgyalrongic languages.

The dissertation proceeds from here by first explaining the methodology used in this study (Chapter 2). Then, Chapter 3 shows the basic phonemic inventory with great articulatory detail. Next, Chapter 4 explains the phonotactics and syllable-related phenomena, with special attention to the onset clusters. From there, Chapter 5 explores observations related to frication in the language, such as aspirated fricatives and distinctions regarding place of articulation in affricates and fricatives. Last, Chapter 6 provides phonological and phonetic evidence for uvularization as a phonemic secondary articulation on vowels and other sonorants. Chapter 7 summarizes this dissertation and provides some final thoughts on its contributions.

Chapter 2

Methodology

The goal of this study is to describe the sound system of Nyagrong Minyag with particular attention to phonetic detail. To that end, this study incorporates both open-ended elicitation techniques and investigation of audio recordings of twenty speakers, which have been analyzed for particular acoustic information such as formants for vowels and spectral information for fricatives, among others. To corroborate the acoustic evidence, the study also provides palatographic evidence from one speaker to shed light on the articulatory details of the sounds investigated here. Section 2.1 is a brief overview of the elicitation techniques that were used as a foundation of the earliest phases of the study of this language. Section 2.2 provides details about how the audio recordings were collected, including design and planning, as well as some of the challenges experienced along the way. Basic demographic information of the speakers who lent their voices to these recordings is also given. Section 2.2.3 goes on to discuss the workflow in which audio recordings were managed and used to extract numerical values which provide evidence for this study. Section 2.2.4 then discusses the normalization procedures and the statistical methods employed to draw conclusions about observations in the data. Finally, Section 2.3 describes the methods employed in the palatography investigations through which corroborating articulatory observations are brought into this study.

2.1 Elicitation

The foundation of this study of Nyagrong Minyag has been a series of open-ended elicitation sessions with native speakers. The methods used in these sessions are wide-ranging in nature, with the intention of eliciting a variety of language information such as lexical items, phonological patterns, grammatical structures, and the social context in which the language is used. Lexical items were gathered using basic instruments such as a Swadesh list, picture dictionaries, discussions of photographs taken in the village, targeted semantic domains, free association, and other techniques that best fit the needs of the session and the participants. The lexical entries formed the backbone of further inquiries into the phonology and grammar. Phonological hypotheses were formed and tested using a variety of techniques, e.g., varying the phonological environment of certain targeted sounds, combining sounds to find out whether those combinations exist in words, are possible but unattested in words, or are impossible combinations, etc. Questions and observations about the grammar, although not a focus of this study, were investigated in a variety of ways, including longer utterances elicited through translation and by examining connected discourse through the analysis of texts.

2.2 Audio recordings

The acoustic data used in this study is primarily comprised of recordings gathered from twenty native speakers of Nyagrong Minyag during fieldwork in 2014 and 2015. Recordings gathered during fieldwork, including those used for the analysis contained in this dissertation, are archived at the Endangered Languages Archive and available for review (Van Way & Bzangpo 2018). The primary source material is a list of fifty words designed to target as wide a range of the sounds as possible and include several minimal (or near-minimal) pairs. This was determined to be an optimal data set for this study because it allowed for simple, clear recordings that are useful for detailed phonetic studies. These data were supplemented by additional recordings of careful speech made during elicitation sessions with certain speakers. Although more natural speech recordings are necessary for creating a broader corpus of language documentation and for understanding how the language is actually used by its speakers, they were not included in this study because they introduce complexities that are challenging to account for in a phonetic study.

The primary collaborator, Bkrashis Bzangpo, who is a native speaker of Nyagrong Minyag, elicited the words in the list and made the recordings. Participants were prompted with each Nyagrong Minyag word orally by Bkrashis Bzangpo, who would help explain or disambiguate the targeted word if necessary. Participants were instructed to repeat each word three times carefully in isolation. The recordings were made using a handheld recorder and a headset microphone. (The recordings made both using the headset and the internal microphones of the recorder were preserved, serving as backup in case the other picked up more noise interference or was simply a bad recording.) Each participant's recording resulted in a .wav file of 48kHz/24bit. These high-quality files were made in order to preserve as much of the audio data as possible, for the purpose of acoustic analysis. The speakers who participated in this study were selected by the primary collaborator, who attempted to recruit a mix of genders and age ranges.

Additional recordings from an earlier phase in the project were also incorporated into this study. These feature the speech of two speakers. They were asked to repeat target words in isolation and in a carrier phrase. (The carrier phrase was ədə [token] dəŋə 'This is [token].' It was designed to accommodate the syllable structure of the language and make uniform the speech rate and intonation.) Where appropriate in this study, it will be noted whether the token in question was uttered in the carrier phrase or in isolation.

2.2.1 Word list

Because the word list served as the primary instrument for acoustic analysis of multiple Nyagrong Minyag speakers, great care was taken in choosing which words to include. First, a limit of fifty words was decided upon because it would not be practical to ask speakers to be recorded carefully saying hundreds of words in one sitting. This number of words, fifty, could easily fit on the front and back of a page that could be carried around the village, and it would not seem too daunting a task for either the speakers or the collaborator who was recruiting participants and making and eliciting the recordings. Second, the list had to include sets of words that varied from each other in minimal ways, in order to illustrate, for example, contrasts in vowel quality or aspiration in consonants. But in order to limit speakers' awareness of the subjects under investigation, these words had to be separated from each other, either by filler words or words that do not resemble one another. This was accomplished by first randomizing the list of words, then manually adjusting it to accommodate these considerations. Finally, some effort was made to consider the meaning of the words included, so that speakers would not be distracted by certain semantic considerations (i.e., imagining that the words are connected in some meaningful way). The finalized word list which was used for eliciting recordings can be found in Table 2.1 on page 19.

Because political unrest in Nyagrong County and in the Chinese Tibetosphere more generally creates challenges for outsiders to visit these areas, the author had limited access to speakers and was not able to collect most of the recordings of word lists in person. Therefore, an arrangement was made in which the primary collaborator recruited participants for these recordings when visiting

Table 2.1. Word list for acoustic analysis

Number	Target	Gloss	Number	Target	Gloss
1	li	‘to release’	26	rtsa	‘vein’
2	kaʶtɕʰiʶ	‘good’	27	qɔ	‘horn (of animal)’
3	ɣvu	‘ice’	28	zə	‘son’
4	zɔ	‘shrine room’	29	xkə	‘garlic’
5	hpʰu	‘sand, grit’	30	ftɕɔ	‘mouse’
6	rkə	‘to cut’	31	qwarwa	‘spider’
7	liʶ	‘to fall’	32	sənɔ	‘agriculture’
8	rdʑy	‘to flow’	33	ɬʰu	‘wood’
9	ʁzəʶ	‘Tibetan dzi bead’	34	qʰa	‘to laugh’
10	xtʂa	‘star’	35	xsɛ	‘glue’
11	rku	‘to like, love’	36	ɣu	‘house’
12	zyʶ	‘excrement’	37	sʰə	‘who’
13	zaʶbuʶ	‘insane’	38	ʒə	‘ghost’
14	katɕʰi	‘big’	39	ɬa	‘easy’
15	xtsə	‘claw’	40	xaʶpə	‘friend’
16	dupʰi	‘piece’	41	ʃə	‘tooth’
17	vdʐə	‘to wake up’	42	fntʂʰi	‘snake’
18	ftsa	‘to get dirty’	43	rʁɔ	‘dirty’
19	xtuʶbuʶ	‘empty’	44	htɕʰɛ	‘six’
20	hpʰy	‘chunk of solid food in soup’	45	ɬy	‘mouth’
21	vli	‘tongue’	46	xsʰɛ	‘new’
22	zɛ	‘root vegetable (sp.)’	47	χɔχɔ	‘empty’
23	xtɕu	‘metal’	48	qa	‘crack’
24	zy	‘female yak’	49	ʃʰə	‘louse’
25	rgy	‘animal’	50	ɬʰa	‘hand’

his home for an extended period. There were many advantages to having a native speaker as the primary gatherer of data for this project. Among them were his access to the community, his ability to explain certain procedures, and his relatively unobtrusive presence when gathering other naturalistic data. There were also, however, accommodations that had to be made for this arrangement. First, while it was easy for the primary collaborator to understand the value of saying words in frames for the purposes of linguistic analysis, it was difficult for him to make other speakers understand the procedure and rationale for saying entire frames, rather than the targeted word. Therefore, it was decided that participants should say only the targeted word, as it greatly eased the ability to collect data from more speakers. Since frames are important for avoiding unnatural speech effects, such as list intonation, not having frames in these recordings means that understanding intonation and duration (especially in final vowels), is limited by the nature of the data in this portion of the study. Also, because the primary collaborator had many tasks when eliciting and recording the word lists, he was not able to constantly monitor whether any extraneous noise was interfering with the recordings. In a few, limited instances, small portions of recordings had to be disregarded because there was noise from the environment such as jostling a table, children playing nearby, or cell phone interference, etc. In many cases, this was mitigated by having more than one microphone recording simultaneously (i.e., both the headset and the internal microphones of the recorder), and the best recording was then chosen after reviewing them all.

2.2.2 Participants

For this portion of the study, speakers were recruited from the Bomei (Bangsmad) dialect area, which includes all villages in Bomei Township. Attempts were made to include speakers from as broad a demographic range as possible. The sample used here is intended to be representative of the Nyagrong Minyag (Bomei dialect) speech community. Although this is a small community (less than 1,000 speakers total), there remains the possibility that the sample is biased in some unforeseen way, such as by the recruitment process. These kinds of limitations are inevitable when working with small, remote populations where access to speakers is a challenge.

In sum, there were seven females and thirteen males: at the time of recording, female speakers ranged in age from 23 to 61; male speakers ranged from 24 to 70. Including both males and females, six speakers were in their twenties, four were in their thirties, three were in their forties, four were in their fifties, two were in their sixties and one was seventy years old. Table 2.2 on page 21 lists the gender, age at time of recording, and year/place of birth for each speaker.

Table 2.2. Participant demographic information

ID:	Gender:	Age:	Year of Birth:	Place of Birth:
1	F	51	1964	Bomei Village
2	M	50	1965	Bomei Village
3	M	70	1945	Bomei Village
4	F	56	1959	Bomei Village
5	M	44	1971	Khalong Village
6	M	34	1981	Bomei Village
7	M	54	1961	Bomei Village
8	M	29	1986	Bomei Village
9	M	62	1953	Bomei Village
10	F	34	1981	Bomei Village
11	F	23	1992	Bomei Village
12	M	29	1986	Bomei Village
13	M	41	1974	Bomei Village
14	F	61	1954	Risne Village
15	F	36	1979	Risne Village
16	F	24	1991	Risne Village
17	M	37	1978	Bomei Village
18	M	42	1973	Bomei Village
19	M	29	1986	Bomei Village
20	M	24	1991	Bomei Village

2.2.3 Acoustic data from audio recordings

Acoustic information from the audio recordings of wordlists from twenty speakers was gathered and extracted using Praat (Boersma & Weenink 2018). Each of the twenty recordings from each speaker was broken down into smaller .wav files, and for each file an accompanying Praat TextGrid file was created. Within each TextGrid file, for each utterance, boundaries were determined and marked by hand by the author. These files were marked for each word in the phrase, each segment, and, in some cases, sub-segmental information such as both the closure and the frication in an affricate, or the frication and aspiration portions in an aspirated fricative (see Figure 2.1 on page 23 for an illustration). In order to decide where one segment or word ends and the next one begins, information from both the waveform and the spectrogram were considered, with greater preference given to the waveform because it is more accurate in the time dimension. The following guidelines were followed in marking boundaries between segments in the audio files:

1. Boundaries were marked at the nearest zero-crossing in the waveform.

2. Any burst or aspiration following a consonant was included in the consonant, not in any following vowel.

3. The boundary between voiceless frication (either from a fricative or affricate) and a vowel was determined by the change from aperiodic to periodic energy. If the frication were voiced, the boundary was determined by the positive change in amplitude transitioning into the vowel.

4. Similarly, when a vowel was followed by a sonorous consonant, such as a nasal, glide or liquid, the boundary was marked at the first sign of a negative change in amplitude, which indicated a transition out of the vowel.

5. When marking transitions between two adjacent fricatives, boundaries are determined by examining where intensity changes, sound quality changes, and spectral range changes.

6. Aspiration in consonants was determined by a visible burst following closure in the case of obstruents. When dealing with aspirated fricatives and affricates, the transition from frication to aspiration was marked where intensity changes, sound quality changes, and spectral range changes.

In many of the recordings, because the speakers were saying the words carefully in isolation, the final part of words, usually vowels, were exaggerated in length. This resulted in many final vowels becoming diphthongs, with a schwa off-glide. In these cases, the author marked an additional boundary that is not present in the canonical form of the word (i.e., an off-glide). These were generally not considered in the analysis because they did not represent the cardinal vowel under consideration, and are instead more rightly considered by-products of the procedure for recording the word list.

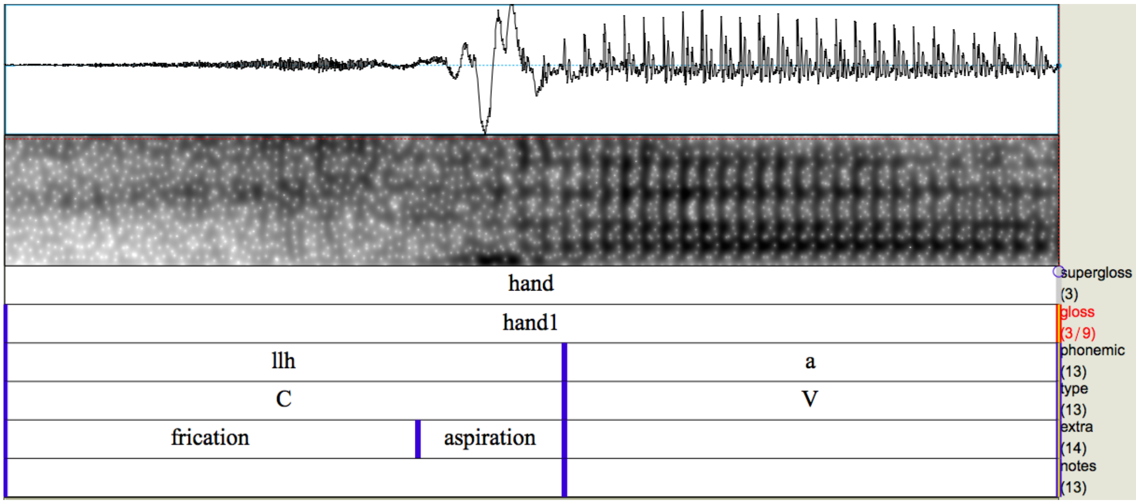


Figure 2.1. Example of a .wav file and time-aligned textgrid in Praat

Once the sound files had all been annotated at the word, segment and sub-segmental levels, files were checked to ensure the proper fit of formant settings in Praat. Next, a script was run using Praat to gather measurements such as duration and vowel formants (at ten percent time intervals from twenty percent to eighty percent), as well as spectral information fricatives such as center of gravity, skewness and kurtosis, which are different measures of the overall tendencies in the waveform. (The default settings in Praat were used for all these measures (Boersma & Weenink 2018); I follow Boersma & Hamann (2008) in computing the spectral mean (center of gravity) by weighing the frequencies in the spectrum by their power densities, not by their intensity values in decibels, which are sensitive to arbitrary recording values.) All the data extracted by the script were exported into a spreadsheet, which was checked carefully for errors and inconsistencies, arising from either human error in the transcription/annotation stage or computer error, such as inaccurate formant tracking. After review, the data were then ready for analysis.

2.2.4 Acoustic data analysis

2.2.4.1 Vowel normalization

When comparing data from multiple speakers of a language, it is essential to factor out variation due to physiological differences, such as the length of speakers' vocal tracts, through a process of vowel normalization. Variation that remains after normalization, therefore, can be reliably attributed to non-physiological factors such as different phonemes, word-environment, speech rate, secondary articulation, or social factors. Vowels in this study were normalized using the Lobanov method (Lobanov 1971). This method works by considering each speaker separately (i.e., speaker-intrinsic) and analyzing formant values for all vowels (i.e., vowel-extrinsic) for that speaker. The following equation is used to compute a scaled value around a centroid at $(0, 0)$ for each measure of each formant of each vowel by subtracting the mean value for all the speaker's measured vowel utterances and dividing it by the standard deviation of the measures of that formant for that speaker, as in the following equation:

$$F_n[V]^N = (F_n[V] - \mu_n)/S_n$$

Where $F_n[V]^N$ is the value of the normalized formant n for an individual speaker's vowel V, $F_n[V]$ is the value of formant n for the same speaker's vowel V before normalization, μ_n is the mean for all the speaker's values of formant n, and S_n is the standard deviation for all the speaker's values of formant n.

For the purposes of this study, the original Lobanov method was extended to measure F3 (in addition to F1 and F2) in order to understand the acoustic nature of secondary articulations and their effect on vowels and other sonorants. Also, because acoustic measures were taken of vowels at successive time steps within the utterance, each measure of each time step was normalized by following Lobanov's method, but taking the mean and standard deviation of the speaker's formants at that time step and using them in the normalization procedure. All calculations were made using R (R Core Team 2014).

Questions about how different portions of a single vowel token changed over time required scaling the normalized formant values back to Hertz. For example, in order to understand how the onsets of vowels were affected by certain consonants, the measure taken at twenty percent (or, in some cases, thirty percent) of the vowel's total duration was subtracted from the measure of the same vowel at the midpoint. Because roughly half the normalized values are negative (since they are given around a $0, 0$ centroid), the subtraction performed to compare different time-steps could potentially create results that are difficult to interpret. Therefore, in order to have all positive values for these calculations, the normalized values were scaled back to Hertz using the following formulas provided by Thomas & Kendall (2007):

$$F_1' = 250 + 500(F^N_{1MIN})/(F^N_{1MAX} - F^N_{1MIN})$$
$$F_2' = 850 + 1400(F^N_{2MIN})/(F^N_{2MAX} - F^N_{2MIN})$$

$$F'_3 = 2000 + 1200(F^N_{3MIN})/(F^N_{3MAX} - F^N_{3MIN})$$

2.2.4.2 Statistical analyses

In order to make inferences about quantitative differences observed in the acoustic measurements, statistical tests were employed to find out whether the differences between two putative groupings were legitimate differences or the result of random chance. Dependent variables such as formant measures or spectral center of gravity were tested against independent variables such as phoneme category or the presence of secondary articulations. To this end, linear mixed-effects regression models were used to test hypotheses about these acoustic variables. All calculations were performed in R (R Core Team 2014) using the lme4 package (Bates et al. 2015). The use of mixed-effects models is necessary because in phonetic studies there are potentially many different factors that could affect the measures observed, and it allows these extra factors to be included as random effects. In this study, statistical models were built to include potential random effects of speaker, the word in which the utterance was spoken, preceding and following environments, and if applicable, the recording device. The models were then trimmed to include only those effects which were shown to account for variation in the data.

Another advantage of linear mixed-effects models is that simple linear regression treats each observation as independent of one another, which is not the case when you have multiple observations from the same speaker. Linear mixed-effects models have different intercepts for each speaker, giving all speakers their own baseline. In order to interpret the output of these models, an additional package, lmerTest (Kuznetsova et al. 2017), was used to bootstrap p-values. Because Bates et al. (2015) consider p-values to be somewhat unreliable in linear mixed-effects modeling, this study also includes t-values where the results of statistical tests are reported.

2.3 Static palatography

Aspects of this study also rely upon evidence obtained through static palatography (see Anderson (2008) for a practical guide). Static palatography is a method used to ascertain the precise articulatory details of certain phones in a language. Static palatography and its companion, linguography, are especially useful in observing and measuring the contact made between the front of the tongue, such as the tongue tip, blade, and forward portion of the tongue body, and the anterior portions of the upper vocal tract, including the dental, post-dental, alveolar, post-alveolar regions and some portions of the hard palate, but excluding the lips. Because Nyagrong Minyag has a large number of contrastive phonemes in the coronal region, such as stops, fricatives, and affricates in three places of articulation, static palatography was used to clarify how these sounds are produced.

Static palatography collects a record of contact made between articulators during a targeted sound. The records produced are palatograms and linguograms. A palatogram is created by painting a speaker's tongue with an edible paint, and observing the record of contact during a targeted word; it indicates what part of the upper vocal tract is contacted by the tongue. A linguogram is created by painting the upper vocal tract (from the hard palate to the back surface of the upper teeth), and observing the accumulated contact on the tongue during a targeted word. By comparing the palatograms and linguograms produced during two different articulations of the same target, and referring to measurements of impressions of the hard palate, inferences can be made about the gestures used in producing certain phones. The steps taken in this study follow closely those described by Anderson (2008).

In order to target certain articulations in Nyagrong Minyag, targeted words elicited during palatography sessions were selected based on certain criteria. First, the word had to include the targeted phone. Second, the word should contain only low vowels, as high vowels can cause unintended tongue-to-palate contact due to the position of the tongue during articulation. Third, a targeted word should contain only one coronal segment, in order to avoid the accumulated contact from two articulations, which would confound any conclusions about the gestures involved in the contact. The words selected for elicitation in the palatography sessions are given in Table 2.3 on page 27, and were elicited by prompting in English.

Palatography is a time-consuming process that requires gathering materials, preparing a work space, minimizing discomforts experienced by the speaker, and processing data. During the sessions, the speaker sat facing a video camera and an external light source. Materials needed nearby included an edible paint mixture (we used digestive charcoal mixed with olive oil) and clean paint brushes, intraoral mirrors, and rinsing liquid (water with a small amount of lemon juice). For producing linguograms, the speaker's palate and inside surfaces of the upper teeth were painted, and then the targeted word was elicited through the contact language. The speaker was then asked to stick his tongue out and down for the video camera to record the contact made on the tongue body and blade, then pointed up to see the underside of the tip, and finally side to side to observe any contact made

Table 2.3. Word list for palatography

Token:	Gloss:
fta	'to remove'
na	'fish'
la	'tree'
sa	'to die'
fʃɔ	'to need'
ʃa(ʃi)	'bundle'
ɬa	'four'
raka	PL
$ts^{h}a$	'goat'
$tɕ^{h}a$	'pair'
$tʂ^{h}ama$	'window'
rkɔ	'to recline'
xkə	'garlic'
rkə	'to cut'

on the sides of the tongue. For producing palatograms, the speaker's tongue was painted and the targeted word was elicited. After the articulation, the speaker put the intraoral mirror into his mouth, resting it behind the backs of the molars. The speaker then leaned back to allow the video camera to capture the pattern of contact reflected in the mirror.

In addition to gathering images of contact markings on the palate and the tongue, it was also necessary to create a three-dimensional impression of the palate used in scaling images and relating them to the mid-sagittal plane. Two impressions were made of the mouth cavity between the occlusal (or biting) plane and the hard palate, using a dental alginate that hardens in the mouth after mixing with water. One impression was used to create a life-size graph of the speaker's palate in the mid-sagittal plane and in 5mm intervals up from the occlusal plane. The second impression was used to create a plaster mold for reference measurements used when creating the graph and correcting palatograms for life-size.

In order to create the two-dimensional graph of the palate and the mid-sagittal plane, the bottom (or occlusal plane) of the first impression was traced on graph paper and then the entire impression was cut in several ways. First, the impression was bisected in half between the two incisors. The resulting pieces were placed on their sides and traced on graph paper; this supplied the mid-sagittal diagram. Next, the two pieces were put back together and cut in the coronal plane (between the first and second molars), creating an x-axis to complement the y-axis in the mid-sagittal cut. Then all four pieces were placed back together and sliced 5mm up from the occlusal plane; the resulting pieces were then traced inside the first tracing of the occlusal plane to show the depth at 5mm. These last steps were repeated at 5mm intervals up to the top of the impression (corresponding to the hard palate). The results of these graphs are shown in Figures 2.2 and 2.3. The two images were then aligned by drawing vertical lines from the edges of the 10mm and 15mm lines in both tracings, as seen in Figure 2.4 on page 29.

The next step was to reconstruct articulations by first processing the images and correcting them to life-size. The digital video recording of each articulation during the session was reviewed and examined frame-by-frame to find the clearest view of the pattern of contact. Still shots were selected and saved. Images of palatograms were processed and corrected for life-size in order to reliably line up with the life-size tracings in Figure 2.2 on page 2.2. (Images in this dissertation are no longer life-size in order to fit the constraints of this publication.) All modifications were made to the images using Adobe Photoshop. The images were converted to black and white in order to maximize the

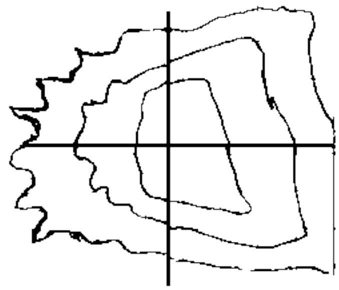


Figure 2.2. Palatography contour tracing

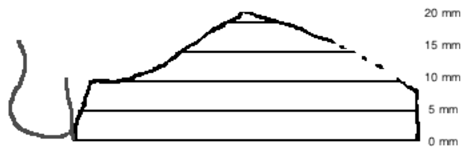


Figure 2.3. Mid-sagittal tracing with horizontal lines added at 5mm intervals from the occlusal plane

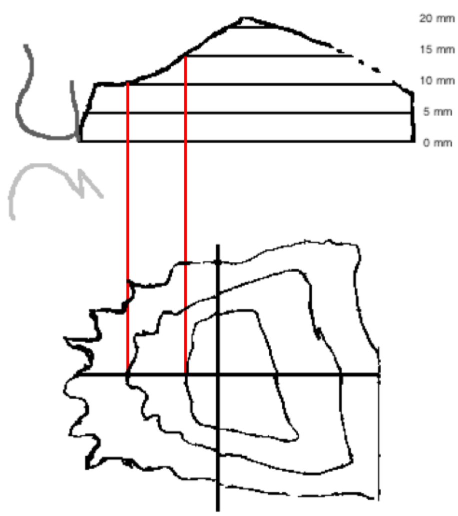


Figure 2.4. Alignment of the palatography contour tracing with the mid-sagittal tracing

contrast of the markings. The length of lines h (horizontal, in the coronal plane, measured from the point between the first and second molar on each side) and v (vertical, in the mid-sagittal plane from the point between the two incisors to the coronal plane) were measured in each image. The ratio of h and v in the image to the life-size h' and v' (determined by measuring their equivalents in the tracing and comparing it with the plaster mold) were calculated and used as correction factors. The images were re-sized to actual size and proportions, such that $h = h'$ and $v = v'$.

Finally, the corrected images were aligned with digital versions of the life-size tracings in order to understand and interpret the gestures involved in the articulations. For each articulation, the extent and place of contact was observed by measuring on the mid-sagittal line the boundaries where the contact begins and ends. These points of boundary were drawn "up" to the mid-sagittal tracing. Then the linguograms were examined to learn what part of the tongue was involved in the articulation and to what extent. From there, the position and shape of the tongue was inferred and drawn on the midsagittal diagram with a dotted-line.

Palatographic studies can then be furthered by taking areal measures of the ratio of contact to non-contact within the area of the occlusal plane bounded by the teeth and the coronal plane. These ratios are then used to compare between different speakers in order to normalize variations in oral anatomy. However, because of the nature of the field situation in which access to speakers was limited, only one speaker was able to be recruited for this palatography study. More speakers would be needed to confirm the conclusions drawn from a single speaker. Nevertheless, the palatographic investigations of one speaker's articulations illuminated the phonetic fieldwork in ways both surprising and revealing.

Chapter 3

Overview of Phonemic System

3.1 Introduction

The following chapter describes in detail the phonemic inventory of Nyagrong Minyag. This chapter provides evidence for the phonemic analysis using phonological reasoning, such as minimal or near-minimal pairs, and uses phonetic evidence, such as acoustic measures and static palatography, to help illustrate phonemic contrasts. Consonants will be discussed first, organized by place and manner of articulation, and then vowels.

3.2 Consonants

The consonant inventory of Nyagrong Minyag, like that of other Rgyalrongic languages, is unusually large. The 42 consonant phonemes are shown in Table 3.1 on page 32. For most consonants, a three-way phonemic distinction for laryngeal setting is observed. Each consonant series is discussed with attention to the articulatory gestures involved in their production.

3.2.1 Labials

There are three bilabial plosives and one nasal, as well as one under-specified labio-dental fricative. The three plosives are characterized by differences in voice-onset time (VOT). Each is formed with a gesture of closure at the lips. Evidence for the phonemic status of each of the bilabial plosives, as well as contrasts with the other two labial phonemes, can be seen in Table 3.2 on page 33.

Regarding labio-dentals, the voiced fricative /v/ is phonemic, while all other labio-dentals are conditioned by their environment. The voiceless [f] occurs before voiceless consonants, e.g., [fkʰɔ]

Table 3.1. Consonant phonemes

	Bilabial	Labio-dental	Denti-Alveolar	Palato-Alveolar	Alveolo-palatal	Post-alveolar	Palatal	Velar	Uvular	Glottal
	p		t					k	q	
Plosive	p^{h}		t^{h}					k^{h}	q^{h}	
	b		d					ɡ		
			ts		tɕ	tʂ				
Affricate			ts^{h}		tɕ^{h}	tʂ^{h}				
			dz		dʑ	dʐ				
			s	ʃ				x	χ	h
Fricative			s^{h}	ʃ^{h}						
		v	z	ʒ				ɣ	ʁ	
Nasal	m		n					ŋ		
Trill			r							
Approx.	(w)						j	w		
Lat. Approx.			l							
Lat. Fric.			ɬ							
			ɬ^{h}							

Table 3.2. Minimal and near-minimal sets for labial consonants

Example	Gloss
/pu/	'male'
/pʰu/	'to collect'
/bu/	'shy'
/mu/	'foot'
/pʰə/	'to beg'
/bə/	'thin'
/xpə/	'fur'
/mə/	'brother'
/və/	'to make'

from /vkʰɔ/ 'to give' or [fsɛ] from /vsɛ/ 'to choose.' Also, [f] never occurs as a single consonant onset preceding a vowel (e.g., *va* 'pig,' but never **fa*. Therefore, [f] and [v] are in complementary distribution with respect to the voicing of the following environment. Another labio-dental [ɱ] is also occasionally observed, but this is the result of an underlying labiodental plus nasal /vn/, e.g., [ɱtʂʰi] from /vntʂʰi/ 'snake.'

3.2.2 Alveolar

Consonants articulated in the alveolar region include three plosives, three affricates, three sibilant (or grooved) fricatives, a nasal, a trill, a lateral approximant, and two lateral fricatives.

3.2.2.1 Plosives

There are three plosives articulated with a gesture targeting the coronal region. Phonemically, they are /t/ /tʰ/ and /d/. Evidence for each one as a phoneme is given in Table 3.3 on page 34. Distinctions between these three phonemes are characterized by differences in voice-onset time (VOT).

Palatographic evidence shown in Figure 3.1 on page 35 suggests that these plosives are formed with the tongue blade making contact with the alveolar region. This is sometimes accompanied by contact between the tongue tip (apex) and the back of the upper teeth. The relatively light markings on the teeth and tongue tip, when compared with the darker markings on the alveolar ridge and tongue blade, suggest that the primary gesture is the tongue blade making contact with the alveolar

Table 3.3. Minimal and near-minimal sets for denti-alveolar plosives

Example	Gloss
/ty/	‘handle’
/tʰy/	‘lightning’
/dy/	‘suffering’
/xtə/	‘to put’
/tʰə/	‘to burn’
/də/	POSS
/ti/	‘good’
/tʰi/	‘correct’
/di/	NEG.IMP

ridge and that the apical-dental contact is secondary or optional. It is possible that this speaker’s relatively steep slope along the back of the upper front teeth contributes to this contact as the tongue tip is pointed forward in this laminal gesture. We can, therefore, with a moderate degree of confidence based upon the evidence from palatography and comparison with other alveolar segments, say that this segment is a laminal alveolar plosive [t̻]. Static palatography with more speakers is needed to confirm this.

3.2.2.2 Sonorants

Three sonorants are observed in the coronal region: a nasal, a lateral approximant, and a trill. They are distinct phonemes (see evidence in Table 3.4 on page 35).

Beginning with the nasal, the palatogram in Figure 3.2 on page 36 shows that there is contact at the alveolar ridge near the 10mm line. The linguogram has markings on the tongue blade, with relatively light markings on the tongue tip, which indicates that the tongue tip is extended toward the teeth. It appears that the primary gesture is the tongue blade extending toward the alveolar ridge. The apical markings in the linguogram could be a result of the tongue tip incidentally touching the backs of the upper teeth, as this speaker appears to have a particularly steep dental slope. Therefore, this segment is identified as a laminal alveolar nasal: [n̻].

The lateral approximant also contrasts with the other sonorants, as shown in Table 3.4 on page 35. From an articulatory standpoint, contact between the articulators is similar to that of the alveolar

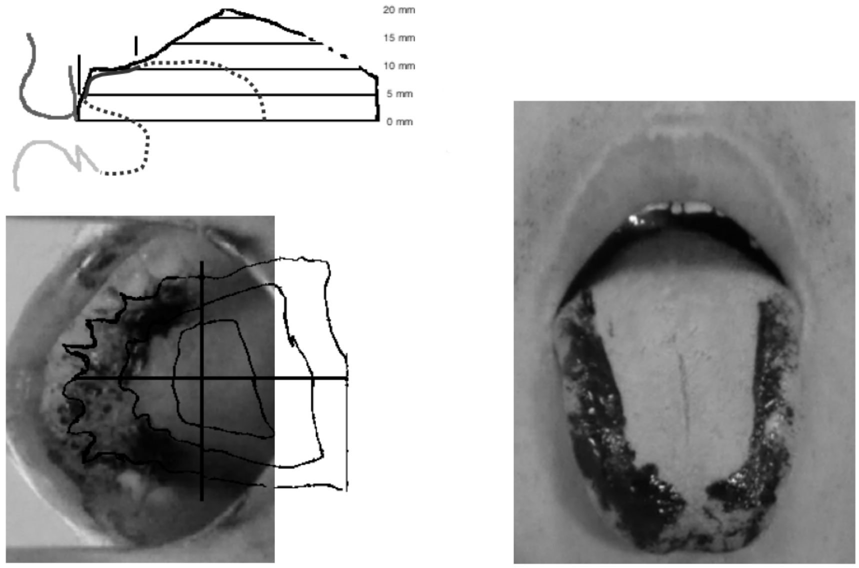


Figure 3.1. Palatogram and linguogram of *fta* ‘to remove’ with aligned mid-sagittal diagram and inferred tongue shape for laminal alveolar plosive [t̻]

Table 3.4. Minimal and near-minimal sets for denti-alveolar sonorants

Example	Gloss
/nə/	‘to rest’
/rə/	POL
/lə/	‘song’
/nu/	‘in’
/lu/	‘wide’
/fru/	‘tent’
/nɔ/	‘to sink’
/rɔ/	‘to buy’
/pɛlɔ/	‘tree’
/ni/	‘you’
/ri/	‘to stand’
/fli/	‘to release’

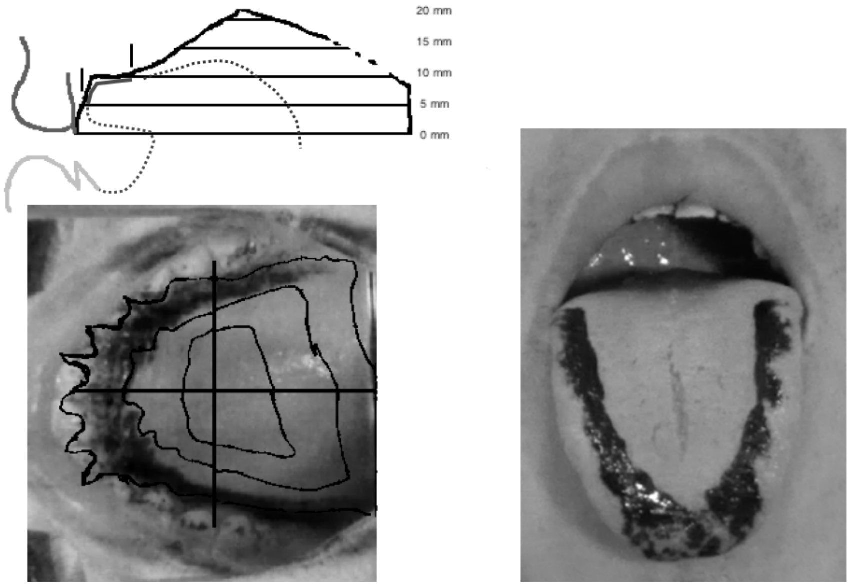


Figure 3.2. Palatogram and linguogram of *na* ‘fish’ with aligned mid-sagittal diagram and inferred tongue shape for laminal alveolar nasal [n̻]

plosives and nasal. Primary contact is between the tongue blade and the alveolar ridge, making this a laminal alveolar lateral approximant: [l̻]. Slight contact is also observed between the tongue tip and the backs of the upper teeth, which could be due to this speaker’s relatively steep dentition. As seen in Figure 3.3 on page 37, there is very little contact between the tongue body and any area posterior to the alveolar ridge. This indicates that the tongue body must remain relatively low throughout the articulation of this sound in order to allow airflow over the sides of the tongue. This is in keeping with the general expectations of the articulation of lateral approximants.

The final sonorant is a trill, which is distinct from other sonorants (as seen in the minimal and near-minimal sets in Table 3.4 on page 35) and other alveolar plosives (as seen in Table 3.5 on page 37).

Among the more unexpected observations revealed by the palatographic investigations is that this Nyagrong Minyag speaker has an apical dental trill: [r̪]. Figure 3.4 on page 38 shows contact just behind the teeth in the post-dental region. The linguogram in Figure 3.4 shows narrow contact up the sides of the tongue, toward the apex. Typologically, dental trills are less common than alveolar trills. According to Maddieson (1984), only two percent of the 451 languages they surveyed have this sound, compared to twenty-one percent with alveolar trills.

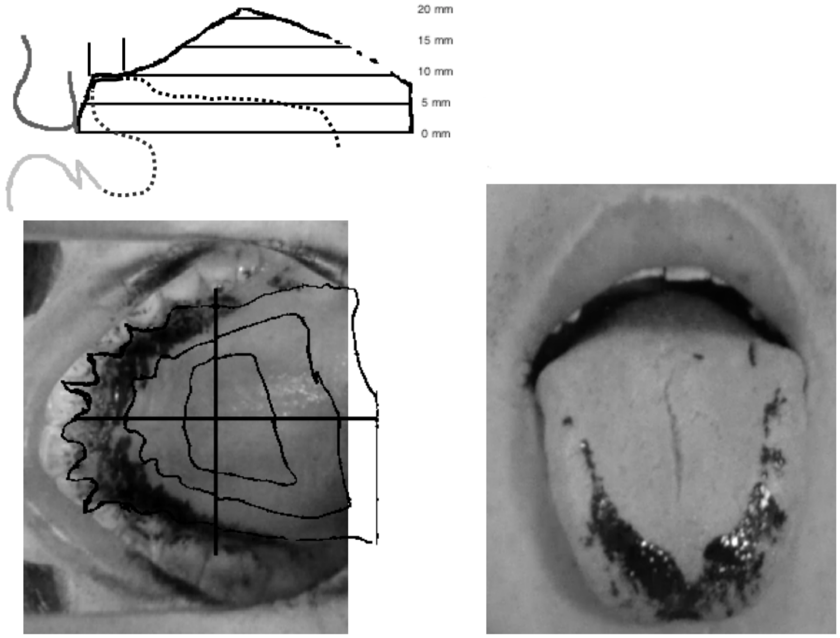


Figure 3.3. Palatogram and linguogram of *la* ‘tree’ with aligned mid-sagittal diagram and inferred tongue shape for laminal alveolar nasal [l̻]

Table 3.5. Minimal and near-minimal sets for trills and alveolar stops

Example	Gloss
/ti/	‘good’
/di/	‘small’
/ri/	‘to stand’
/tɔ/	‘to beat’
/rɔ/	‘to buy’
/ty/	‘handle’
/t^hy/	‘lightning’
/dy/	‘suffering’
/dʑyry/	‘extrusion’

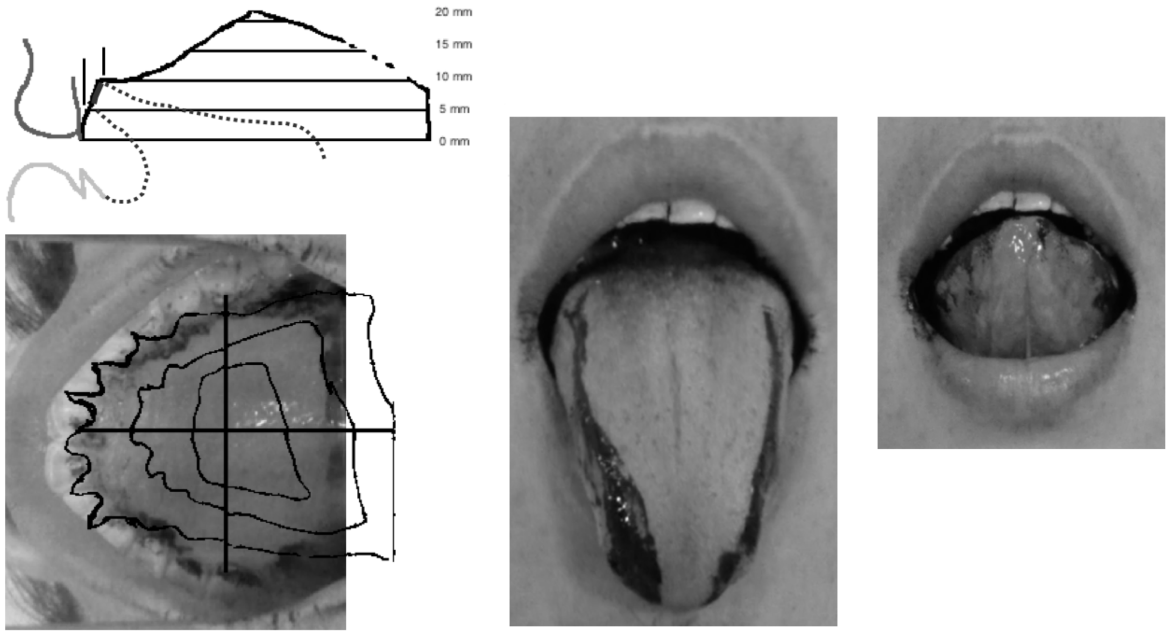


Figure 3.4. Palatogram and linguogram of *raka* 'PL' with aligned mid-sagittal diagram and inferred tongue shape for apical dental trill [r̪]

In Figure 3.4, the markings show an apparent mismatch, but this can be explained by the inherent phonetic variation of this segment, which has been preserved by the palatographic process since palatograms and linguograms show different tokens of the same segment (in the same word). The palatogram shows very light contact on the backs of the upper teeth, or perhaps just behind the teeth. The light contact is likely a result of the manner of this articulation. Trills require very precise aerodynamic conditions in order for pulsing to occur. The primary articulator makes very light contact when pulsing takes place, which appears to have happened in the articulation depicted in the palatogram. In the linguogram, on the other hand, there is no apical contact made during this particular articulation. Trills quite commonly vary with articulations in which no tongue pulsing takes place because of the delicate aerodynamic requirements. This appears to be the case with the articulation depicted in this linguogram.

3.2.2.3 Affricates

The three anterior affricates in this language include a plain /ts/, aspirated /tsʰ/ and voiced /dz/. Table 3.6 shows that these three affricates are phonemically distinct from one another.

Table 3.6. Minimal and near-minimal sets for denti-alveolar affricates

Example	Gloss
/tsu/	'edge'
/fts^{h}u/	'milk'
/ts^{h}y/	'salt'
/hdzy/	'to churn'
/ts^{h}ak^{h}i/	'hot'
/dzaki/	'moon'
/tsə/	'food'
/dzə/	'to eat'
/ndzə/	'to hide'

Affricates involve multiple articulatory gestures, generally at the same or nearly the same point of articulation. This affricate is articulated with the tongue blade making contact with the alveolar ridge, first for a stop, then the tongue makes a groove to allow a high-frequency rush of air that strikes the back of the upper teeth to form a sibilant fricative. Because static palatography shows a record of the accumulation of contact between the articulators, seeing the exact contact from each portion of the affricate (i.e., the stop and the fricative) is not possible. However, it can be inferred from the linguogram in Figure 3.5 on page 40 that the primary gesture is with the tongue blade, and, from the palatogram in Figure 3.5, that there can be optional apical-dental contact as well.

Differences between these affricates and the other two places of articulation for affricates will be discussed in Chapter 5. Specifically, the claim that this affricate is laminal will become relevant when looking at an apical affricate in section 3.2.5.

3.2.2.4 Sibilant (or grooved) fricatives

Like other obstruents, there are three contrasting phonemes that can be described as alveolar grooved fricatives (or sibilants): /s/, /s^{h}/, and /z/. Minimal or near-minimal sets exemplify their phonemic contrasts in Table 3.7 on page 40.

To form these sibilants, the speaker creates a groove with the tongue to channel air at a high velocity, which creates a high-frequency sound when a turbulent stream of air strikes the backs of the upper teeth. The palatogram and linguogram in Figure 3.6 on page 41 show that the tongue blade

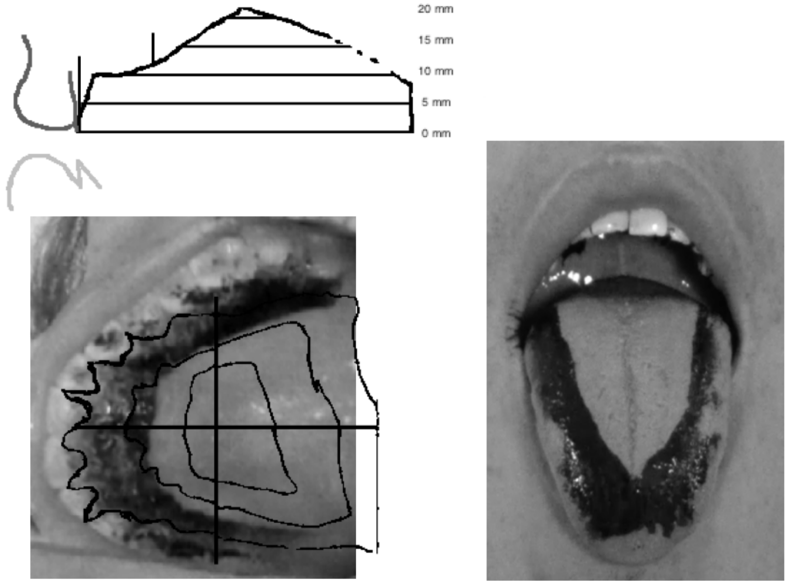


Figure 3.5. Palatogram and linguogram of *ts^{h}a* ‘goat’ with aligned mid-sagittal diagram for laminal alveolar affricate [t̪s̪]

Table 3.7. Minimal and near-minimal sets for alveolar sibilant fricatives

Example	Gloss
/səpu/	‘plant’
/s^{h}ə/	‘liver’
/zə/	‘son’
/sɛ/	‘gold’
/xsɛ/	‘glue’
/xs^{h}ɛ/	‘new’
/zɛ/	‘root vegetable’
/s^{h}arə/	‘fear’
/sarbu/	‘new’
/fza/	‘dirty’

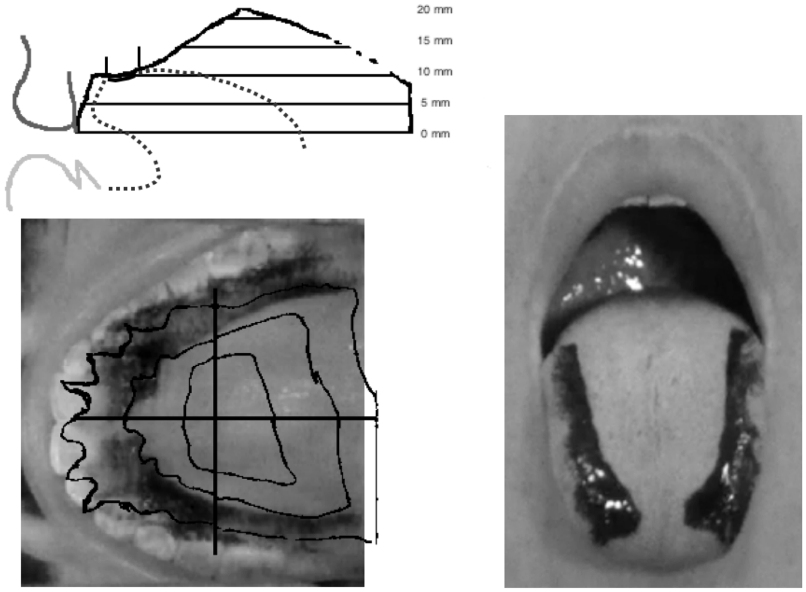


Figure 3.6. Palatogram and linguogram of *sa* ‘to die’ with aligned mid-sagittal diagram and inferred tongue shape for laminal alveolar sibilant

makes contact with the alveolar ridge. Therefore, this segment is a laminal alveolar sibilant fricative [s̻]. The tongue tip is down and the tongue body is relatively low. Because of the groove of the tongue during this articulation, it is not possible to represent with complete accuracy the shape of the tongue in the mid-sagittal line. Instead, the contact follows the 10mm line, and thus it is inferred that the tongue blade makes contact at this point. The reconstructed outline of the tongue in Figure 3.6 represents the sides of the tongue, rather than the position in the mid-line.

The contrasting plain /s/ and aspirated /sʰ/ are typologically unusual. Maddieson’s (1984) survey of 451 languages finds only 0.67% contain an aspirated sibilant, though they are relatively common in nearby related Tibeto-Burman languages of which Maddieson’s survey contains very few. Differences in VOT are observed between these, but these and the other aspirated fricatives, including their acoustic correlates, are investigated in greater detail in Chapter 5.

3.2.2.5 Lateral fricatives

Finally, the last series of alveolar consonants is a pair of lateral fricatives. There are both plain and aspirated lateral fricatives contrasting phonemically, as shown in Table 3.8. The voiced lateral fricative [ɮ] only occurs when voicing spreads from a nearby voiced segment to a plain lateral fricative (e.g., *kała* > [kaɮa] 'easy'), or when frication spreads from a nearby fricative to a lateral (e.g., *vli* > [vɮi] 'tongue'). The voiced lateral fricative [ɮ] can thus be seen as an allophone of either /ɬ/ or /l/.

Table 3.8. Minimal and near-minimal sets for denti-alveolar lateral fricatives

Example	Gloss
/ɬə/	'month'
/ɬʰə/	'field'
/ɬa/	'easy'
/ɬʰa/	'hand'
/ɬi/	'trough'
/ɬʰi/	'wheat'
/ɬu/	'time-consuming'
/ɬʰu/	'wood'

To articulate this lateral fricative, the speaker places her/his tongue blade on the alveolar ridge (with optional apical contact on the backs of the upper teeth), and allows a turbulent airflow over the sides of the tongue, while maintaining a very narrow constriction between the sides of the tongue body and the sides of the hard palate and molars. Because complete constriction is formed with the tongue blade on the alveolar ridge, this is a laminal alveolar lateral fricative [ɬ̻]. By examining the contact markings in the palatogram and linguogram in Figure 3.7 on page 43, it is apparent that the tongue is much higher in the mouth during the articulation of this sound than in the lateral approximant in Figure 3.3 on page 37.

Acoustic correlates of the lateral fricatives, which allow for listeners to discriminate between the plain /ɬ/ and aspirated /ɬʰ/, are discussed in more detail in Chapter 5.

3.2.3 Palato-alveolar

Nyagrong Minyag also contains another set of sibilants that contrast in three ways, which are characterized by a post- or palato-alveolar gesture. Like other sets of obstruents in the language, it has plain /ʃ/, aspirated /ʃʰ/, and voiced /ʒ/, all contrasting phonemically. Table 3.9 on page 43 illustrates these contrasts.

As the palatogram in Figure 3.8 on page 44 shows, this fricative appears to be purely laminal (not optionally apico-laminal as in the alveolars in the previous section). The contact is much wider on

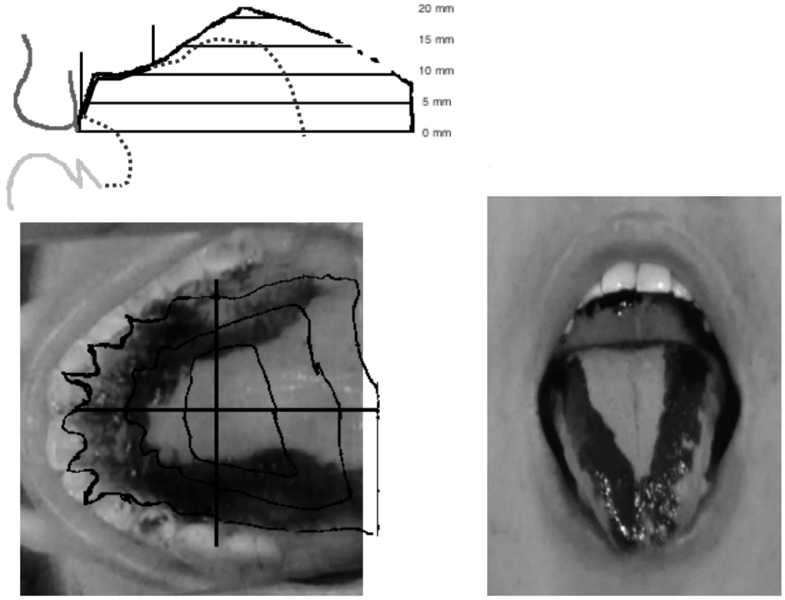


Figure 3.7. Palatogram and linguogram of *ɬa* ‘four’ with aligned mid-sagittal diagram and inferred tongue shape for laminal alveolar lateral fricative [ɬ̻]

Table 3.9. Minimal and near-minimal sets for palato-alveolar grooved fricatives

Example	Gloss
/ʃə/	‘tooth’
/ʃʰə/	‘louse’
/ʒə/	‘ghost’
/ʃi/	‘barley’
/ʃʰi/	‘plane (tool)’
/ʒi/	‘horse’
/ʃɔ/	‘to go’
/ʃʰɔvə/	‘careless’
/ʒɔ/	‘water’
/ʃʰy/	‘to send’
/ʒy/	‘dry’

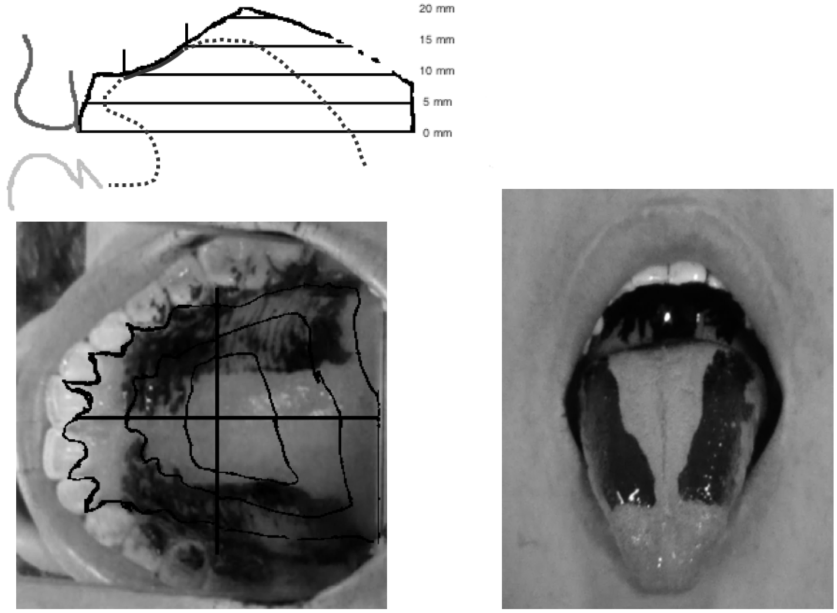


Figure 3.8. Palatogram and linguogram of *ʃa(ʃi)* ‘bundle’ with aligned mid-sagittal diagram and inferred tongue shape for palato-alveolar sibilant [ʃ]

the tongue and, on the palate, occurs entirely behind the alveolar ridge. The wider contact suggests that the tongue body is high in the mouth and has a “domed” shape (as opposed to “flat”). Compared to the laminal alveolar sibilant shown in Figure 3.6 on page 41, which shows a rather flat tongue, the tongue gesture in this palato-alveolar sibilant is much higher in the mouth.

3.2.4 Alveolo-palatal

The three affricates in the alveolo-palatal place of articulation are /tɕ/, /tɕ^h/ and /dʑ/. Evidence for phonemic contrasts among these three is found in Table 3.10.

Figure 3.9 on page 46 shows the accumulation of contact in the production of [tɕ^h] in tɕ^{h}a ‘pair.’ It appears that the primary gesture in this affricate involves the tongue blade making contact with the post-alveolar region. The tongue appears to be bunched up in the top of the mouth during this articulation, and this allows for markings that are relatively wide and back. This bunching of the tongue is consistent with the palatalization that characterizes alveolo-palatals, which are also called palatalized post-alveolars (?). The active articulator in this sound is laminal and the tongue shape is domed, which contrasts with the other post-alveolar series /tʂ tʂ^h dʐ/, which has an apical active articulator and a flat tongue shape. Both the alveolo-palatal (i.e., laminal post-alveolar) series /tɕ tɕ^h

Table 3.10. Minimal and near-minimal sets for alveolo-palatal affricates

Example	Gloss
/tɕi/	'road'
/tɕʰi/	'big'
/dʑi/	'long'
/χtɕy/	'barley flour'
/tɕʰy/	'hot'
/dʑy/	'tea'
/ftɕɔ/	'rat'
/tɕʰɔ/	'bad'
/dʑɔ/	'to hang'
/tɕwa/	'suitable'
/tɕʰwa/	'to even'
/ndʑwa/	'fast'

dʑ/ and the retroflex (i.e., apical post-alveolar) series /tʂ tʂʰ dʐ/ are characterized as [-anterior], while the other series /ts tsʰ dz/ is [+anterior].

It is important to note that there is a rather unexpected assymetry between these alveolo-palatal affricates and the palato-alveolar fricatives discussed in the previous section. Evidence from the palatography suggests that these are the correct place-of-articulation descriptions for these segments. Other clues, such as formant transitions in following vowels, corroborate this. This will be explored in greater depth in Chapter 5.

3.2.5 Post-alveolar

The final set of coronals is the set of three contrasting post-alveolar affricates: /tʂ/, /tʂʰ/ and /dʐ/. These three are phonemically distinct sounds, as shown in Table 3.11.

As shown in Figure 3.10 on page 47, there is much less accumulation of contact than in the other affricates. This suggests that the gesture involved in articulating these sounds is quite different from the alveolar and aveolo-palatal affricates. The linguogram in Figure 3.10 shows that the tongue tip or apex has heavy markings, but that the underside of the tongue does not. (Some dripping has occurred under the tongue, but the markings are not enough to suggest that this there is sub-apical contact.)

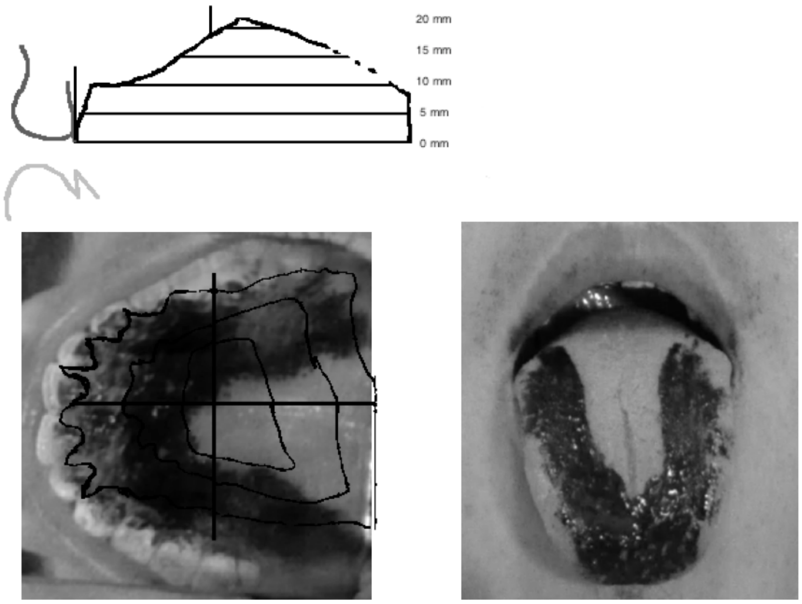


Figure 3.9. Palatogram and linguogram of *tɕʰa* ‘pair’ with aligned mid-sagittal diagram and for alveolo-palatal affricate [tɕ]

Table 3.11. Minimal and near-minimal sets for post-alveolar affricates

Example	Gloss
/tʂi/	‘mule’
/tʂʰi/	‘depth’
/ndʐi/	‘wood (for pillar)’
/ftʂu/	‘plow’
/ftʂʰu/	‘bright’
/dʐu/	‘straight’
/tʂə/	‘tendon’
/ftʂʰə/	‘to hold’
/ndʐə/	‘to distribute’
/tʂɛlwa/	‘root’
/ftʂʰɛ/	‘to tie up’
/dʐɛ/	‘second floor’
/tʂarara/	‘locust’
/tʂʰama/	‘glass’

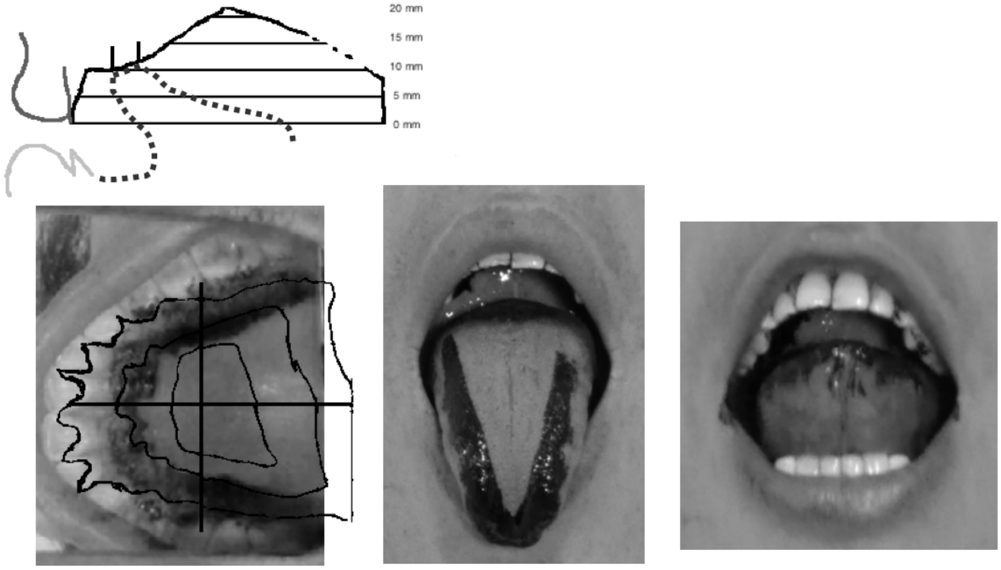


Figure 3.10. Palatogram and linguogram of *tʂ*^{h}*ama* 'window' with aligned mid-sagittal diagram and inferred tongue shape for apical post-alveolar affricate [t̠s̠]

This suggests, therefore, that these are apical post-alveolars [t̠s̠], etc., rather than true retroflexes, which would be sub-apical palatal. For convenience, however, I have chosen to use retroflex symbols /tʂ/, /tʂ^{h}/ and /dʐ/ to represent these phonemes in order to be consistent with conventions in the literature on closely related languages.

That there appears to be less accumulated contact in this affricate is corroborated by acoustic evidence as well. Periods of frication are much shorter in the post-alveolar affricates than either the alveolar or alveolo-palatal affricates. These and other issues relating to affricates and fricatives will be explored in greater depth in Chapter 5.

3.2.6 Comparing affricates

The three places of articulation for affricates are all distinct, and not conditioned by any phonological environments. Evidence for their contrasting phonemic status is seen in Table 3.12, which shows minimal or near-minimal sets for affricates across place of articulation, organized by laryngeal setting (unaspirated, aspirated and voiced).

Table 3.12. Minimal and near-minimal sets for affricates of different places of articulation, organized by laryngeal setting

Unaspirated		Aspirated		Voiced	
Example	Gloss	Example	Gloss	Example	Gloss
/tsə/	'food'	/ts^{h}y/	'salt'	/dzə/	'to eat'
/tɕə/	'handspan'	/tɕ^{h}y/	'hot'	/dʒə/	'to melt'
/tʂə/	'tendon'	/tʂ^{h}y/	'cloth'	/ndʐə/	'to distribute'
/tsu/	'edge'	/tɕ^{h}i/	'big'	/hdzy/	'to churn'
/tɕu/	'metal'	/tʂ^{h}i/	'depth'	/dʑy/	'tea'
/ftʂu/	'plow'	/fts^{h}u/	'to milk'	/ndʐy/	'dragon'
		/ftʂ^{h}u/	'bright'		

3.2.7 Velar/Palatal

3.2.7.1 Plosives

There are three velar plosives: /k/, /k^{h}/ and /g/. They are phonemically distinctive as shown in Table 3.13 on page 49. The plosives are characterized by differences in VOT. When immediately followed by a front vowel, velars are fronted to palatals. (This includes all non-continuant velar segments, i.e., stops, fricatives, and nasal.)

$$\begin{bmatrix} + \text{consonantal} \\ + \text{high} \end{bmatrix} \rightarrow \begin{bmatrix} \text{- back} \end{bmatrix} / \_\begin{bmatrix} - \text{consonantal} \\ + \text{front} \end{bmatrix}$$

3.2.7.2 Fricatives

There are two velar fricatives: voiceless /x/ and voiced /ɣ/. They contrast phonemically, as shown in Table 3.13 on page 49. When followed by front vowels, /x/ and /ɣ/ become [ç] and [ʝ], respectively. Acoustically, this pair is distinguished by a voicing bar present throughout the [ɣ], and absent for [x].

3.2.7.3 Nasal

There is also a velar nasal phoneme /ŋ/ which is distinct from other velars as shown in Table 3.13 on page 49. When followed by a front vowel, /ŋ/ becomes palatal [ɲ].

Table 3.13. Minimal and near-minimal sets for velars and palatals

Example	Gloss
/rkɔ/	‘to go to bed’
/kʰɔ/	‘dog’
/gɔ/	‘to gather’
/ɣɔ/	‘house’
/ŋɔrŋɔ/	‘green’
/rku/	‘to love’
/rkʰu/	‘robe’
/rgu/	‘dinner’
/ŋu/	‘pain’
/xu/	‘fat’
/ɣu/	‘bundle’
/rawu/	‘old horse’
/kavu/	‘pillar’
/kʰavu/	‘snow’
/ŋa/	‘I’
/waja/	‘to agree’
/kɛ/	‘year’
/kʰɛ/	‘key’
/ŋgɛ/	‘to bloom’
/ŋɛ/	‘five’
/ɣɛ/	‘to grow’

3.2.7.4 Approximants

Two approximants or glides are found phonemically in Nyagrong Minyag as well. The palatal approximant /j/ is formed with the tongue body high in the mouth, moving toward the hard palate, but not back. The labio-velar approximant /w/ is formed with the tongue body moving high and back toward the velum and with simultaneous rounding of the lips. Evidence for each of these as phonemes can be seen in Table 3.13 on page 49.

3.2.8 Uvular

Two uvular stops and two uvular fricatives are found phonemically in Nyagrong Minyag. They are phonemically distinctive from one another and from velars, which are also back consonants. Evidence for these contrasts is shown in Table 3.14 on page 51. The uvular consonants are articulated with the back of the tongue body moving toward the uvula. For stops, there is only a two-way contrast plain /q/ and aspirated /qʰ/, as opposed to the three-way series (including a voiced counterpart) observed for most of the other consonants in this language. The absence of a voiced uvular stop [ɢ] is not unexpected as the place of articulation of this consonant creates closure at a point sufficiently back to make it difficult for speakers to create the necessary pressure differential between the supra- and sub-glottal cavities, as the supra-glottal cavity is significantly smaller than in more front closures (e.g., bilabial, alveolar, etc.)

The language also contains a pair of uvular fricatives: voiceless [χ] and voiced [ʁ]. They are articulated with the back of the tongue body moving toward the uvula, but leaving a degree of openness to allow for airflow. The voiced uvular [ʁ] is generally more of a uvular approximant than a fricative, as it shows little to no frication.

It is notable that there are no aspirated versions of the back fricatives $*x^h$ or $*\chi^h$ in Nyagrong Minyag. Although most consonant series, including fricatives, come in sets of three—plain, voiced and aspirated—both the velar and the uvular lack an apsirated version. Aspirated velar x^h is attested in related languages Cone and Melung Tibetan (Jacques 2011), while χ^h is apparently unattested in any language. This likely has a phonetic explanation. In order to produce an aspirated consonant, a speaker must build up pressure behind a closure in the vocal tract. When producing an aspirated fricative, the effort required to build pressure is greater because the airflow is not completely impeded (due to the constant flow of air through the point of constriction). In an aspirated fricative produced in the back of the vocal tract (velar or uvular), building up enough air pressure would be greatly challenged by the shortened vocal tract, i.e., distance from the glottis to the place of articulation.

Table 3.14. Minimal and near-minimal sets for velars and uvulars

Example	Gloss
/xa/	‘strength’
/ɣa/	‘fox’
/qa/	‘crack’
/qʰa/	‘laugh’
/ʁa/	‘door’
/rku/	‘leg’
/rkʰu/	‘robe’
/xu/	‘fat’
/ɣu/	‘bundle’
/qu/	‘valley’
/χu/	‘to stare’
/ʁu/	‘ten’
/rkɔ/	‘to go to bed’
/kʰɔ/	‘dog’
/fxɔ/	‘to wear’
/ɣɔ/	‘pillow’
/qɔ/	‘horn’
/χɔχɔ/	‘empty’
/ʁɔ/	‘in’

3.2.9 Glottal

Finally, there is a voiceless glottal fricative /h/. It contrasts phonemically with other fricatives as seen in Table 3.15 on page 52. This phone is rare in CV syllables, but commonly precedes other consonants in CCV syllables. The behavior of this phoneme in initial consonant clusters is explored in greater depth in Chapter 4.

Table 3.15. Minimal and near-minimal sets for glottals

Example	Gloss
/ha/	'how'
/s^{h}a/	'to die'
/ʃaʃi/	'bundle'
/hɔrdʑɛ/	'sitting platform'
/ʃɔ/	'to go'

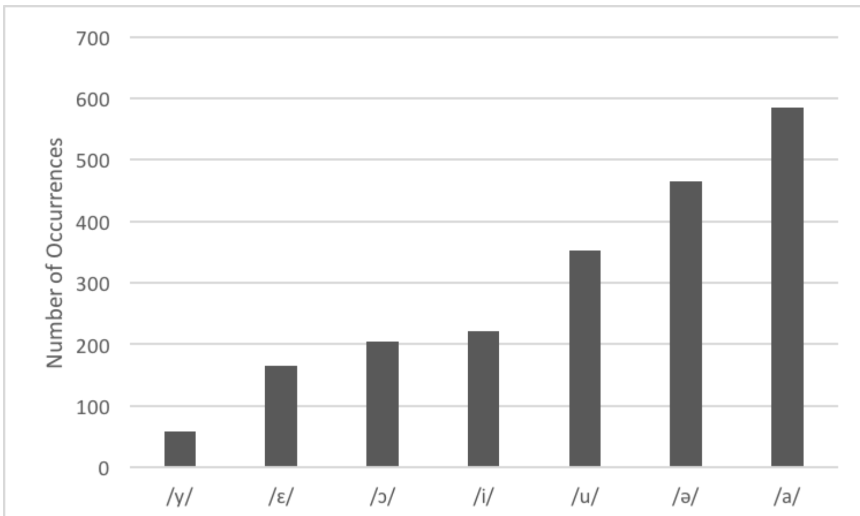


Figure 3.11. Frequency of vowel phonemes in a lexical database of 1,248 entries

3.3 Vowels

Nyagrong Minyag has seven vowels: /i/, /y/, /u/, /ə/, /ɛ/, /ɔ/ and /a/. The vowel space is represented phonologically in Figure 3.12 on page 54. Each of these is a separate phoneme; evidence for their phonemic contrasts can be found in Table 3.16 on page 54. Figure X shows the lexical frequency for each of these vowels from a database of 1,248 lexical entries. The most frequent vowel in the lexical database is /a/, while the least frequent is /y/.

Figure 3.13 on page 55 plots measurements at the midpoints of vowels for twenty Nyagrong Minyag speakers. The values have been converted from raw Hertz values to normalized values around a $(0, 0)$ centroid. This plot shows the areas of greatest density for each vowel at its midpoint. For each vowel in this density plot, the center-most shape shows the highest concentration of values, and the surrounding concentric shapes show the density of that vowel's points within that area.

A few vowel alternations are observed in Nyagrong Minyag. The mid-central vowel [ə] is raised to [ɨ] when it follows alevolo-palatals [tɕ $tɕ^h$ dʑ], alveolars [s s^h z] and [ts ts^h dz], and post-alveolars [tʂ $tʂ^h$ dʐ], but not before alveolar stops [t t^h d]. For example, *tsə* > [tsɨ] 'food' and *zə* > [zɨ] 'son,' but *dəku* > [dəku] but not *[dɨku]. This raising, therefore, happens after coronal consonants that are continuant. This is likely due to the tongue being in a forward position for an extended period of time in an affricate, but only momentarily in the case of a stop.

$$\text{ə} \rightarrow \text{ɨ} \; / \begin{bmatrix} \text{coronal} \\ \text{+continuant} \end{bmatrix} \_$$

Another alternation involves the low vowel [a] in the environment of rounding. When [a] follows labio-velar glide [w], it becomes a rounded low vowel, in between [ɒ̹] and [ɔ̹]. For example, *pwa* becomes [pwɔ̹] or [pwɒ̹] 'to kiss' and *twa* becomes [twɔ̹] or [twɒ̹] 'to pluck.' Presumably, the labio-velar glide [w], which is produced with lip rounding, passes the feature [+rounded] to the following vowel.

$$\begin{bmatrix} \text{+syllabic} \\ \text{+low} \end{bmatrix} \rightarrow \begin{bmatrix} \text{+rounded} \end{bmatrix} / \begin{bmatrix} \text{+approximant} \\ \text{+rounded} \end{bmatrix} \_$$

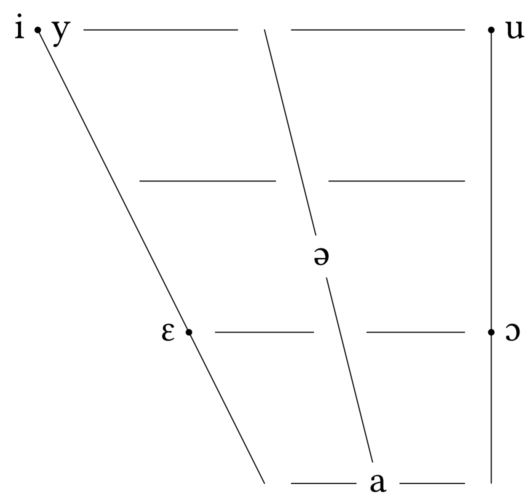


Figure 3.12. Phonemic vowel space

Table 3.16. Minimal and near minimal sets for vowel phonemes

Example	Gloss
/ɣi/	‘sheep’
/ɣy/	‘light’
/ɣɛ/	‘to grow’
/ɣa/	‘fox’
/ɣə/	POSS
/ɣu/	‘bundle’
/ɣɔ/	‘pillow’
/ni/	‘you’
/nɛ/	‘breast’
/na/	‘dark’
/nə/	‘to rest’
/nu/	‘in’
/nɔ/	‘to sink’
/nyri/	‘behind’

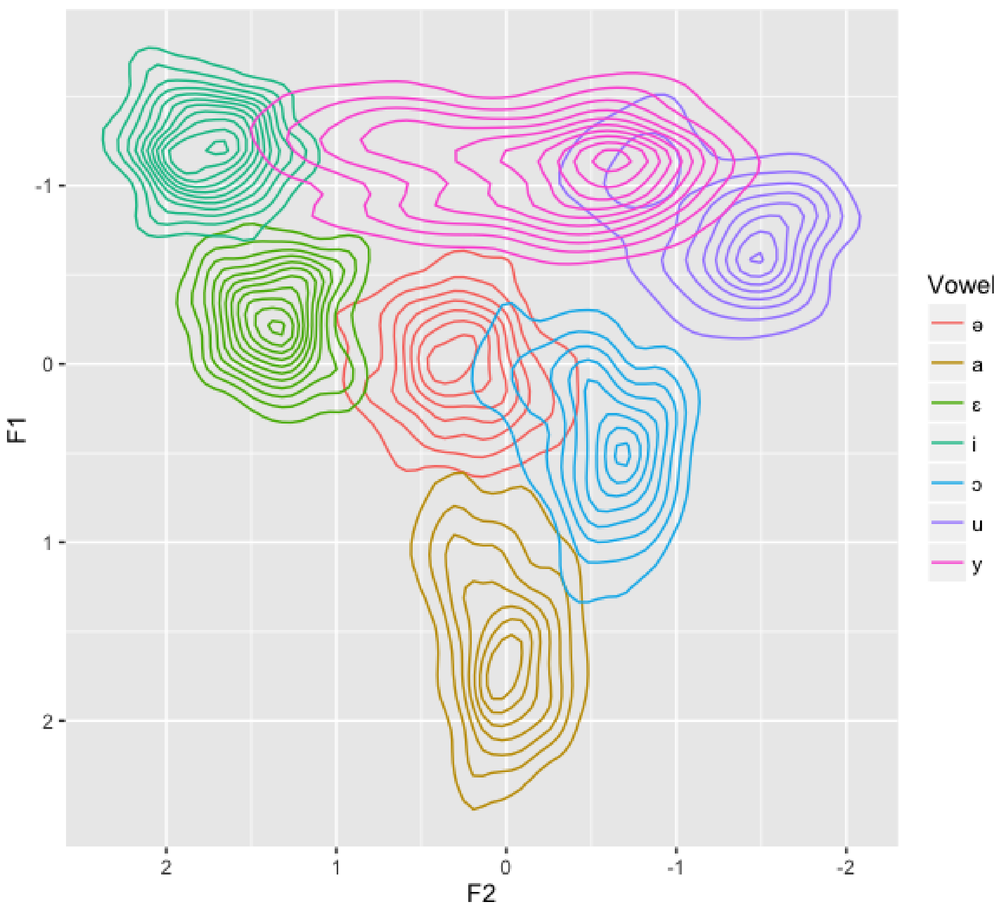


Figure 3.13. Density plots of midpoints of vowels from 20 speakers, normalized using the Lobanov method

Chapter 4

Syllables, Phonotactics and Related Phonological Processes

This chapter provides details on the syllable structure of Nyagrong Minyag, as well as the phonetics and phonology of the clustering of phones into syllables. Because Nyagrong Minyag allows for complex initial clusters and no underlying codas, particular attention will be paid in this chapter to the onsets of syllables.

4.1 Syllable structure

Syllables in Nyagrong Minyag are generally open, and are composed minimally of a single vowel, V, and maximally of a four-consonant onset plus up to two vowels, CCCCVV. Observed syllables, with examples, are given in Table 4.1 on page 57. Underlyingly, syllables do not contain codas, but codas can occur phonetically when a following consonant cluster resyllabifies or when a final vowel is deleted. This happens both within a word (e.g., /qwa.rwa/ > [qwar.wa] 'spider') and across word boundaries (e.g., /k^{h}ɔ ɦnɛ/ > [k^{h}ɔi̯ nɛ] 'two dogs'). In polysyllabic words, final vowels are sometimes deleted, e.g., /katɕ^{h}i/ > [katɕ^{h}] 'big'; in this case the final aspiration portion of [tɕ^{h}] is longer in duration and becomes a voiceless vowel [i̥].

The nucleus of a syllable is generally a single vowel. Only one vowel combination [ai̯] has been observed in the underlying lexical forms of words, and there is no evidence that it is a true, phonemic diphthong. Other seeming [V][V] combinations are actually a result of pre-initial consonant mutations, usually [h ɦ] or [x ɣ], in the environment of a preceding vowel. These will be discussed futher in Section 4.2.6.

In syllable onsets, Nyagrong Minyag allows up to four consonants to cluster together. Because there are 41 consonant phonemes and these can cluster together in the onset, Nyagrong Minyag allows

Table 4.1. Syllable types with examples

CV pattern	Examples	Gloss
V	/aba/	‘father’
	/ərənɔ/	‘Nyagrong’
CV	/ɬi/	‘trough’
	/pu/	‘full’
CCV	/pwa/	‘to kiss’
	/rgy/	‘animal’
CCCV	/brwa/	‘to burn (TR)’
	/mbwa/	‘gift’
	/fntʂ̩ʰi/	‘snake’
CCCCV	/hprwa/	‘to burn (INTR)’

for a dizzying number of initial onsets. Only one position within an initial onset cluster freely allows for any consonant to occur. We will call consonants in this position “initial” (C_i). We can further distinguish between those consonants which occur before an initial obstruent (we will call these “pre-initials”) and those which occur after the initial obstruent but before the vowel. Disambiguating between these two positions helps reveal generalizations about the syllable structure and phonotactics in this language. Although it may seem strange to label segments as “initial,” even when they do not appear as the first segment in a syllable with a complex onset, I have chosen to maintain these terms—“initial” and “pre-initial”—in order to be consistent with the literature on nearby related languages, e.g., Manqing dialect of Nyagrong Minyag (Suzuki 2009, 2010), Wobzi Lavrung (Lai 2017), Japhug (Jacques 2004), etc.

The pre-initials are all fricatives, approximants or nasals, and their sonority is greater than or equal to the initial consonant. In natural speech, pre-initials are observed to be subtle, and are sometimes deleted altogether. The combination of one pre-initial with an initial, CC_iV, is the most prolific type of cluster in Nyagrong Minyag. The observed CC_iV consonant clusters are shown in Table 4.2 on page 58.

When taken together, pre-initial consonants produce clear phonemic contrasts, which can be observed in the minimal sets in Table 4.3 on page 59. Some features of pre-initials, such as voicing

Table 4.2. Onset clusters with one pre-initial

	p-	pʰ-	b-	m-	v-	t-	tʰ-	d-	ts-	tsʰ-	dz-	s-	sʰ-	z-	n-	r-	l-	ɬ-	ɬʰ-	ʃ-	ʃʰ-	ʒ-	tɕ-	tɕʰ-	dʑ-	tʂ-	tʂʰ-	dʐ-	j-	k-	kʰ-	g-	x-	ɣ-	ŋ-	w-	q-	qʰ-	χ-	ʁ-	h-
n-	mp-	mpʰ-	mb-			nt-	ntʰ-	nd-	nts-		ndz-			nz-								nʒ-	ntɕ-	ntɕʰ-	ndʑ-	ntʂ-	ntʂʰ-	ndʐ-				ŋg-					ɴq-				
v-						ft-	ftʰ-		fts-	ftsʰ-		fs-	fsʰ-	vz-	vn-	vr-	vl-	fɬ-	fɬʰ-	fʃ-	fʃʰ-	vʒ-	ftɕ-	ftɕʰ-	vdʑ	ftʂ-	ftʂʰ-			fk-	fkʰ-		fx-	vɣ-	vŋ-		fq-				
r-			rb-	rm-		r̥t-		rd-	r̥ts-	rtsʰ-	rdz-			rz-						r̥ʃ-					rdʑ-				rj-	r̥k-	r̥kʰ-	rg-				rw-				rʁ-	
j-																																				jw-				jʁ-	
x-	xp-	xpʰ-		ɣm-	ɣv-	xt-	xtʰ-		xts-	xtsʰ-		xs-	xsʰ-		ɣn-		ɣl-					ɣʒ-	xtɕ-			xtʂ-	xtʂʰ-			xk-	xkʰ-										
χ-	χp-					χt-		ʁd-	χts-	χtsʰ-		χs-		ʁz-	ʁn-	ʁr-	ʁl-			χʃ-			χtɕ-	χtɕʰ-	ʁdʑ-	χtʂ-			ʁj-	χk-				ʁɣ-	ʁŋ-		χq-	χqʰ-			
h-	hp-	hpʰ-	ɦb-	ɦm-	ɦv-	ht-	htʰ-	ɦd-			ɦdz-	hs-		ɦz-	ɦn-	ɦr-	ɦl-					ɦʒ-	htɕ-	htɕʰ-	ɦdʑ-			ɦdʐ-			hkʰ-	ɦg-		ɦɣ-	ɦŋ-					ɦʁ-	

for fricatives and place of articulation for nasals, are predictable by their environment. These will be discussed further in Section 4.2.

Table 4.3. Minimal sets for pre-initials

Example	Gloss
/rtsə/	'to count'
/xtsə/	'claw'
/χtsə/	'earth'
/rkɛ/	'old'
/xkɛ/	'to hug'
/χkɛ/	'ladder'
/vnə/	'to suck'
/ɣnə/	'lips'
/ɦnə/	'mouth'
/arnə/	'plant sp.'
/ɣnɛ/	'seven'
/ɦnɛ/	'two'
/ʁnɔ/	'finger'

Up to two pre-initials are observed to occur before the initial obstruent, creating CCC$_i$V syllables. Excluding those clusters which involve an approximant or glide that follows the initial, we observe clusters of three consonants such as *ɦrn*-, *ɦvz*-, *fnt*-, *fndẓ*- and *fntṣʰ*- occurring in the onsets of words. Examples of these are given in Table 4.4.

Table 4.4. Examples of words with two pre-initials

Example	Gloss
/ɦrŋə/	'to borrow'
/ɦvzy/	'to stab'
/fntɔ/	'to knock'
/fndẓɔ/	'saliva'
/fntṣʰi/	'snake'

Following the initial obstruent, approximants (up to two) can occur before the vowel, C_iCCV. Unlike the clusters involving pre-initials, these exhibit an ascending sonority, i.e., their sonority is greater than or equal to the preceding initial consonant, and less than the following vowel. The combination possibilities of one initial with one approximant can be seen in Table 4.5 on page 61.

Up to two approximants can follow the initial, creating (C)C_iCCV syllables, though they are rare. Three examples of these are *brwa* 'to burn (TR)' *hprwa* 'to burn (INTR)' and *rjwa* 'yak.'

Finally, because syllables allow up to two pre-intials, followed by an initial, followed by up to two approximants, there is an expectation to perhaps find an example that includes all of these, i.e., an initial cluster of five consonants, CCC_iCCV. No example like this is observed, however; four-consonant clusters are the most complex onsets found. This could be the result of a gap in the data, or perhaps there is a constraint that disallows such a cluster, or causes them to be reduced or simplified in some way.

4.2 Phonological processes related to consonant clusters

4.2.1 Voicing assimilation

Pre-initial consonants assimilate with respect to voicing in the initial consonant. For example, the pre-initials [f] and [v] in *ftɕə* 'to wear' and *vdʑə* 'to wake up' differ with respect to voicing because [f] is followed by a voiceless initial [tɕ] and [v] is followed by a voiced initial [dʑ]. Underlyingly, both of these words have the same pre-initial phoneme /v-/ with allophones [f] and [v] conditioned by the voicing (or lack thereof) in the following segment. This process can be written as:

$$\begin{bmatrix} \text{-syllabic} \end{bmatrix} \rightarrow \begin{bmatrix} \text{+voice} \end{bmatrix} / \_ \begin{bmatrix} \text{-syllabic} \\ \text{+voice} \end{bmatrix}$$

When a consonant cluster is found medially, voicing can assimilate from the preceding environment. Medial clusters are usually broken up, with a pre-initial becoming a coda in the preceding syllable. These codas often gain voicing that spreads from the preceding vowel. For example, *fɬi* 'dust' has a voiceless pre-initial [f] while *kʰɔfɬi* 'ash' is often realized [kʰɔv.ɬi] or [kʰɔv.ɮi]. (While **kʰɔ* is not a stand-alone morpheme, it does occur in other words such as *tʰakʰɔ* 'fireplace, hearth.')

Table 4.5. Onset clusters with one approximant following the initial

	p-	p^{h}-	b-	m-	v-	t-	t^{h}-	d-	ts-	ts^{h}-	dz-	s-	s^{h}-	z-	n-	r-	l-	ɬ-	ɬ^{h}-	ʃ-	ʃ^{h}-	ʒ-	tɕ-	tɕ^{h}-	dʑ-	tʂ-	tʂ^{h}-	dʐ-	j-	k-	k^{h}-	g-	x-	ɣ-	ŋ-	w-	q-	q^{h}-	χ-	ʁ-	h-
w	pw-		bw-	mw-		tw-	t^{h}w-	dw-		ts^{h}w-		sw-		zw-	nw-	rw-	lw-	ɬw-	ɬ^{h}w-	ʃw-	ʃ^{h}w-	ʒw-	tɕw-	tɕ^{h}w-	dʑw-	tʂw-			jw-	kw-	k^{h}w-	gw-		ɣw-			qw-	q^{h}w-			
r	pr-		br-		vr-			dr-																																	

We also see this progressive voicing assimilation across word boundaries into initial clusters. For example, *fty* ‘to see’ in the phrase *ŋa fty gə* ‘I am seeing’ is observed as either [ŋav.ty.gə] or, in more careful speech, [ŋa.fty.gə], with the pre-initial [f] becoming voiced from the vowel in the preceding word. This process is shown as:

$$\left[\text{-syllabic} \right] \rightarrow \left[\text{+voice} \right] / \left[\text{+syllabic} \right] \_ \left[\text{-syllabic} \right]$$

4.2.2 Nasal assimilation

When nasals occur in consonant clusters, they assimilate to the place of articulation of the following consonant. This occurs both in medial clusters (e.g., *pɛntsɛ* ‘cabbage’ or *tɕ^{h}əmbə* ‘buttock’) and in initial clusters (e.g., *mbu* ‘tender’ or *ntu* ‘tall’). This process can be written as the following:

$$\left[\text{+nasal} \right] \rightarrow \alpha\text{place} / \_ \begin{bmatrix} \text{-syllabic} \\ \alpha\text{place} \end{bmatrix}$$

In initial clusters, therefore, because the place of articulation of the nasal is predictable based on the place of articulation of the initial consonant that follows it, only one underspecified nasal pre-initial *N*- is posited, which is shown in Table 4.2 on page 58.

There do exist in their surface forms, however, some words which appear not to undergo this nasal assimilation process. The following surface forms are encountered:

[ɱtʂ^{h}i] ‘snake’
[ɱtɔ] ‘to knock’
[ɱdʑɔ] ‘saliva’

The best explanation for these are that they underlyingly have two pre-initial consonants: one labio-dental /f/ and one nasal. These two consonants mutate into one surface form retaining the place of articulation of the fricative, yet nasal. I therefore analyze these as /fntʂ^{h}i/, /fntɔ/ and /fndʑɔ/. This ordering of pre-initials *fn*- is preferred because there are no occurrences of nasals preceding fricatives **nf*, **ns*, **nx*, etc.

4.2.3 Fronting

When a velar fricative pre-initial *x-* occurs before a velar stop *k-* or *k^h-*, a process of dissimilation causes it to front. This causes words like *xkə* 'garlic,' to have a surface form of [çkə] or [ɕkə].

$$\begin{bmatrix}\text{-syllabic}\\ \text{+continuant}\end{bmatrix} \rightarrow \begin{bmatrix}\text{-back}\end{bmatrix} / \_ \begin{bmatrix}\text{-syllabic}\\ \text{+back}\end{bmatrix}$$

4.2.4 Retroflex

Pre-initial *r-* before a voiceless initial becomes [r̥], through devoicing, or [ʂ]. Because voiceless trills require precise tongue pressure and aerodynamics, they are often lenited in pre-initial position and substituted with the apical retroflex sibilant [ʂ].

4.2.5 Pre-initial sibilants

In some cases, we observe *s-* and *ʃ-* as variants of the pre-initials *x-*, *h-*, and, to a lesser extent, *r-*. These sibilant alternations are observed to occur before velars, coronals, and labials. Examples of these alternations can be seen in Table 4.6.

Table 4.6. Examples of words that exhibit sibilant variants for pre-initial voiceless fricatives

Citation	Alternate(s)	Gloss
xkə	[skə]	'garlic'
rkə	[ʃkə]	'to cut'
rku	[ʃku]	'to like'
xtu^{ʁ}pu^{ʁ}	[stu^{ʁ}pu^{ʁ}]	'empty'
xsɛ	[ʃsɛ]	'glue'
xs^{h}ɛ	[ʃs^{h}ɛ]	'new'
hp^{h}y	[sp^{h}y], [ʃp^{h}y]	'soup chunk'
hpu	[ʃpu]	'sand'
htɕ^{h}ɛ	[ʃtɕ^{h}ɛ]	'six'

While these sibilant alternants appear to vary freely with these pre-initials, there are a few different factors that may help explain this variation.

First, as seen in Section 4.2.3, *x-* is fronted to [ɕ] or [ç] before velars in a process of dissimilation. Because these fricatives are produced with a flat-tongue gesture in the direction of the alveolar ridge, the further push forward into the coronal region is a natural progression forward to the alveolar sibilant [s].

Also before velars, *r-* is observed to surface as [ʃ] as in [ʃkə] (*rkə* 'to cut') and [ʃku] (*rku* 'to like'). In Section 4.2.4, we observed that *r-* before a voiceless pre-initial is a retroflex sibilant [ʂ̥] (or voiceless trill [r̥]). The retroflex [ʂ̥] optionally changes further to [ʃ] in anticipation of the velar [k]. This can be explained by the shape of the tongue gestures in these two adjacent sounds. The retroflex involves an apical gesture toward the post-alveolar region, and the velar requires the tongue body to contact the velum. It stands to reason that less articulatory effort is involved in the transition to a velar stop from a palato-alveolar with a flat tongue [ʃk] than from a pointed, apical gesture in a retroflex [ʂ̥k].

When back fricative pre-initials like *x-* occur before coronal initials, we also observe them optionally changing to sibilants. Before the alveolar stop [t], *x-* can become [s], while before an alveolar sibilant [s s^{h}], *x-* can become [ʃ] (see examples in Table 4.6 on page 63). We can see two processes at work in this alternation: (1) place assimilation turns the velar fricative /x/ into an alveolar [s] (as in *xt-* becoming [st] in the previous example); and (2) a process of dissimilation changes it from an alveolar to a palato-alveolar. This dissimilation is necessary because, without it, the longer consonant in *[sːɛ] (*xsɛ* 'glue') would be difficult, if not impossible, for a listener distinguish from [s^{h}ɛ]. (See more on aspirated fricatives in Chapter 5.)

Finally, pre-initial *h-* also alternates with the sibilants [s] and [ʃ]. When followed by a coronal in the initial position, as in *htɕ^{h}ɛ* [ʃtɕ^{h}ɛ] 'six,' it is attributable to the same process of place assimilation as we saw with the way that coronals affect the pre-initial *x-*. On the other hand, we also see this optional alternation before the labials [p] and [p^{h}] (*hpu* [ʃpu] 'sand' and *hp^{h}y* [ʃp^{h}y] or [sp^{h}y] 'soup chunk'). This alternation is not observed, however, in such words as *xpə* 'feather'; neither *[spə] nor *[ʃpə] is observed. These alternations of pre-initials are likely a result of vowel height within the syllable. In anticipation of high vowels [u] and [y], the *h* can alternate as [s] or [ʃ], which also involve high tongue gestures.

4.2.6 Vocalization of voiced glottal fricative

The pre-initial glottal fricative *h-* in voiced environments, always becomes a voiced glottal fricative [ɦ]. These voiced glottal fricatives are often auditorily indistinguishable from a short, neutral vowel,

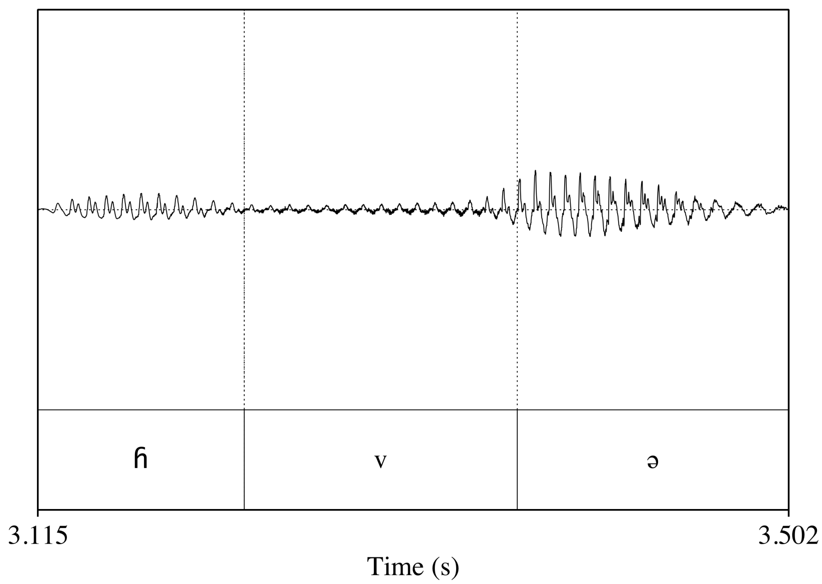


Figure 4.1. Waveform of *ɦvə* 'handmill' showing vocalized pre-initial *ɦ*- as [ə]

usually either the mid central [ə] or the near-high front lax vowel [ɪ]. An example waveform of the word *ɦvə* 'handmill' shows the vowel-like pre-initial [ɦ] in Figure 4.1 on page 65.

Although these are generally realized without the frication or breathiness that usually characterizes [ɦ], there are several reasons why they should be thought of as pre-initial consonants rather than vowels. First, they behave as pre-initial consonants, in that sometimes they are inaudible to the point of not being present, or deleted entirely. We observe this deletion with many other pre-initials such as *r*-, *x*-, *f*-, etc. Second, if we consider them to be vowels, then they would be the nuclei of their own syllables. Speaker intuition about syllables containing pre-initial *ɦ*-, however, are that these are monosyllabic. Finally, like other pre-initials, when they follow another syllable they are resyllabified (CV + CCV = CVC.CV = CVV̯.CV). For example, the phrase *kʰɔ ɦnɛ* 'two dogs' becomes [kʰɔi̯ nɛ]. In addition, this process neutralizes distinctions between pre-initial *ɦ*- and *ɣ*-, as *kʰɔ ɦnɛ* 'two dogs' and *kʰɔ ɣnɛ* 'seven dogs' both become [kʰɔi̯ nɛ].

In some cases, what appears to be a voiced glottal fricative is not one at all, but an instance of pre-voicing before an initial voiced consonant. Recall from Chapter 3 that Nyagrong Minyag has three-way contrasts for many consonant series (i.e., voiceless aspirated, voiceless unaspirated, and voiced). To distinguish between a voiceless unaspirated and a voiced initial, speakers sometimes

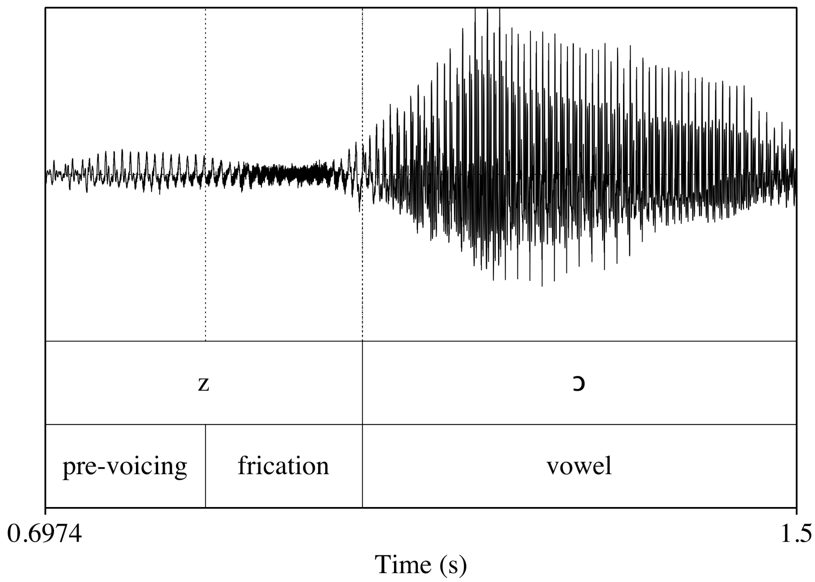


Figure 4.2. Waveform of *zɔ* 'room for worshipping health deity' showing pre-voicing in [z]

exaggerate the negative voice onset time to draw attention to the voicing throughout the segment. For example, *zɔ* 'room for worshipping health deity' is observed as [ə̥zɔ] in Figure 4.2 on page 66.

Despite the presence of this phenomenon, not all pre-initial vowel sounds can simply be lumped together as phonetic pre-voicing. The presence of several minimal pairs (see Table 4.7 on page 67) means that some of these are phonemic, even if they are phonetically similar or identical to pre-voicing.

4.3 Phonetics of pre-initials

4.3.1 Articulation

Next, pre-initials are examined through the lens of articulation. For certain pre-initials, it is possible to investigate articulatory mechanisms through the use of static palatography. Because static palatography is only able to provide a record of articulation produced with the tongue tip, blade and body when it makes contact with the region of the vocal tract from the backs of the upper teeth to the hard palate, only a subset of the pre-initials—those in the coronal region—can be investigated with it. In addition, because static palatography provides a record of accumulated contact, words selected for

Table 4.7. Minimal pairs showing the contrastive nature of pre-initial *ɦ* and voiced initials, which are also subject to pre-voicing

Example	Gloss
/di/	'small'
/ɦdi/	'wall'
/lɛ/	'answer'
/ɦlɛ/	'forehead'
/na/	'fish'
/ɦna/	'plant sp.'
/ni/	'you'
/ɦni/	'corpse'
/va/	'pig'
/ɦva/	'shoulder'

investigation must involve contact between these articulators only by the pre-initial, and no other segments.

Two pre-initials *x*- and *r*- in the words *xkə* 'garlic' and *rkə* 'to cut,' respectively, meet these criteria and are therefore included in this study. Recall that *x*-, when followed by initial [k], is fronted by a process of dissimilation to [ɕ] or [ç]. Indeed, we find articulatory evidence for just that: a palatalized post-alveolar (alveolo-palatal) grooved fricative in the palatogram and linguogram in Figure 4.3 on page 68. The broad contact in the alveolar ridge and post-alveolar region, combined with markings across a relatively wide portion of the tongue blade, show that the tongue is relatively flat and extended across the coronal region and the anterior parts of the hard palate.

Pre-initial *r*-, on the other hand, produces a more varied set of surface forms, which are also observed in the palatography. When followed by a voiced initial, *r*- is generally an alveolar trill [r] or a dental trill [r̪]. When followed by a voiceless initial, *r*- is generally either a voiceless trill [r̥] or a sub-apical post-alveolar fricative [ʂ]. For reasons of economy, we also see [ʂ] changing to a laminal palato-alveolar fricative [ʃ] with a flat tongue shape which eases the transition to the velar [k] (see Section 4.2.5 for further details). Within one palatography session, both of these phones, [ʂ] and [ʃ], were recorded. (Static palatography procedure requires separate articulations for the palatogram and the linguogram.) The palatogram in Figure 4.4 on page 69, shows markings all the way across the alveolar ridge and post-alveolar region, which are consistent with the sub-apical [ʂ]. The linguogram

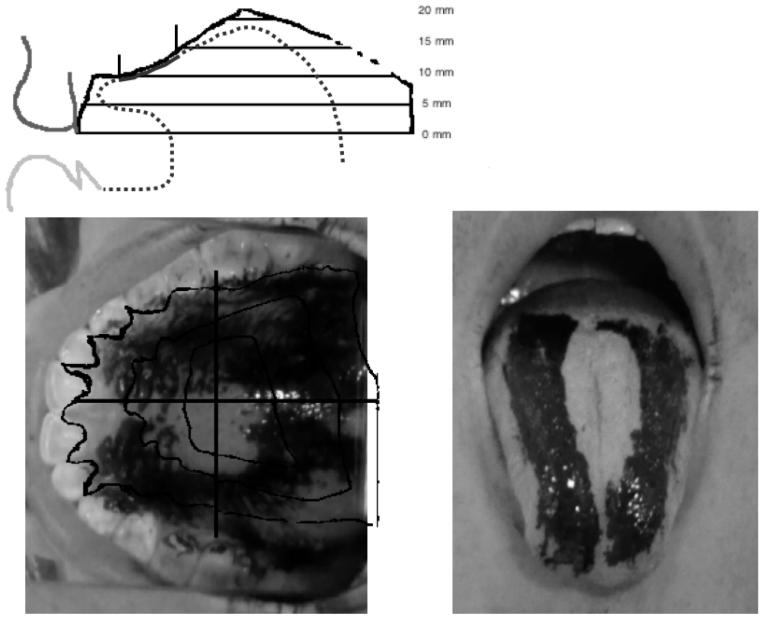


Figure 4.3. Palatogram and linguogram of pre-initial *x*- in *xkə* ‘garlic’

in Figure 4.5 on page 69, however, shows no sub-apical contact. The narrow markings along the sides of the tongue, ending in the laminal region, indicate a grooving formation of the tongue, and are more likely the result of a laminal post-alveolar grooved fricative [ʃ].

4.3.2 Acoustics

For pre-initials, there are acoustic correlates that help listeners distinguish between similar sounds. Voiceless fricatives, for example, have spectral properties that differ with respect to the place and manner of articulation. Additionally, in connected speech the formant transitions in the preceding vowel are likely to be useful in disambiguating a pre-initial (or any other obstruent) that follows.

As Chapter 5 shows, the most reliable spectral information for a voiceless fricative is its center of gravity, which is a measure of the mean of the frequencies produced by the frication (Gordon et al. 2002, Boersma & Hamann 2008). We can compare measures of center of gravity between those pre-initial segments articulated in similar regions, and are thus most likely to need disambiguation. Therefore, we will compare the pairs *r*- vs. *x*- and *x*- vs. *χ*-, with respect to their spectral centers of gravity.

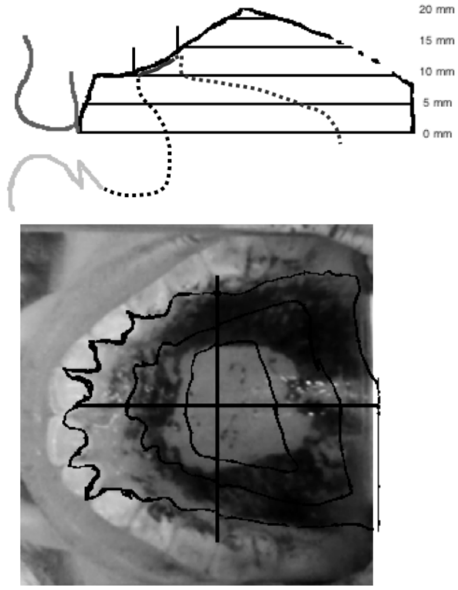


Figure 4.4. Palatogram of pre-initial *r*- in *rkə* 'to cut'

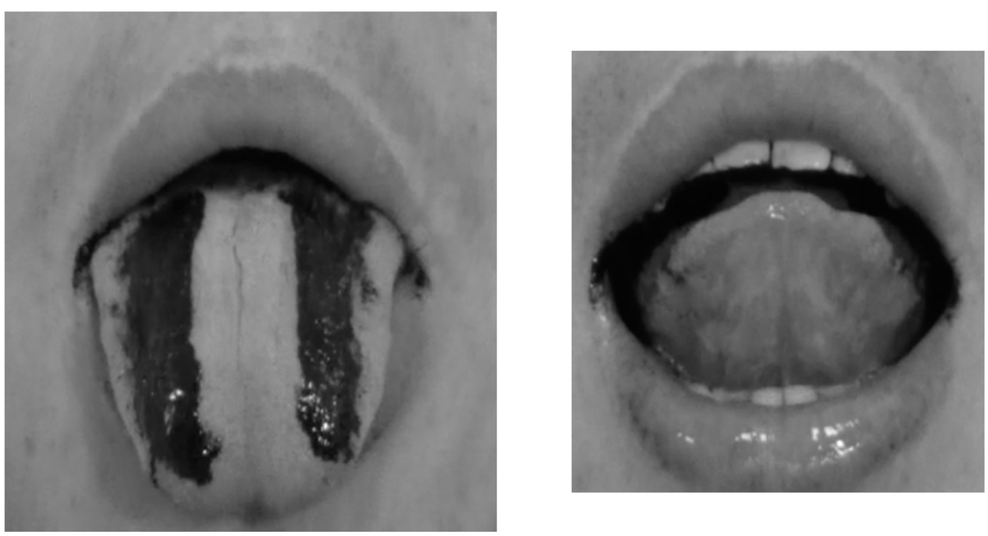
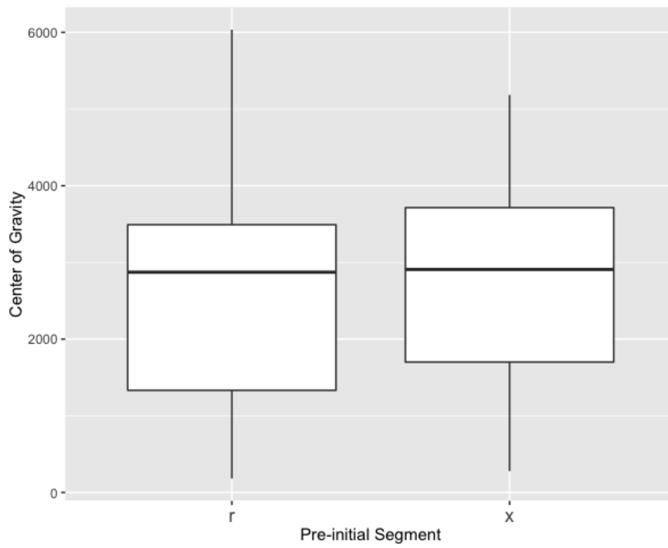
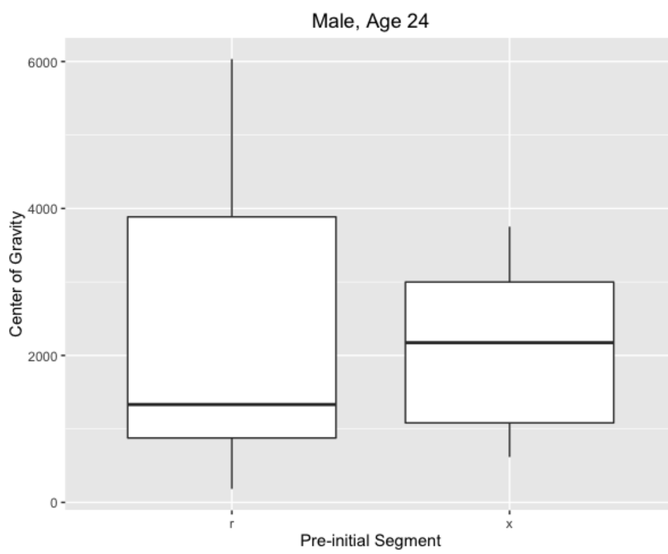


Figure 4.5. Linguogram of pre-initial *r*- in *rkə* 'to cut'



(a)



(b)

Figure 4.6. (a) Spectral center of gravity measures for pre-initial *r*- and *x*- for all twenty speakers. (b) Measures for one speaker (male, 24).

In Figure 4.6a on page 70, which measures center of gravity in *x*- and *r*- for twenty speakers, it is apparent that, although the center of gravity in *x*- appears to be slightly higher overall than that of *r*-, there is great overlap between these two, and there is no significant difference between these two groups. We can speculate about some reasons why we do not observe more center-of-gravity differences between these two pre-initials. First, it is possible that the spectral measures are not enough information for listeners to distinguish between these two pre-initials, without additional cues such as formant transitions in the preceding vowel. Second, we have observed that there is a high degree of variation when it comes to the articulation of both *r*- ([ɽ̊ ʂ̊ ʃ]) and *x*- ([ç̊ s]). It is likely that this high degree of variability has effected the overall variance in the data. Third, it is possible that speaker vocal-tract differences play a role in the variation we observe. These differences are the reason why, when comparing vowels across speakers, we must normalize their values. However, no such normalization method has been developed for comparing fricatives. (The solution taken in other parts of this dissertation is not to normalize fricatives, but to instead make 'speaker' a random effect in the statistical models used to compare differences, which is standard practice in phonetic studies with multiple speakers. See Chapter 2 for more details on the statistical methodology employed in this dissertation.) Finally, some combination of the above factors may play a role in producing the variance, and thus the obscured differences, that we observe in the data.

In fact, if we just look at data from one speaker, we can see that *x*- has a higher average center of gravity than *r*- as shown in Figure 4.6b. The greater variance observed for *r*- is likely due to greater variability in articulation for this segment for this speaker. Also, the data for *r*- are not normally distributed: the lower frequencies have a much smaller range than the higher frequencies. This suggests that the tokens in which this speaker produces a lower-frequency fricative, such as [ʂ̊], exhibit less variation, and that the higher-frequency fricatives probably come in a wider range of variants.

Formant transitions from the preceding vowel are likely to play an important role in disambiguating *x*- and *r*- as well. In Figure 4.7 on page 72, in which both [x] and [r] are preceded by [ə], there is an overall lowering of the second and third formants in the vowel preceding [r] on the right, when compared with that before [x] on the left.

Comparing pre-initial segments articulated further back, *x*- and *χ*-, reveals clearer differences in spectral center of gravity. To do this, all tokens which are actually [ç̊] or [s] are omitted by eliminating all instances before a velar [k]. Figure 4.8 on page 73 shows that *x*- is higher than *χ*- across all

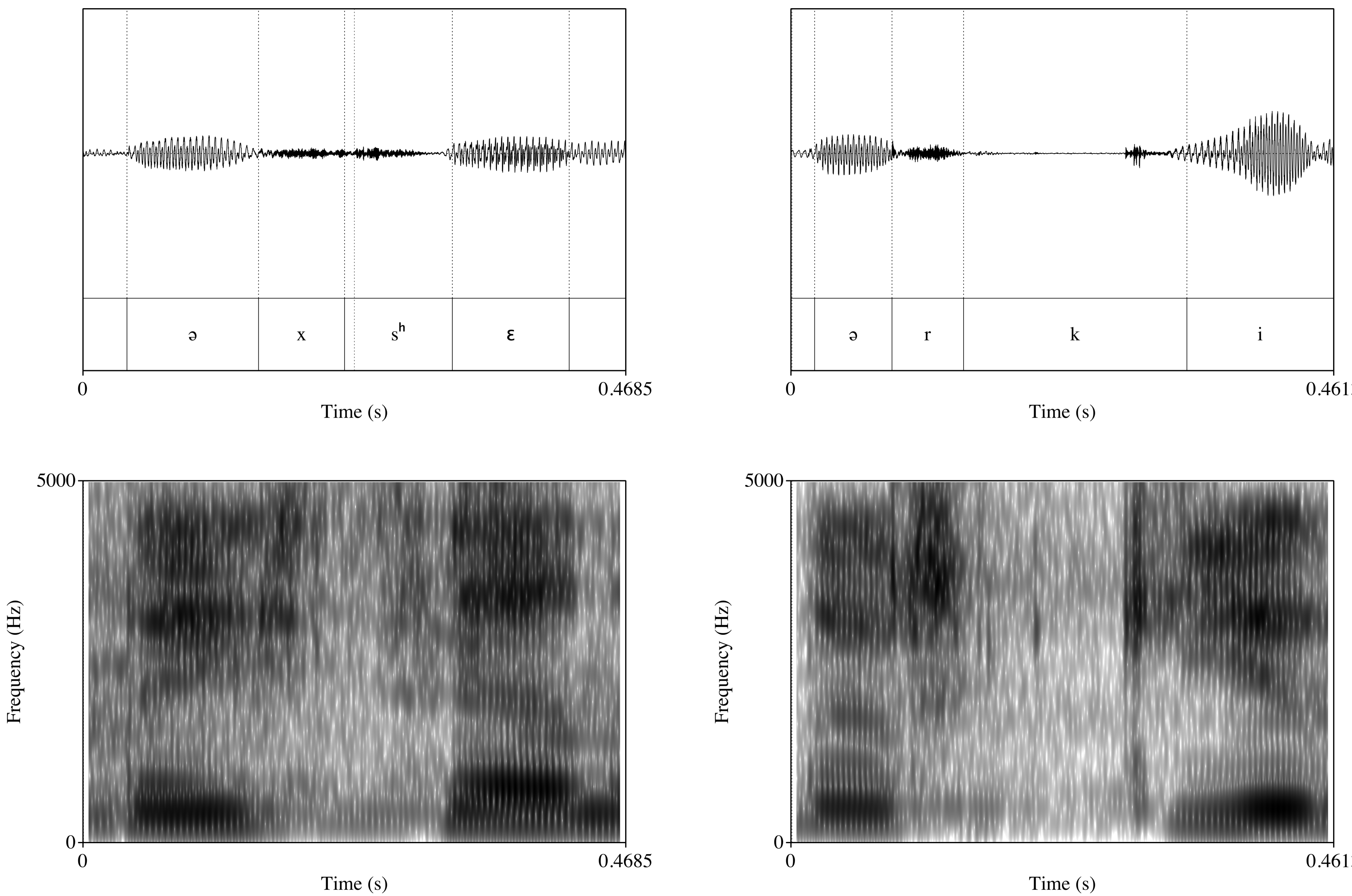


Figure 4.7. Side-by-side waveforms and spectrograms of *xsʰɛ* ‘new’ and *rki* ‘baby yak,’ each preceded by [ə]

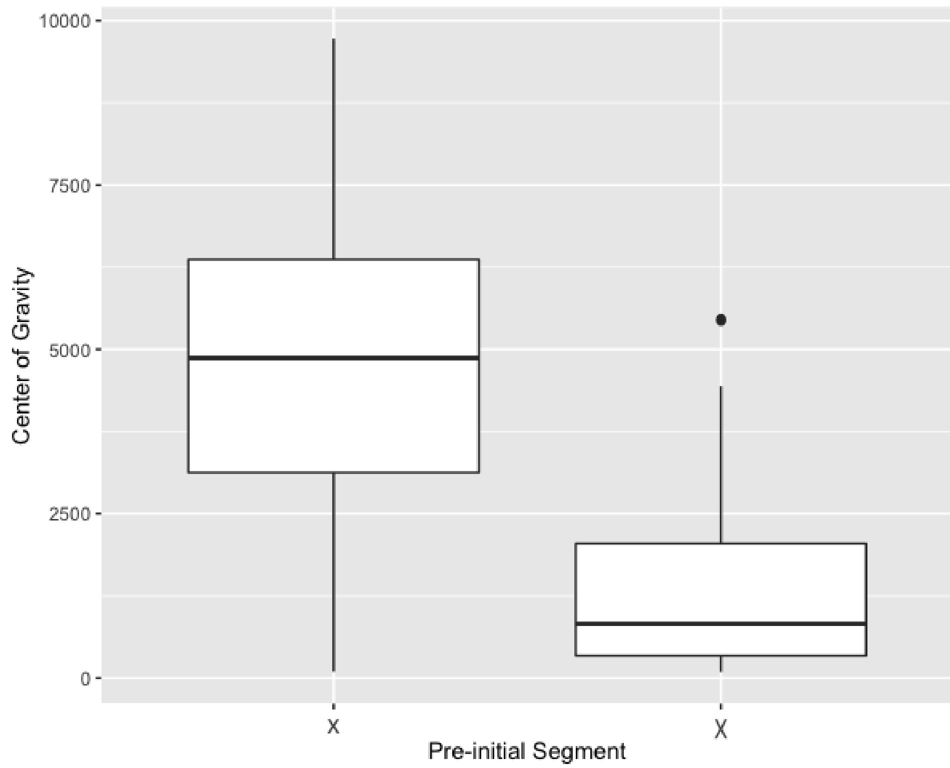


Figure 4.8. Spectral center of gravity measures for pre-initial *x*- and *χ*- for all speakers

twenty speakers in this study. The difference measured between these two is approaching significance (p=0.059). (A linear mixed effects model was used in which speaker, word, preceding and following environments, and recording device were all treated as random effects [n=217, t=-1.899].)

Other pre-initials such as *f*- and *h*- were not available for acoustic study because the recordings did not contain an appropriate number of tokens that would allow for control over the varying surface forms.

4.4 Discussion

First, regarding the phonetic observations of pre-initial consonants, the voiceless fricatives follow an expected pattern. The more anterior the fricative, the higher its overall frequency, i.e., spectral center of gravity (Forrest et al. 1988, Gordon et al. 2002, Boersma & Hamann 2008). Figure 4.9 shows how voiceless fricatives in the coronal region relate to one another with respect to their spectral mean or

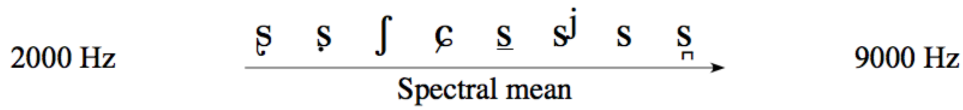


Figure 4.9. Continuum of coronal fricatives (sibilants) in the dimension of spectral center of gravity (adapted from Boersma & Hamann (2008))

center of gravity. We also find that for non-coronal fricatives [x] and [χ] these patterns also hold: [x] has a higher spectral mean than [χ].

The variation observed in the pre-initial fricatives, which can widen the range of acoustic phenomena for a single phoneme, leads to questions about perception. Although perception was not overtly investigated in this study, the range of variation suggests that perhaps the cues needed to perceive these pre-initials accurately are not acoustic, but gestural. We can surmise that the differences between *r*- and *x*-, though they may have correlates in the acoustic stream, are found in the underlying gestures of the tongue during the articulation of these sounds. Pre-initial *r*-, is observed as [r], [r̥], [ʂ] and sometimes [ʃ]; these variants have in common an apical or laminal gesture of the tongue. Pre-initial *x*-, on the other hand, which surfaces as [x], [ɕ], [s] and [ʃ] is derived from a gesture driven by the tongue body/back. This is obviously true for [x] and [ɕ], with [s] and [ʃ] occurring as a result of the following back consonant, usually [k].

In general, onset clusters in Nyagrong Minyag defy some cross-linguistic tendencies about syllables and sonority. First, pre-initials, such as the voiced [ɣ] and [ɦ], increase their sonority through the vocalization process discussed in Section 4.2.6, by which they surface as [ə] or [ɪ]. In a classic sonority scheme (Kenstowicz & Kisseberth 1979), we expect sonority to be flat or rising throughout the cluster until sonority peaks at the nucleus. The tendency for these pre-initials to increase sonority in pre-initial position, though, runs counter to these expectations. Second, it is assumed that languages which allow CCV syllables must also allow CVC syllables, i.e., that the presence of CCV implies the presence of CVC (Kaye & Lowenstamm 1981). In Nyagrong Minyag, we observe that this pattern holds, as V + CCV commonly resyllabifies as VC.CV, e.g., *ɣurkɛ* 'uncle' is [ɣur.kɛ]. If we extend this analogy though, should we not expect that CCCV syllables implies the presence of CVCC syllables? We do not observe these in Nyagrong Minyag, even through resyllabification of CCCV syllables.

Chapter 5

Frication

This chapter is devoted to the fricatives and affricates in Nyagrong Minyag. There are nine different affricates in Nyagrong Minyag, which leads to questions about precisely what gestures are involved in their articulation, and what acoustic cues listeners may use to perceive and discriminate among them. The first part of this chapter is devoted to exploring these questions. The second part deals with aspiration in fricatives, a typologically rare phenomenon. I explore how aspiration in fricatives differs from aspiration in stops, what acoustic correlates allow speakers to identify aspirated fricatives, and what challenges they pose to feature-based theories of phonology.

5.1 Affricates

Chapter 3 showed that Nyagrong Minyag has three places of articulation for affricates: (denti-) alveolar, alveolo-palatal, and post-alveolar. For each of these three places of articulation, there are three affricates varying with respect to laryngeal setting, i.e., plain, aspirated, and voiced. First, I look at how articulatory details, especially tongue shape, illuminate our classification of these affricates. Next, I turn to observations about the acoustics, such as spectral measures of frication and formant loci in the following vowels. Finally, I examine an apparent phonological asymmetry between the affricates and fricatives in this language.

5.1.1 Articulation

In describing the affricates in Nyagrong Minyag, place of articulation, which is based on the passive target, fails to accurately distinguish the two posterior affricates, /tɕ/ and /tʂ/. Both are post-alveolar in that the passive target is directly behind the alveolar ridge. When we examine what the active

Table 5.1. Affricate phonemes by place of articulation

(denti-)alveolar	alveolo-palatal	post-alveolar
ts	tɕ	tʂ
ts^{h}	tɕ^{h}	tʂ^{h}
dz	dʑ	dʐ

Figure 5.1. Side-by-side linguograms of [ts] (left), [tɕ] (center) and [tʂ] (right)

articulator (i.e., the tongue) does during these articulations, we can better organize and classify them based on the area of the tongue making contact in the gesture and the overall shape of the tongue during the articulation. The affricates can be either apical (with the tongue tip active in the articulation) or laminal (with the tongue blade active in the articulation). In addition, the tongue body is either flat, remaining relatively neutral and relaxed and not arching up toward the hard palate, or domed, where the tongue body bunches up near the hard palate, resulting in much wider and more extensive contact with the roof of the mouth and teeth.

In Figure 5.1, in the linguogram on the left ([ts]), the tongue blade is the primary articulator with no involvement of the tip, and contact with the tongue body (behind the central contact on the blade) is relatively narrow when compared with the linguogram in the center. The linguogram in the center ([tɕ]) has much broader and wider contact on the tongue body, and also shows a primarily laminal articulation (with additional dental contact), when compared with the linguogram on the left. These observations about the width of contact in these two articulations reveal the tongue's relative shape:

on the left, the tongue remains relatively flat, while in the center, the tongue is bunched up high in the mouth, making more contact with the hard palate. Both of these affricates are laminal, but they are distinct from one another in both place of articulation and tongue shape: /ts/ (on the left) is a flat laminal alveolar affricate and /tɕ/ (in the center) is a domed laminal post-alveolar affricate.

The linguogram on the right in Figure 5.1 shows another post-alveolar affricate (written phonemically as /tʂ/ for reasons explained in Chapter 3). The markings on this linguogram are connected at the tip of the tongue, indicating an apical gesture. On the tongue blade and body, the markings are quite narrow, showing that, since very little contact is made between these more posterior parts of the tongue and the upper vocal tract, the general shape of the tongue during this articulation is rather pointed and erect. This supports the claim that this affricate is apical, where the other two are laminal. Unlike the other post-alveolar affricate /tɕ/, which has a domed tongue shape, /tʂ/ is produced with a flat tongue. A summary of each affricate, characterized by tongue articulator and shape, is presented in Table 5.2.

Table 5.2. Affricates classified by lingual characteristics

	active articulator		tongue shape	
	apical	laminal	flat	domed
/ts/	-	+	+	-
/tɕ/	+/-	+	-	+
/tʂ/	+	-	+	-

5.1.2 Acoustics

Articulatory differences may explain what is happening inside a speaker's mouth, but we have to look to other evidence from acoustics to find out how listeners are able to perceive the sounds produced by these different affricates.

First, each three-way set of affricates—plain, aspirated and voiced—are distinguishable by their differences in voice-onset time (VOT). Speakers are able to distinguish within a set of affricates by VOT cues. Figure 5.2 shows the affricate plus vowel portions of three contrasting words. On the left, the voiced affricate [dʐ] shows voicing beginning earliest (lowest VOT): during the closure portion of the affricate and maintaining through the frication and into the vowel. In the center, the plain unvoiced [tʂ] shows voicing beginning right after the frication followed by a short burst. On the right, the

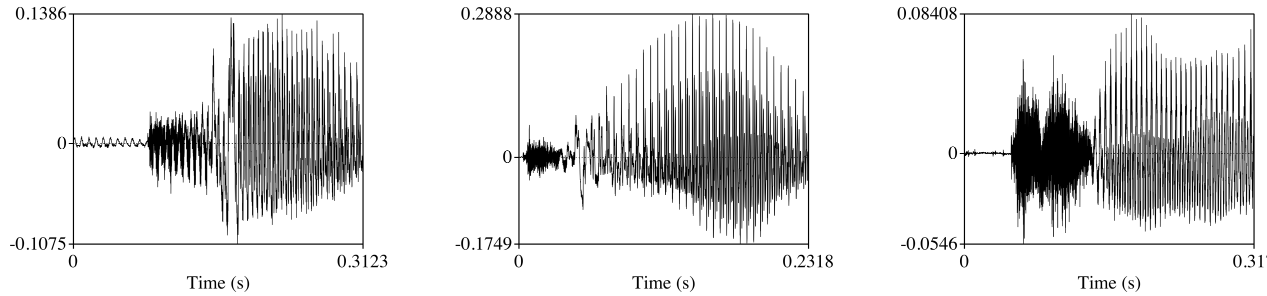


Figure 5.2. Waveforms showing the affricate plus vowel combinations in *(v)dʐə* 'to wake up' (left), *(x)tʂa* 'star' (center) and *(fn)tʂ^{h}i* 'snake' right

voicing begins the latest (highest VOT) for the aspirated [tʂ^{h}]: after the closure, the frication and a period of aspiration.

How speakers hear differences among the three sets of affricates (i.e., places of articulation) is another matter. It is likely that speakers receive salient acoustic cues from the spectral information in the frication portion of the affricate, similar to those found in fricatives (see, e.g., Heinz & Stevens (1961)). In Figure 5.3 on page 79, three spectral slices taken from the middle of the frication portion are shown for three affricates—[ts], [tɕ] and [tʂ]—spoken by the same speaker. Each spectrum has a smoothed LPC curve overlayed in red. These spectra with LPC smoothing show which frequency ranges contain the highest and lowest concentrations of acoustic energy. The peaks and valleys in an LPC curve are different enough from one fricative to another (or from one affricate's frication portion to another) to understand spectral patterns that distinguish these sounds (see, e.g., Forrest et al. (1988) and Jassem (1979)). We can make the following observations from the spectra in Figure 5.3 on 79: that [ts] has the highest overall frequency and the most energy at higher frequencies; that [tɕ] has a single peak below 10,000 Hz, but that the energy for frequencies above this peak are much lower; [tʂ] has two peaks, both below 10,000 Hz with low energy at the higher frequencies, but more diffuse than that of [tɕ]. These observations are useful, but in order to compare these spectra quantitatively, we must turn to mathematical averages of these curves.

The spectral center of gravity, which tells us how high the frequencies are on average (see Chapter 2 for more on how this is calculated), shows a lowering effect based on the relative posteriority of the affricate's place of articulation. Figure 5.4 on page 80 plots measures of spectral center of gravity across twenty speakers. (In each affricate, a stable portion of frication was identified and marked, and the center of gravity was measured from that period of frication.) The frication in [ts] has a higher

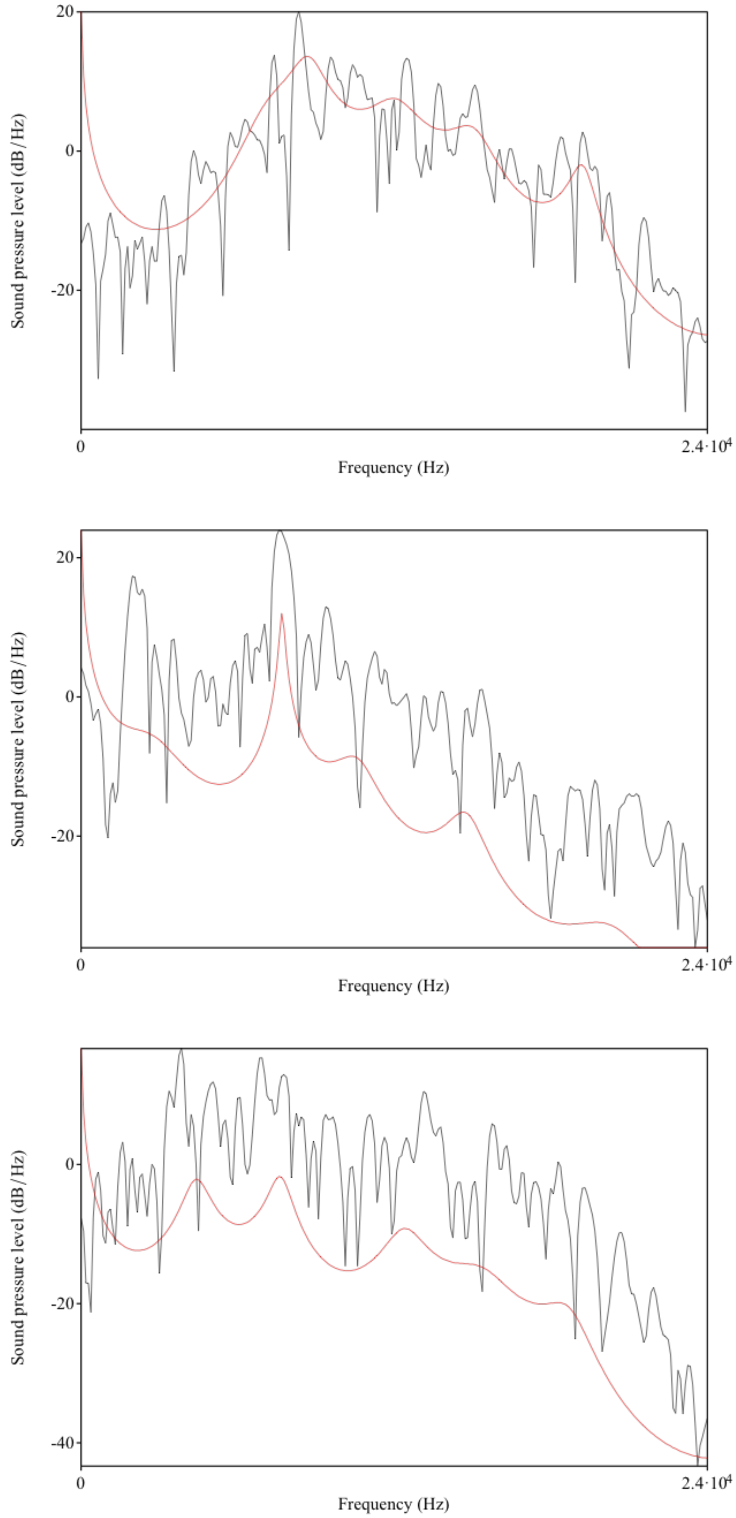


Figure 5.3. Spectra of the frication portions of [ts] (top), [tɕ] (middle) and [tʂ] (bottom) from a single speaker

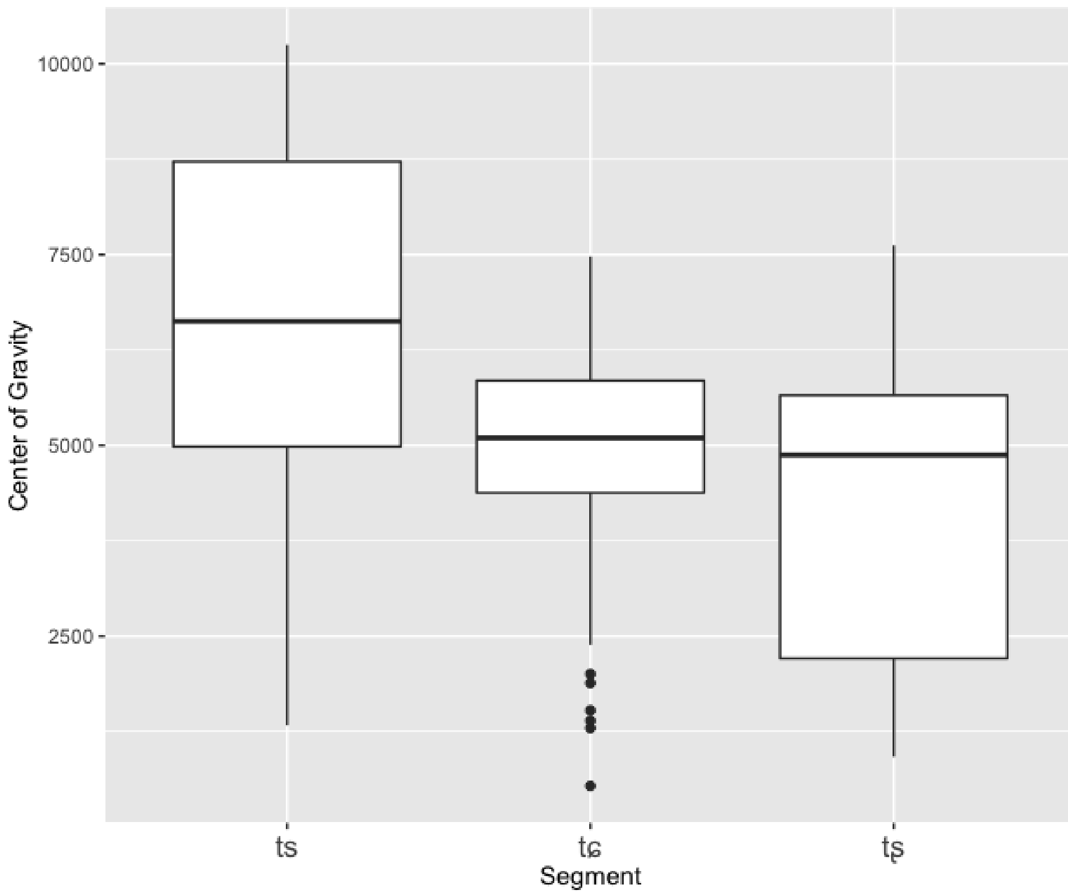


Figure 5.4. Spectral center of gravity measures of the frication portion of three sets of affricates, by place of articulation, for twenty speakers

center of gravity than both [tɕ] and [tʂ] (see Table 5.3 for a summary of statistical results). Because [ts] is more anterior than the other two affricates, its higher frequencies are explained by the shorter vocal cavity in front of the point of constriction. Also, [tɕ] has a higher center of gravity than [tʂ], though the difference is not as large as that observed between [ts] and [tɕ]. The domed or palatalized shape of the tongue in [tɕ] (see Section 5.1.1) could make the point of frication in this affricate far enough back that the differences observed in the frequency between it and the post-alveolar [tʂ] are comparatively small.

For other acoustic cues available for perceiving and discriminating these different affricates, we can look at the vowels that follow these consonants. The "formant locus," i.e., where formants in a neighboring vowel appear to originate before reaching steady state, is shown in study after study, beginning with Delattre et al. (1955), to be a reliable acoustic cue for consonant place of articulation.

Table 5.3. Summary of statistical results from comparing center of gravity in three affricates *ts*, *tɕ* and *tʂ*

	ts : *tɕ*	*tɕ* : *tʂ*	*ts* : *tʂ*
d.f.	16.12	23.04	13.91
T value	-3.02	-1.47	-3.67
p value	< 0.01**	> 0.05	< 0.01**

Perturbation theory, as first described by Chiba & Kajiyama (1941) and later by Mrayati et al. (1988), predict where in the vocal tract resonant frequencies (i.e., formants) will be affected by constrictions made by the articulators. Because the hard palate is near a point of maximum pressure for the second formant, constrictions near to it should cause F2 to raise.

Figure 5.5 charts the effect on F2 measures in the vowel [a], when it follows the three sets of affricates. It shows the difference between the value of F2 at 20 percent of the duration of the vowel and the value of F2 at the midpoint. Because the earlier measure is subtracted from the midpoint, the more negative the value, the greater the raising of F2. We can see in Figure 5.5 that F2 raises more after [tɕ] (-170 Hz) than after [ts] (-86 Hz, t=2.195, p<0.05*) or [tʂ] (-105 Hz, t=1.589, p>0.05), although the latter pair ([tɕ]:[tʂ]) does not show statistically significant differences. From this raising we can infer that this is a consonant articulated with a constriction near the hard palate, which is near a pressure maximum for the second formant. It follows that this palatalization in [tɕ], with its consequences on the movement of the second formant, should be considered an acoustic correlate that could allow listeners to distinguish between this affricate and the others, beyond any spectral cues from the frication.

5.1.3 Place asymmetries between fricatives and affricates

Upon examination of the phonetic details of Nyagrong Minyag phonemes, a question arises about the unexpected asymmetry between the place of articulation in fricatives and affricates: why is there a palato-alveolar series of fricatives (/ʃ/, /ʃʰ/, /ʒ/) and an alveolo-palatal series of affricates (/tɕ/, /tɕʰ/, /dʑ/), rather than sets of fricatives and affricates all in one region, either palato-alveolar or alveolo-palatal? These two sets are comparable in that they are both laminal, while the other fricatives /s sʰ z/ and affricates /tʂ tʂʰ dʐ/ are apical. If the phonological inventory were symmetrical these two post-alveolar laminal series would be articulated in the same place or include other phonemes in that place of articulation.

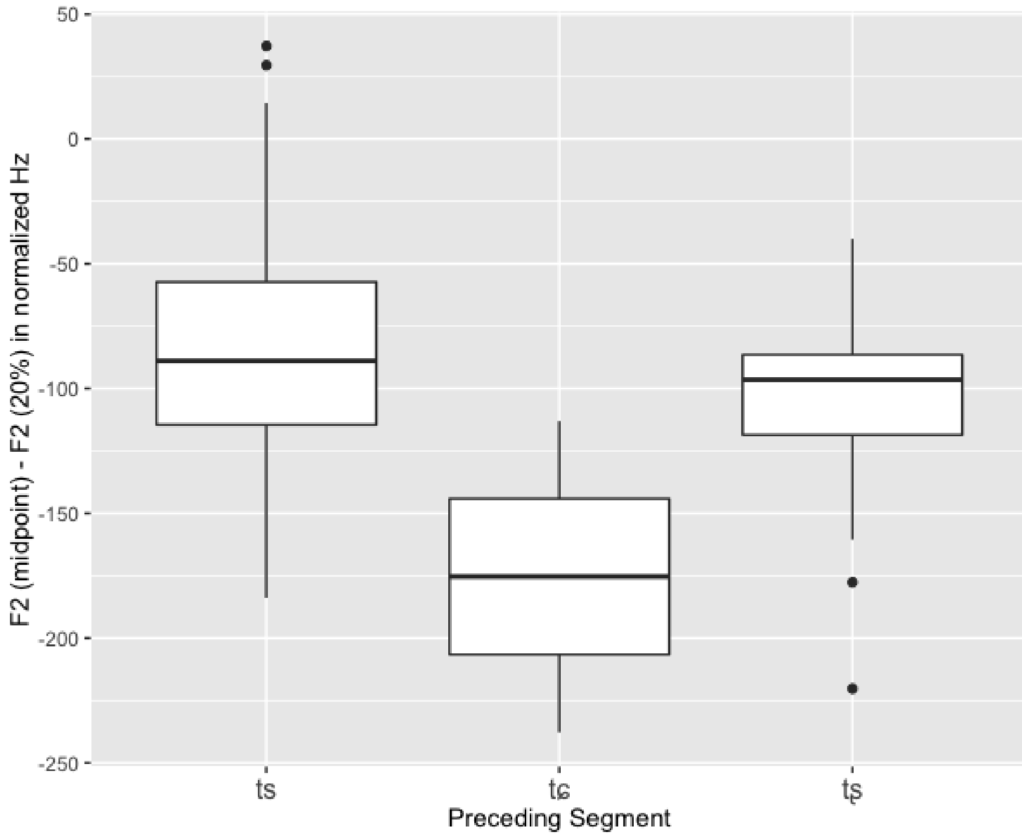


Figure 5.5. F2 onset (20 percent time step) subtracted from F2 midpoint measures for the vowel /a/ following affricates, in normalized Hertz

Table 5.4. Asymmetrical fricative and affricate series

	palato-alveolar	alveolo-palatal
affricates		tɕ tɕʰ dʑ
fricatives	ʃ ʃʰ ʒ	

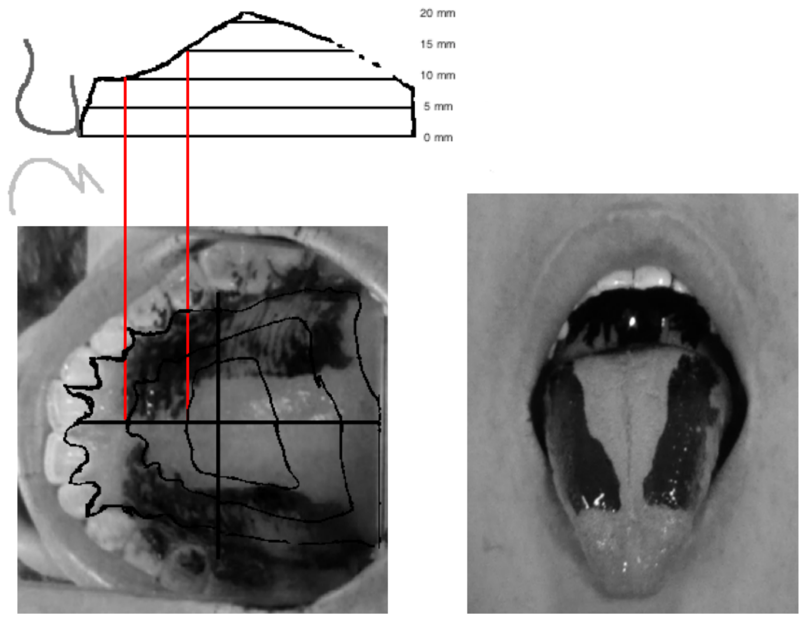


Figure 5.6. Palatogram and linguogram for palato-alveolar fricative [ʃ]

That /tɕ/ is not a palato-alveolar /tʃ/ was shown in the previous section with evidence based on F2 raising in the following vowel indicating palatalization. What about the obverse assumption—could /ʃ/ actually be /ɕ/? That this fricative is in fact the palato-alveolar /ʃ/, rather than an alveolo-palatal /ɕ/, is corroborated both by articulatory observations of the palatographic studies and acoustic evidence from recordings.

This fricative, as shown in Figure 5.6 on page 83, is identified as a palato-alveolar because of the marking patterns observed in the palatogram and linguogram. The linguogram on the right shows that it is entirely laminal and involves no contact on the tip of the tongue. The palatogram on the left shows that there is no contact anterior to the alveolar ridge. This effectively rules out the possibility that this is an alveolo-palatal fricative. From what we have seen of alveolo-palatals in this language, they appear to involve a much more forward position of the tongue tip. An alveolo-palatal would also likely leave markings on the tongue tip and on the backs of the upper front teeth, which are not observed here.

In addition to the articulatory evidence, we also have acoustic evidence that the affricate phonemes /tɕ tɕ^{h} dʑ/ and the fricative phonemes /ʃ ʃ^{h} ʒ/ are not in the same place of articulation. We observe a higher F2 in vowels following [tɕ] than those following [ʃ]. Figure 5.7 on page 84 illustrates this pattern with arrows pointing to the approximate locus frequencies of the vowel [ɔ] following the

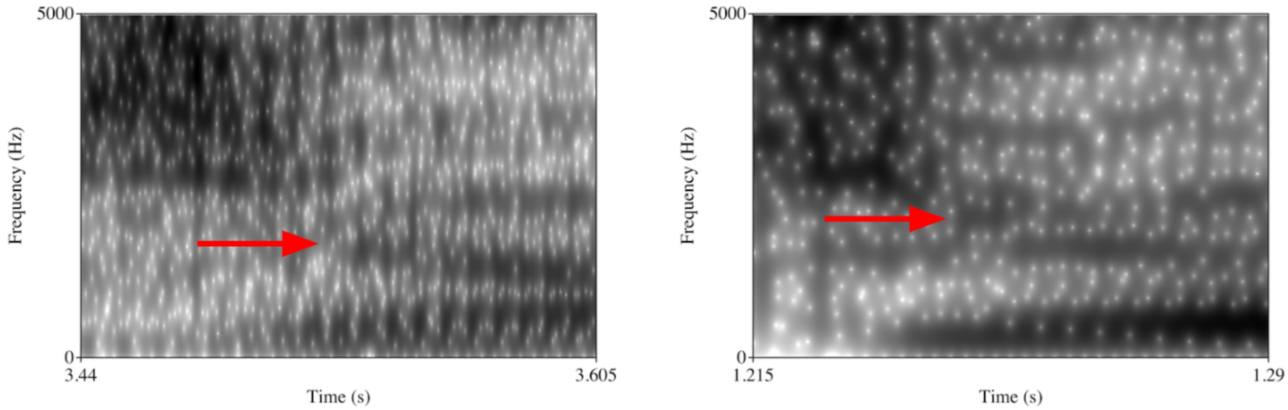


Figure 5.7. Spectrograms showing the F2 loci in *ʒɔ* 'water' and *ftɕɔ* 'mouse' from the same speaker.

palato-alveolar in *ʒɔ* 'water' on the left and *ftɕɔ* 'mouse' on the right. F2 is noticeably higher after the avlveolo-palatal than after the palato-alveolar. This is because the tongue shape, which is more domed in [tɕ] than the flatter tongue shape in [ʃ], creates more constriction at the hard palate, which is a point of maximum pressure for the second formant.

This asymmetry in the phonological inventory may be explained if we allow for the possibility of an underlying representation for this affricate. We could imagine that the phonemic form of the affricate is /tʃ/, which would be in balance with the fricative /ʃ/, and that its surface representation is [tɕ]. Recall that the stop articulated at the alveolar region /t/ was shown through palatographic evidence in Chapter 3 to be an apico-laminal denti-alveolar ([t̺] or [t̪]). The forward position of the tongue is likely to be the target in the stop portion of the affricate /tʃ/. The position of the tongue during the transition from the stop to the frication portion of this affricate may effect the place of articulation and tongue shape for the frication portion, effectively turning the [ʃ] in /tʃ/ into a [ɕ] in /tɕ/. In descriptions of other languages (e.g., labials in Arabic), such asymmetries are often ignored or smoothed out by proposing phonemes that do not match the phonetic realities. Because this dissertation is focused on the phonetic details and how those details aid in understanding the language's phonology, I have instead chosen to highlight these differences and refer to the phonemes /tɕ/ and /ʃ/ in a way that is consistent with their phonetic characteristics.

5.2 Aspirated fricatives

Nyagrong Minyag has among its phonemes the aspirated fricatives /sʰ/, /ʃʰ/ and /ɬʰ/. These exist in the phonemic inventory alongside fricatives that are not aspirated—plain unvoiced /s/, /ʃ/ and /ɬ/, and voiced /z/ and /ʒ/. Table 5.5 illustrates these.

Table 5.5. Fricatives by place and manner of articulation

	(denti-)alveolar	palato-alveolar
grooved fricatives	s	ʃ
	sʰ	ʃʰ
	z	ʒ
lateral fricatives	ɬ	
	ɬʰ	

On the one hand, these follow a familiar pattern of three- or two-way sets of consonants that are differentiated with respect to their laryngeal setting, which is consistent language internally. On the other hand, their presence is highly unexpected since aspirated fricatives are much less common cross-linguistically than aspirated forms of other consonants, such as stops or affricates.

Aspirated fricatives are typologically rare in the world's languages. Of all the phones listed in Maddieson's (1984) UPSID survey, only one type of aspirated fricative, /sʰ/, is listed, and of the 451 languages in the survey, only three are reported to contain this sound, while 115 (25.5 percent) have aspirated stops and 78 (17.9 percent) have aspirated affricates. Two of these are Sino-Tibetan (Burmese and Karen) and the other is Oto-Manguan (Mazahua). Jacques (2011) reviews the literature for additional languages which contain these sounds. He finds that the Sino-Tibetan family has the most reported aspirated fricatives, adding to those already mentioned Tibetic languages, Bai, Zhaba, Pumi, and Rtau/Horpa, a large language complex in which Nyagrong Minyag has been grouped (Sun to appear). Languages from nearby families in Asia also have them, such as Shan (Tai-Kadai) and Yanghao (Hmong-Mien), increasing the likelihood that the presence of aspirated fricatives is an areal trait. Korean is well known for its unusual tense/lax distinction in sibilants, in which lax /s/ is observed with more aspiration than tense /s*/ (Kim et al. 2010). Other languages which contain aspirated fricatives are found in Oto-Manguean (Mazatec, Ixcatec, Amuzgo) in Central America; Siouan (Ofo), Chumashan and Iriquoian (surface aspirates only) in North America; and one reconstructed language,

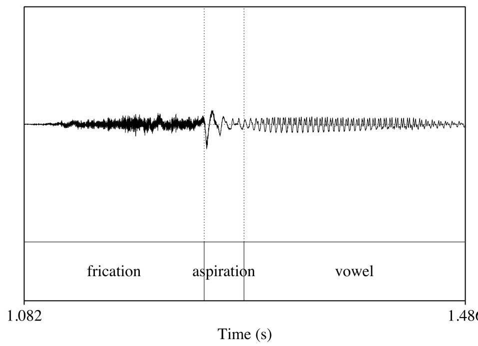


Figure 5.8. Waveform of *ʃʰə* 'louse' illustrating an aspirated fricative

Late Middle Chinese. At the time of writing, no other languages with phonemic aspirated fricatives are known to the author.

Challenges in production may be a cause of the rarity of these sounds in the world's languages. For other consonants with aspiration, such as stops or affricates, the airflow is completely impeded by the articulators at the point of constriction. The aspiration that follows stops and affricates releases air that has built up as a result of this impedance. Fricatives, on the other hand, never completely impede the air flow. They allow air to escape through a narrow constriction which creates a turbulent noise either at the point of constriction or by moving around an obstacle such as the upper front teeth or the upper lip. Because the air is always flowing in the production of a fricative, the build-up of air that we see in an aspirated stop or affricate is not available for producing an aspirated fricative. One of the most reliable cues in determining aspiration when it occurs after a stop is voice-onset time (VOT), which is a measure of the amount of time after a stop burst that voicing in the following sonorant begins. Unlike aspirated stops, however, aspirated fricatives do not contain a burst because there is no sudden release of intraoral air. Therefore, VOT is not available to distinguish aspirated from plain fricatives.

When we turn to aspirated fricatives in Nyagrong Minyag specifically, we are able to determine some acoustic cues that distinguish aspirated fricatives from non-aspirated fricatives. First, within the segment itself, we observe changes in spectra from the frication portion to the aspiration portion that are characterized by differences in spectral center of gravity. These spectral changes may also be accompanied by differences in segment duration. Second, we see effects on the following vowel as well. Comparing aspirated fricatives with their non-aspirated counterparts, differences in pitch (i.e., f_0) and formant loci (F1 and F2) are observed.

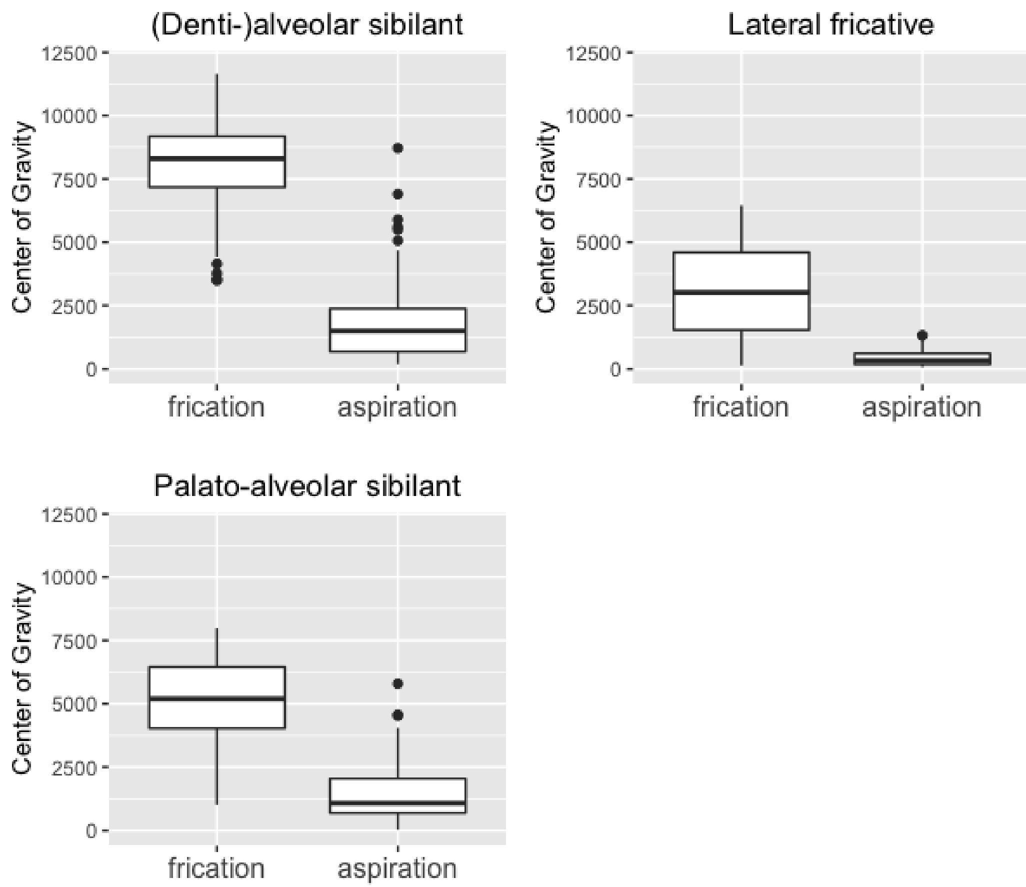


Figure 5.9. Spectral center of gravity measures in the frication and aspiration portions of aspirated fricatives

Figure 5.8 shows a typical waveform for an aspirated fricative, with a period of frication, followed by aspiration. In aspirated fricatives, the portion of aspiration which follows the period of frication has a significantly lower center of gravity (or spectral mean) than in the preceding frication. The spectral mean values are shown in Figure 5.9 on page 87. Table 5.6 gives a summary of the effect on spectral mean when comparing the frication and aspiration portions within aspirated fricatives. Although both the aspiration and frication are characterized by aperiodic noise, the aspiration, with its lower overall frequencies, should be distinguishable from the frication portion, thus making this drop in overall frequency a putative correlate of aspiration. This could be confirmed with a perception test. Would Nyagrong Minyag speakers, presented with aperiodic noise that shifts its center of gravity from higher to lower, identify an aspirated fricative?

Another putative acoustic correlate inherent in the fricative segment itself is duration. It is thought that aspirated segments will be longer in duration than their non-aspirated counterparts

Table 5.6. Summary of effect on spectral center of gravity for frication and aspiration portions of three aspirated fricatives *sʰ*, *ʃʰ* and *ɬʰ*

	sʰ	ʃʰ	ɬʰ
Effect	-6287	-3523	-2577
n	220	122	188
d.f.	232.85	85.95	173.48
T value	38.44	21.42	16.07
p value	< 0.001***	< 0.001***	< 0.001***

(Catford 1977, Umeda 1977, Hankamer et al. 1989). This hypothesis is not testable with these data because the recordings contain only carefully spoken tokens in isolation, causing some speakers to exaggerate their speech style in unpredictable ways, which would confound the results. Therefore, duration measures for fricatives are not included here.

Fricatives, like other consonants, are also distinguishable by the vowel following them. In particular, the fundamental frequency and the formant loci of the following vowel are affected by the presence or absence of aspiration.

In vowels following an aspirated fricative, we observe a trend of slightly lower overall pitch (i.e., fundamental frequency or f_0). This was measured by taking the maximum pitch over the entire vowel. Results of these measures are shown in Figure 5.10 on page 89. The effect of aspiration on [a] when it is preceded by aspirated [ɬʰ] as compared with plain [ɬ] is a drop of approximately 15 Hz in f_0 (n=71, t=2.71); the effect on f_0 of [ə] when followed by aspirated [ʃʰ] as compared with plain [ʃ] is a drop of approximately 12 Hz (n=66, t=0.83). Differences in f_0 following consonants that differ in terms of another laryngeal property, voicing (i.e., voiced vs. unvoiced), are commonly observed and are thought to be a significant factor in tonogenesis (Hombert et al. 1979). Languages with both voiced and voiceless stops show a higher f_0 in vowels following voiceless stops than in vowels following their voiced counterparts. Over time, these differences can become phonologically distinct high and low tones, while the voicing distinction is neutralized. It turns out that, in Nyagrong Minyag, vowels following the plain voiceless fricatives have a slightly higher f_0 than their aspirated counterparts. These differences may be explainable by the voicing lag in the onset of the vowel. It is possible that these aspiration differences in fricatives, which are both rare and diachronically unstable (Jacques 2011), will be lost and replaced by phonemic tone distinctions.

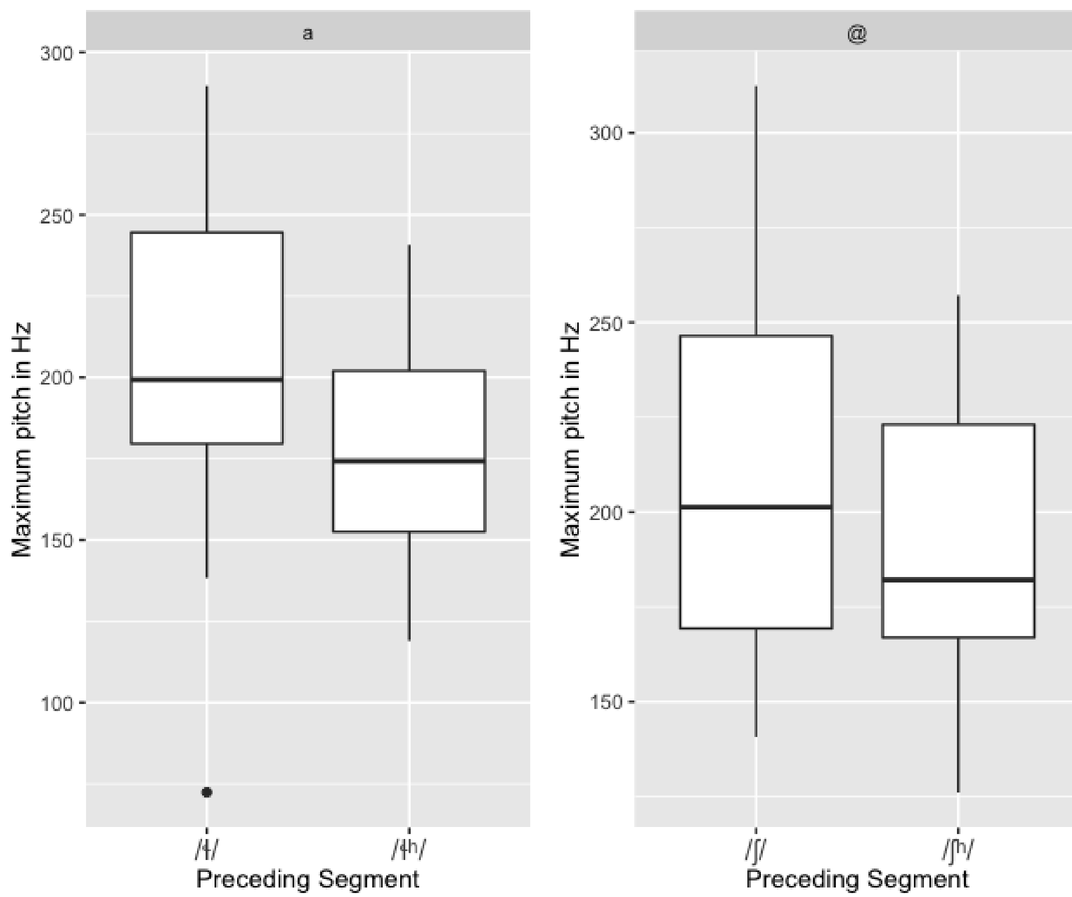


Figure 5.10. Maximum pitch values (Hz) in vowels following aspirated and non-aspirated fricatives

5.2.1 Cross-linguistic perspectives on aspirated fricatives

Perhaps the delicate nature of the articulatory timing and mechanisms at play in the production of aspirated fricatives contributes to their rarity and instability within languages. In languages with aspirated fricatives such as Burmese, not all speakers maintain the contrast, with younger speakers merging /s^h/ with /s/ (Wheatley 2003). As Jacques (2011) points out, in Late Middle Chinese, the reconstructed *f and *f^h contrast has no reflexes in any of its daughter languages. In Nyagrong Minyag, words with an initial aspirated fricative are characterized by a lower overall pitch. The primary collaborator for this project, who was trained in basic linguistic analysis, often characterized words with aspirated fricatives as having "lower tone." This perhaps contributes some insight into the diachronic trajectory of these rare sounds.

In feature-based phonological theories, aspirated segments are distinguished from unaspirated segments with the feature [spread glottis]. Within a language, consonants without aspiration are [-spread glottis] and consonants with aspiration are [+spread glottis]. This is problematic, however, when we attempt to analyze languages that have aspirated and unaspirated fricatives using this feature. Voiceless fricatives are understood to be produced with an open glottis (Stevens 1998, Vaux 1998), which is plausible given the need for upstream air pressure from the lungs, through the glottis, and into the oral cavity to create a turbulent noise at or near the point of constriction. Voiceless fricatives are therefore [+spread glottis]. But in a language with a voiceless fricative and a voiceless aspirated fricative, if the only feature available to distinguish between the two is [spread glottis], then the voiceless aspirated fricative is [+spread glottis] and the plain voiceless fricative is [-spread glottis]. The result of this is that the same sound, a voiceless unaspirated fricative, carries one set of features in one language and a different set of features in another language. Feature-based theories of phonology then still need to account for languages with both aspirated and plain fricative phonemes, like Nyagrong Minyag.

The precise nature of articulation for aspirated fricatives, upon which these features ought to be based, has not been well studied. An instrument that monitors the airflow and air pressure throughout the articulation of an aspirated and a non-aspirated fricative would be ideal for understanding the timing and volume of airflow during speech and how the two segments differ. In addition, an electroglottograph could be used to observe the movement and setting of the glottis, which would help settle the question of whether the glottis is spread (or at least more spread) during an aspirated fricative when compared with a plain fricative. Investigations in these areas are needed in order to settle the remaining questions about the phonetics and phonology of aspirated fricatives.

Chapter 6

Uvularization

An examination of the phonetics and phonology of Nyagrong Minyag reveals a secondary articulation in the uvular region. Vowels and other sonorants can be articulated with the back of the tongue targeting the uvula. In some cases, the secondary articulation is caused by the presence of a uvular segment, which spreads uvularization to neighboring syllables, words, and sometimes even phrases. Occasionally, the uvular segment itself is not realized on the surface, and is only detectable by the presence of uvularization in the vowels and other sonorants. In other cases, phonemically uvularized vowels are the only plausible explanation for the presence of uvularization.

In this chapter, I examine the uvularization phenomenon in depth. I look at how it compares with similar secondary articulations such as pharyngealization and velarization. I examine phonological evidence for the processes by which uvularization spreads and provide evidence for the phonemic status of at least some of the uvularized vowels in Nyagrong Minyag. Inter- and intra-speaker variation observed in this phenomenon are also examined. Through an exploration of the acoustic properties, I show that uvularization correlates with a drop in F2 and an increase in the space between the second and third formants (i.e., higher F3-F2), which are consistent with tongue retraction. Finally, suggestions for future acoustic and articulatory research will be discussed.

6.1 Background

Secondary articulations (also called secondary manners of articulation) are those in which a constriction is made in the vocal tract that is of a lesser degree and combines with another articulation, considered primary, which is generally of a higher degree of constriction (Ladefoged & Maddieson 1996). Secondary articulations are considered a phenomenon relating to both consonants and vowels.

Among those which relate to vowels, the secondary articulations with the most relevance to the current study of uvularization are those which involve movement or shaping of the tongue. The most widely reported of these deal with the advancement or retraction of the tongue root, and are given various labels in different languages such as advanced tongue root [+/- ATR], Pharyngealized, or Tense/Lax. In languages where this phenomenon has been observed, articulatory studies have revealed differences in tongue shape between plain vowels and their marked counterparts, including differing degrees of proximity between the tongue root and the pharyngeal wall, often accompanied by a bunching of the tongue in the oral cavity. The combination of these two leaves a hollowed cavity near the uvula for some vowels. Acoustic studies have revealed formant differences such as a lowered F1 and a greater difference between F2 and F1 (i.e., higher F2-F1) in [+ATR] vowels in Akan (Lindau 1979), DhoLuo (Jacobson 1978) and Ateso, Ebira, Igbo and Ijo (Ladefoged & Maddieson 1996). In Tsakhur, Catford (1992) reports that pharyngealized vowels have a markedly lowered F3 and a slightly raised F1.

Of particular interest to the current study are reports of velarized vowels in Rgyalrongic languages (Sun 2000b, 2004, 2005b, Lin et al. 2012), the branch of Sino-Tibetan languages to which Nyagrong Minyag belongs. All three branches of Rgyalrongic are described as having vowels with the secondary articulation "velarization," which contrast phonemically with plain, non-velarized vowels. During the production of the vowel, the tongue back moves toward the soft palate, similar to the tongue movement in a labio-velar approximant. Lin et al. (2012) identify lowered F2 as a consistent acoustic correlate for velarized vowels in Puxi Horpa, a Rgyalrongic language closely related to Nyagrong Minyag. Because of the close areal and genetic relations to Qiang, another Sino-Tibetan language reported to have uvularized vowels, Evans et al. (2016) hope that an articulation imaging study will help determine whether the vowels in Puxi Horpa and other Rgyalrongic languages are actually uvularized vowels, rather than velarized.

Finally, some examples of secondary articulations relating to consonants include labialization, in which the lips are rounded, velarization, where the tongue back arches toward the soft palate, and pharyngealization, in which the tongue root retracts toward the pharyngeal wall between the uvula and the epiglottis. All of these involve a gesture that coordinates temporally with the articulation of the consonant, even if they are not simultaneous. For example, Ladefoged & Maddieson (1996) show that non-labial consonants with lip rounding affect the formants of the following vowel more than the preceding vowel, which shows that this secondary articulation mostly follows the consonant in terms of timing. For languages that have labio-velarized consonants, the velarization occurs earlier than the labialization (Ladefoged & Maddieson 1996). These observations are in line with the hypothesis, advanced by Sproat & Fujimura (1993), that a secondary articulation, even if it is nominally of a consonant, will manifest closer to the syllable nucleus than that of the primary articulation.

6.1.1 Previous studies on uvularization

Uvularization as a secondary articulation has been studied as a property of consonants in some languages and vowels in others. In Ju|'hoan, a Khoisan language of Namibia and Botswana, a series of consonants that are uvularized exist alongside non-uvular consonant phonemes (Miller-Ockhuizen 2003). These are characterized by uvular frication in the release of the consonant, which also affects the onset of the following vowel. This affected portion of the vowel exhibits a raised F1 and an increased spectral slope, i.e., a greater difference between the values of the first two harmonics. St'át'imcets (also known as Lillooet), a Salish language of British Columbia, Canada, has consonants and vowels which are described as "retracted," which are part of a system of harmony producing eight vowels, four retracted /ẹ ọ ə̣ ạ/ and four non-retracted /e o ə a/. Articulatory studies show that all of these consonants and vowels involve retraction of the tongue root toward the lower pharyngeal wall, while uvulars also exhibit a retraction of the tongue dorsum toward the uvula or upper pharyngeal area (Namdaran 2006). In Semitic languages, emphatic consonants, which historically contrasted with voiced and voiceless obstruent counterparts, are realized in a variety of ways, including secondary articulations described as velarization, uvularization and pharyngealization. Jordanian Arabic is reported to have emphatic consonants which are either uvularized (Zawaydeh 1999, Zawaydeh & de Jong 2011) or pharyngealized (Al-Tamimi & Heselwood 2011). As in Ju|'hoan, the acoustic effects of the uvularized and pharyngealized consonants in Jordanian and Palestinian Arabic are observed on neighboring vowels. Zawaydeh & de Jong (2011) report a lowered F2 in vowels affected by uvularized consonants in Ammani-Jordanian Arabic; Shahin (2003, 2011) reports a medium-high rise in F1 and a medium drop in F2 for vowels affected by uvularized consonants in Palestinian Arabic and St'át'imcets.

Evans et al. (2016) thoroughly explore uvularization as a secondary articulation on vowels in Qiang, a language related to Nyagrong Minyag and also spoken in Sichuan Province, in areas east of Nyagrong. In the Mawo and Yunlinsi dialects spoken in Heishui County, they describe uvularized vowels that exist as phonemes alongside plain vowel counterparts, with contrasting minimal pairs.

The uvularized vowels are restricted with respect to the environments in which they are found: plain vowels are never found immediately following uvular consonants, and uvularized vowels are never found after velar consonants. Furthermore, they describe a system of vowel harmony in which the feature [+uvularized] spreads regressively to preceding vowels and syllables. They argue that uvularization in these dialects of Qiang is a property of vowels and not of syllables or consonants due to the phonotactic constraints on the co-occurrence of uvularized vowels and velar consonants.

In exploring the phonetics, Evans et al. (2016) examined the acoustics and articulatory mechanisms observed in vowel uvularization in Qiang. They found the most reliable acoustic cues to be a lowering of F2 and a greater F3-F2 (i.e., a greater separation between these two formants) for uvularized vowels, when compared to their plain counterparts. Both of these measures are indicators of vowel backness or retraction. They also observed a consistent lowering of F2-F1 (i.e., the first two formants were closer together), with or without a raising of F1. Using ultrasound, they examined the movement and position of the tongue in uvularized vowels and compared them with their plain vowel counterparts. They found that the highest point of the tongue in a uvularized vowel was retracted toward a target in the uvular region.

6.2 Uvularization in Nyagrong Minyag

Uvularization as a secondary articulation exists in two forms in Nyagrong Minyag. First, uvular segments pass the feature of uvularization to neighboring vowels in both directions, passing through certain sonorants, and can even spread to entire phrases. Second, because not all uvularized vowels and words can be explained by a process of spreading, there must exist some phonemically uvularized vowels. I first examine the process by which uvularization spreads, and then with what is left over, I discuss the uvularized vowel phonemes.

In its most basic form, uvularization spreads from uvular segments /q qʰ χ ʁ/ to neighboring vowels. This happens progressively, e.g., /qa/ > [qaʶ] 'crack,' and regressively, e.g., /xaχpə/ > [xaʶχpə] 'friend.' Figure 6.1 on page 96 shows side-by-side waveforms and spectrograms of the words /katɕʰi/ [katɕʰi] 'big' and /kaχtɕʰi/ [kaʶχtɕʰiʶ] 'good' spoken by the same speaker. The uvularized vowels on the right show lower formants than the corresponding plain vowels on the left. Other examples of uvularization spreading from uvular consonants can be seen in Table 6.1 on page 97.

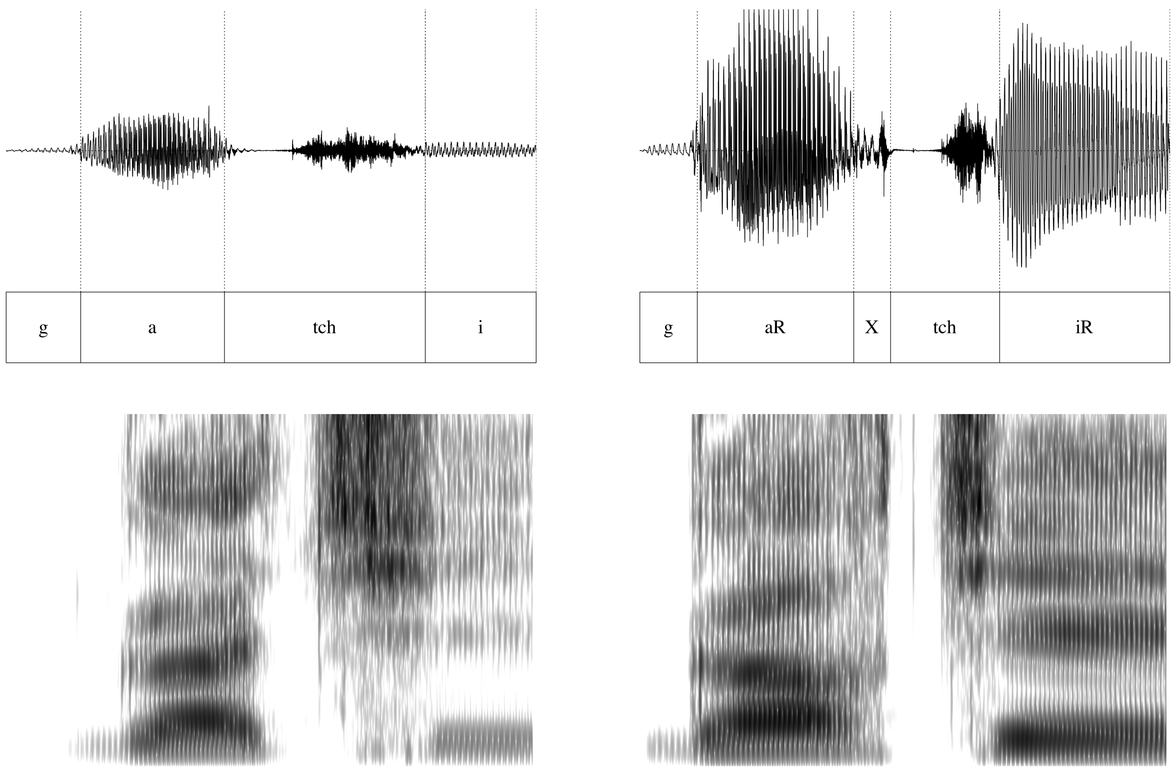


Figure 6.1. Waveforms and spectrograms for [katɕʰi] ‘big’ and [kaʶχtɕʰiʶ] ‘good’ illustrating plain and uvularized vowels

Table 6.1. Examples of uvularization spreading

Example	Gloss
[ʁliʶ]	'to fall'
[diʶʁliʶ]	'goodbye'
[ʁzəʶ]	'Tibetan dzi bead'
[ʁzyʶ]	'excrement'
[ʁzaʶbuʶ]	'insane'
[ʁzəʶraʶ]	'shifty-eyed'
[ʁduʶpuʶ]	'tree trunk'
[χtsaʶ]	'rust'
[χtsʰuʶmuʶ]	'clean'
[qaʶ]	'crack'
[qʰaʶ]	'laugh'
[dʑuʶqaʶ]	'to separate'
[maʶquʶ]	'grandmother'
[tɕaʶχtsiʶ]	'table'
[kaʶχtɕʰiʶ]	'good'

When a uvular occurs as part of an initial consonant cluster, the feature of uvularization can spread through the adjacent segment to the rest of the syllable, e.g., /ʁli/ > [ʁliˠ] 'to fall.' Not all sonorants allow uvularization to spread. Table 6.1 shows examples of words in which uvularization has spread from an overt uvular segment. It is worth noting that considerable inter-speaker variation has been observed with respect to the spread of uvularization: not all speakers exhibit uvularized sonorants as a result of spreading in every context where it is permitted.

Uvularization can also spread to entire words and phrases. For example, /qwarwa/ > [qwaʁrwaʁ] 'spider' exhibits uvularization, starting with the initial /q/, across the entire word, including the glides and the vowels. When the word /dutwa/ [dutwa] 'web' (containing no uvularization) is added to create the phrase /qwarwa dutwa/ 'spider web,' the uvularization spreads through the entire phrase, producing [qwaʁrwaʁ duʁtwaʁ].

The spread of uvularization is blocked by velar /k k^h g x ɣ/ and palatal /j/ segments. For example, in words that contain a uvular approximant pre-initial before a velar initial such as /ʁɣi/ 'threshing floor' and /χki/ 'to gnaw' they are realized with a plain [i] ([ʁɣi] and [χki]) and never a uvularized /iʁ/ (*[ʁɣiʁ] or *[χkiʁ]). In some cases, the uvularization will spread progressively until it is blocked by a velar or palatal consonant. For example, /qwaɣwa/ > [qwaʁɣwa] 'rake' has a uvularized first syllable spreading from the uvular [q], but the second syllable is not uvularized because it is blocked by the velar [ɣ]; when compared with /qwarwa/ > [qwaʁrwaʁ] 'spider,' which contains no velars and exhibits uvularization throughout the word, we can isolate the apparent effect of the velar. Notably, the labio-velar glide [w] does not appear to block the spread of uvularization. Instead, the coarticulatory effect of the uvulars changes [w] to a labio-uvular glide [wʁ] or [w̞]. See Table 6.2 for more examples of words with velars and palatals that block the spread of uvularization.

A change in the configuration of the tongue is the likely reason that velars and palatals block the spread of uvularization. In order to articulate a uvular or uvularized segment, the tongue dorsum moves up and back toward the uvula by constricting the muscles of the styloglossus. To articulate a velar segment, the tongue dorsum moves toward the soft palate, which is anterior to the uvular place of articulation. To articulate a palatal segment, the tongue body moves up toward the hard palate. In both of these cases, it would be difficult, if not impossible, for the tongue dorsum/body to create a constriction in two places that are so close to each other at the same time. We can surmise that the articulation of a velar or palatal reconfigures the tongue to a neutral, non-uvularized setting. This reconfiguration does not appear to occur as a result of segments articulated with the tongue blade or

Table 6.2. Examples of velars and palatals blocking the spread of uvularization

Example	Gloss
[ʁɣi]	'threshing floor'
[ʁjɛvə]	'to slander'
[χki]	'to gnaw'
[χkɛ]	'ladder'
[qʰaʶji]	'boiled flour'
[qwaʶɣwa]	'rake'
[ʁzəʶrkɔ]	'shifty-eyed person'
[ʁzaʶbuʶ xɛka]	'mentally ill person'

tip, or other articulators such as the lips. For example, /χtsa/ > [χtsaʶ] 'rust' and /ʁzabu/ > [ʁzaʶbuʶ] show uvularization spreading even through the coronals /ts/ and /z/ and the labial /b/. See Table 6.1 for more examples of when spreading is observed.

Regarding the spread of uvularization in Nyagrong Minyag, it is important to note significant inter- and intra-speaker variation. In certain words, such as /ʁli/ 'fall' and /ʁzy/ 'excrement,' some speakers reliably exhibit spreading uvularization as [ʁliʶ] and [ʁzyʶ], while others produce [ʁli] and [ʁzy] with plain, non-uvularized vowels. Additionally, the same speaker will sometimes say, for example, [ʁliʶ] and other times [ʁli]. From this, we can say that the spreading of uvularization is, to a certain extent, optional. Other examples of optional spreading of uvularization can be found in Table 6.3.

Table 6.3. Examples of variable uvularization spreading

Example	Gloss
[qaʶpə] or [qaʶpəʶ]	'throat'
[qaʶrdu] or [qaʶrduʶ]	'uvula'
[χaʶlu] or [χaʶluʶ]	'nearly blind'
[χaʶmu] or [χaʶmuʶ]	'plane tool'
[xaʶpə] or [xaʶpəʶ]	'friend'

6.2.1 Uvularization without an overt uvular segment

The presence of uvularization, which is especially salient on vowels, is observed also when there is no overt uvular consonant in the word or phrase. For example, we observe [niʶ] 'to get married (female)' and [zyʶ] 'face, appearance' with no uvular segment on the surface. One solution is to posit an underlying uvular segment that is not realized on the surface, yielding underlying representations such as /ʁni/ and /ʁzy/ (*/niʁ/ and */zyʁ/ are not allowed because codas do not occur except when resyllabified from a following onset; see Chapter 4). This pattern fits with the observed variation in the presence of the uvular pre-initial in words like /ʁzabu/ 'insane,' which can be both [ʁzaʶbuʶ], with an overt uvular segment in the pre-initial position, and [zaʶbuʶ], with no overt uvular segment.

The solution of positing an underlying uvular segment, which is not necessarily realized on the surface, however, adequately explains some, but not all, of the observed uvularization in Nyagrong Minyag. For example, the aforementioned word [zyʶ] 'face, appearance,' which we analyzed as underlyingly represented as /ʁzy/, is part of a minimal set with the words [ʁzyʶ] 'excrement' and [zy] 'female yak.' A phonological system in which uvularization is explained only by the underlying presence of uvular consonants cannot differentiate between /ʁzy/ 'excrement' and /ʁzy/ 'face, appearance.' These two words, *ʁzyʶ* and *zyʶ* are also not reported to be homonyms by native speakers. Similarly, we observe [ʁduʶpuʶ] 'tree trunk,' [duʶpuʶ] 'first,' and [duʶpu] 'empty' (none of which are homonyms). To differentiate the underlying representations of these three using only segmental uvulars, we could imagine that the first two are /ʁdupu/ and /duʁpu/, respectively. But then how do we represent the third example? In light of these minimal sets, we must posit that at least some of these uvularized vowels are phonemic, as spreading from uvular segments does not adequately explain all instances of uvularization. Because of these phonemic uvularized vowels, there is no need to propose abstract underlying consonants of the kind Kiparsky (1976) describes, to analyze uvularization in Nyagrong Minyag.

6.2.2 Uvularized vowels – phonemes and allophones

Thus far, I have described a system in which the secondary articulation uvularization spreads from uvular consonants to vowels and other sonorants, but also, for reasons just given, must contain some phonemically uvularized vowels. The minimal pairs in Table 6.4 on page 101 show that there are five uvularized vowel phonemes /iʶ yʶ uʶ əʶ aʶ/ which exist alongside the seven plain vowels /i y u ɛ ɔ ə a/. Neither /ɛ/ nor /ɔ/ are observed to have phonemic uvularized counterparts.

Table 6.4. Minimal pairs for plain and uvularized vowels

Example	Gloss
/ni/	'you'
/niʶ/	'get married (female)'
/zy/	'female yak'
/zyʶ/	'appearance'
/du/	'bright'
/duʶ/	'hole'
/zə/	'son'
/zəʶraʶ/	'shifty-eyed'
/la/	'tree'
/laʶwaʶ/	'lungs'

With this evidence, we can see that on the surface, some uvularized vowels are phonemes, while others are allophones of the plain vowels that become uvularized through a process of spreading from a nearby uvular consonant. In some cases, then, it may be impossible to know whether a certain uvularized vowel is a phoneme or an allophone. But because it has been shown that at least some of these are phonemes, this debate is of little importance. In English, vowels lacking stress often are realized as schwa, e.g., the first syllable in <photography> [fəˈtagɹəfi], as compared to <photograph> [ˈfotəgɹæf]. Since English has a phonemic schwa, we could ask whether this is a representation of the phoneme or an allophone of another vowel. Similarly, [aʶ] is found as an allophone of /a/ in some instances, but also [aʶ] representing the phoneme /aʶ/ in other instances. The fact that [aʶ] can represent two different phonemes is acceptable within the phonology of uvularization in Nyagrong Minyag, and poses no analytical problems of the sort that plagued followers of American Structuralism.

A vowel system in which there exist both uvularized variants of plain vowels and phonemic uvularized vowels, despite its complexities, is necessary for the analysis of this language. A hypothetical system in which all uvularized vowels were phonologically conditioned would simplify the vowel inventory (seven vowel phonemes, instead of twelve) and goes a long way in capturing important generalizations about the phonological conditions that trigger uvularization, but it would require proposing a great number of abstract segments that are not present on the surface, some of which cannot adequately explain the minimal sets observed and explained previously. A system in which all uvularized vowels are assigned phonemic status does account for these minimal sets, but does not adequately explain the apparent phonological conditions that can trigger uvularization, and is not consistent with the inter- and intra-speaker variation observed for this phenomenon. Therefore, it is necessary that we analyze the system as containing both phonetic uvularized vowels derived from plain vowels in the context with uvulars and underlying, non-varying, contrastive uvularized vowels.

This proposed system, however, does not answer every question about the nature of uvularization in Nyagrong Minyag. For example, the uvular pre-initial in /ʁzabu/ 'mentally ill' is sometimes present on the surface, i.e., [ʁzaʶbuʶ], and sometimes absent, i.e., [zaʶbuʶ]. On one hand, if the uvularized vowels in this word are phonologically conditioned by the pre-initial ʁ-, then we may imagine that the variation in its surface representation is possible because the feature of uvularization is perceived through the vowels. On the other hand, if the vowels are phonemically uvularized, i.e., the phonological representation is /zaʶbuʶ/, then the presence of the pre-initial ʁ- could be a result of phonetic anticipation of the uvularized vowels. This would be not unlike the explanation proposed by Evans et al. (2016) for a similar phenomenon in Qiang in which uvular approximants can appear word initially in anticipation of a uvularized vowel (e.g., [ʁliʶ] for /liʶ/ 'wide'). Nevertheless, because we have proposed that at least some of the uvularized vowels are contrastive phonemes and that at least some of the uvular segments trigger uvularized allophones, we must accept a certain degree of opacity in the underlying representations.

What, then, can be said about the functional load of uvularization in Nyagrong Minyag? If it were simply a result of co-articulation from a uvular segment that is present on the surface form, and we could argue that it is in cases like /qa/ [qaʶ] 'crack,' then the functional load of uvularized vowels would be pretty low. It might help a listener distinguish between [q] and some other stop (perhaps [k]), but so would the stop burst and the formant transitions in both the preceding and following vowels. In words like /kaʶχtɕʰiʶ/ 'good' in which the uvular fricative [χ] is sometimes absent, i.e., [kaʶtɕʰiʶ], the uvularized vowels carry a very high functional load when [χ] is not present, especially when compared with /katɕʰi/ 'big.' Indeed, we have seen several instances in which uvularization is detectable only as a secondary articulation on the vowel and not as any overt uvular consonant. Even though we do not have to posit that all of these are phonemically uvularized, we must admit that the functional load is high since, when we consider the minimal pairs, we see that the uvularization must be perceived in order for a listener to disambiguate this word from another.

6.3 Acoustics of uvularization in Nyagrong Minyag

Since we have established that uvularization is an independent gesture that must be learned as part of the sound pattern of Nyagrong Minyag, then we should expect it to have observable acoustic consequences which allow listeners to distinguish uvularization from all other possible ways of achieving similar acoustic effects. In measuring the acoustic correlates of uvularization, the values of the first three formants (F1, F2, F3), both statically at the midpoint of vowels, and dynamically, at ten percent time intervals throughout each vowel's duration, are examined. The overall F1xF2 vowel space, as well as F2xF3, and the space between these three formants, i.e., F2-F1 and F3-F2, are considered. The values for the latter are calculated after normalized formant values are scaled back to Hertz. (See Chapter 2 for more information on how this is accomplished.) Finally, all these values are plotted along the dimension of time to check for temporal differences.

Uvularization's effect on the F1xF2 vowel space depends on whether the vowel is high or not. For high vowels [i y u], the uvular counterparts occupy more interior space: they tend to be lower (i.e., higher values of F1), while the front vowel [iʁ] and the back vowel [uʁ] are retracted. Non-high vowels [ə ɔ a] all have uvularized counterparts [əʁ ɔʁ aʁ] that are consistently more back (i.e., have lowered F2 values).

The effect on the third formant appears to be more mixed. F3 shows slight raising in all vowels except [iʁ] and [aʁ], though none of the F3 differences for any vowel class are found to be statistically significant. When we examine the space between the second and third formants, we find F3-F2 increases in each uvularized vowel, compared to its plain counterpart. This is likely to be a result primarily of the lowering of F2, combined with the slight raising of F3.

6.3.1 Statistical tests

To test the differences between formant measures between vowels of the same class (e.g., [a] vs. [aʁ]), linear mixed-effects models are used. In each model, formant measures (dependent variable) are tested against the presence or absence of uvularization (independent variable), while speaker and word are treated as random effects. All calculations are made using R (R Core Team 2014).

A summary of the results is listed in Table 6.5 on page 105. For each vowel class, Table 6.5 shows the number of observations (n), the effect size, the T value and the p value. The effect sizes on the formants themselves are given in normalized values derived using the Lobanov method (for more details on the normalization method used, see Chapter 2). Because the normalized values are centered around a $(0, 0)$ centroid, F1, F2 and F3 all have normalized values in the same or similar ranges. Therefore, since subtracting normalized values from each other yields misleading results, the values used for subtraction, i.e., F2-F1 and F3-F2, are made using Hertz values that are scaled from the normalized values. In Table 6.5, the effect on F2-F1 and F3-F2 are given in these scaled Hertz values. Statistically significant results are marked with asterisks.

6.3.2 High front vowels [i] and [iʶ]

The high front vowel [i] and its uvularized counterpart [iʶ] occupy overlapping, but distinctly separate spaces in the F1xF2 vowel space. When compared with its plain counterpart, [iʶ] appears to be both lowered and retracted. The top of Figure 6.2 on page 106 shows the F1xF2 measures for these two vowels at their midpoints in Lobanov normalized values for all speakers. F1 differences, which are correlates of vowel height, are shown in Figure 6.3 on page 107. Although there is no significant difference between F1 measures for [i] and [iʶ], the vowel [i] appears to be higher (i.e., has values that are more negative) than [iʶ]. F2 measures appear lower in /iʶ/ than in /i/, though there are no statistically significant differences. Finally, F3 may be slightly lower in /iʶ/ than /i/, though they are largely overlapping as seen at the bottom of Figure 6.2, and it appears that F3 is generally not affected by uvularization in this high front unrounded vowel. Across all three formants, we see a distinctive drop over time in [iʶ] as shown in the graphs on the right in Figure 6.3, while the formants in [i] are relatively stable over time.

Although the F2 and F1 values alone do not show statistically significant differences between [i] and [iʶ], when we move to the difference between these formants, i.e., F2-F1, we find that [iʶ] is significantly higher than [i] ($p < .05$). This means that the space between these formants is widened as a result of uvularization in [iʶ] when compared with [i], and because we observe both a lowering and retraction in [iʶ], we can surmise that this greater difference is a product of both of these movements.

Table 6.5. Summary of statistical tests for each vowel contrast; formants in normalized values, formant differences in scaled Hertz values

Vowel class	Statistic	F1	F2	F3	F2-F1	F3-F2
/i/ vs. /iʶ/	n	231	231	231	231	231
	effect	-0.026	-0.056	-0.085	252.95	1.9
	T value	-0.361	-0.73	-0.599	8.055	0.086
	p value	> 0.05	> 0.05	> 0.05	< 0.001***	> 0.05
/y/ vs. /yʶ/	n	214	215	215	214	215
	effect	0.119	-0.164	0.246	-171.38	60.03
	T value	0.454	-1.64	1.5	-0.829	0.564
	p value	> 0.05	> 0.05	> 0.05	> 0.05	> 0.05
/u/ vs. /uʶ/	n	311	311	310	311	310
	effect	-0.003	-0.35	0.236	-609.62	104.1
	T value	-0.034	-2.218	1.221	-18.82	2.627
	p value	> 0.05	< 0.05*	> 0.05	< 0.001***	< 0.05*
/ə/ vs. /əʶ/	n	422	422	422	422	422
	effect	-0.124	-0.146	0.225	-176.55	59.49
	T value	-1.435	-1.962	1.053	-3.294	1.844
	p value	> 0.05	0.0504	> 0.05	< 0.01**	0.0659
/ɔ/ vs. /ɔʶ/	n	239	239	239	239	239
	effect	0.205	-0.462	0.168	352.91	138.75
	T value	1.149	-4.965	0.439	3.57	2.053
	p value	> 0.05	< 0.01**	> 0.05	< 0.01**	0.0794
/a/ vs. /aʶ/	n	456	456	456	456	456
	effect	-0.052	-0.17	0.128	171.31	80.06
	T value	-0.772	-2.438	0.872	1.871	3.704
	p value	> 0.05	> 0.05	> 0.05	0.0765	< 0.001***

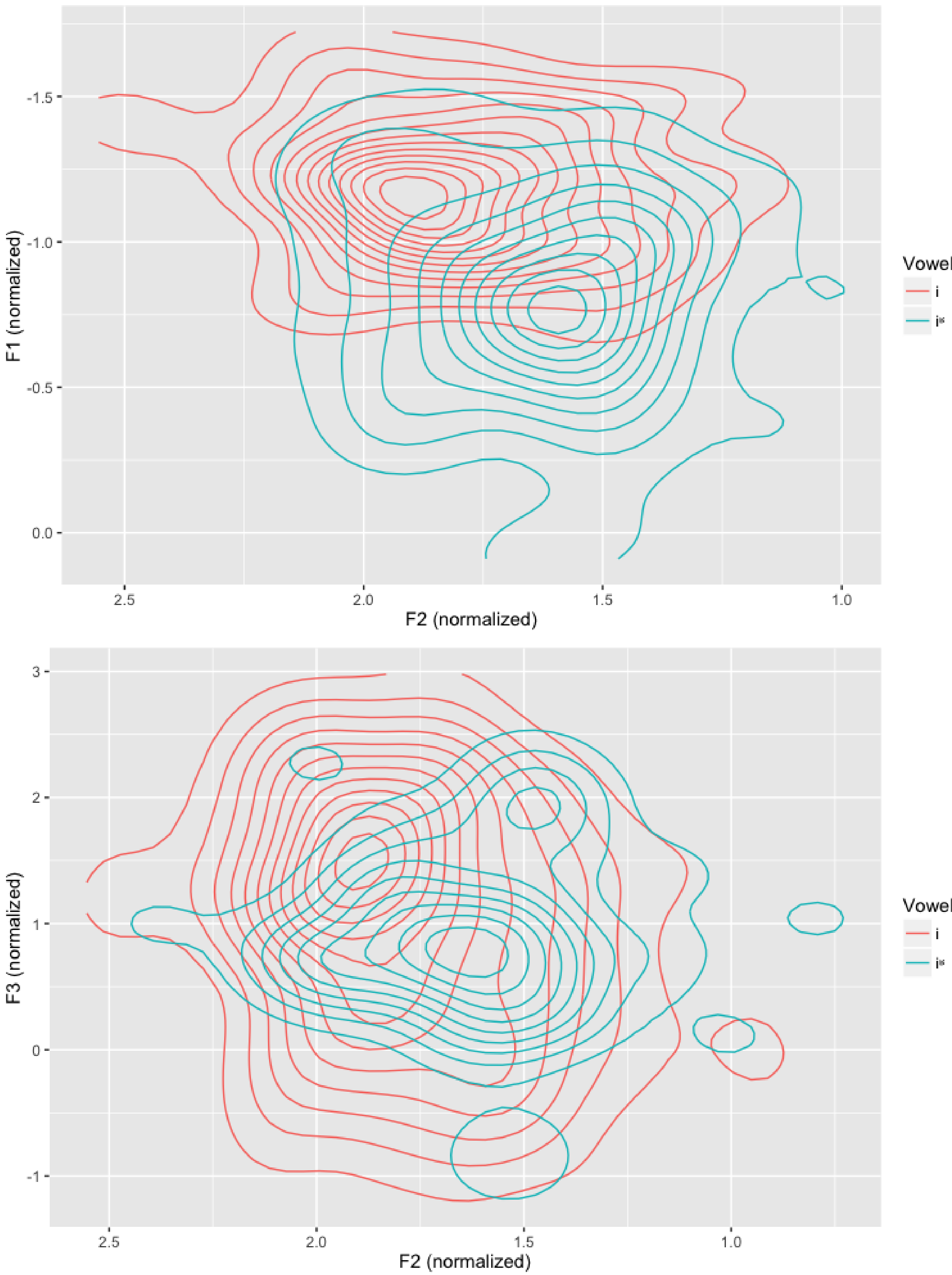


Figure 6.2. F1xF2 and F2xF3 density plots for [i] and [iʶ]

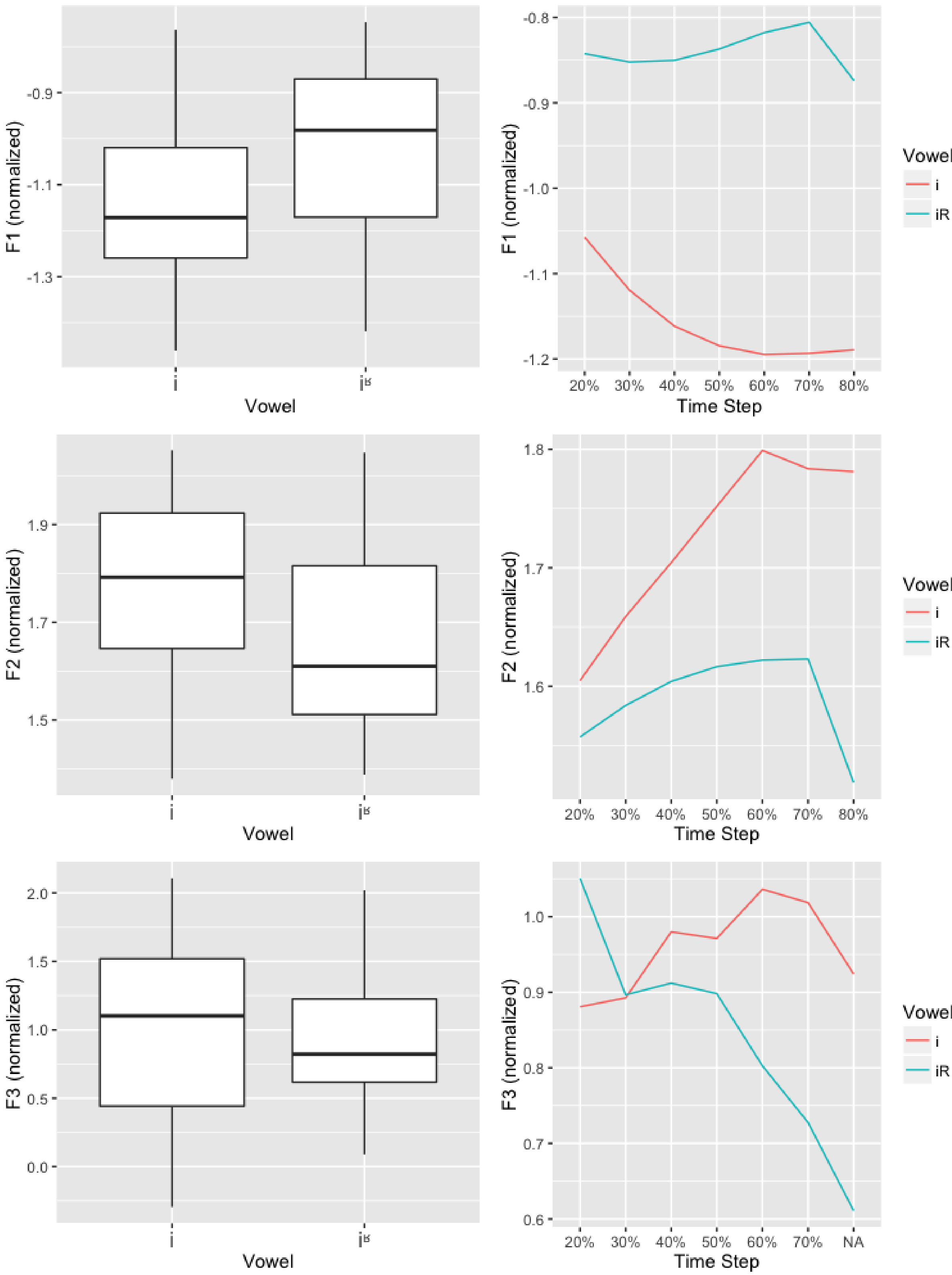


Figure 6.3. Formant values at midpoint (left) and formant values across time (right) in Lobanov normalized values for [i] and [iʁ]

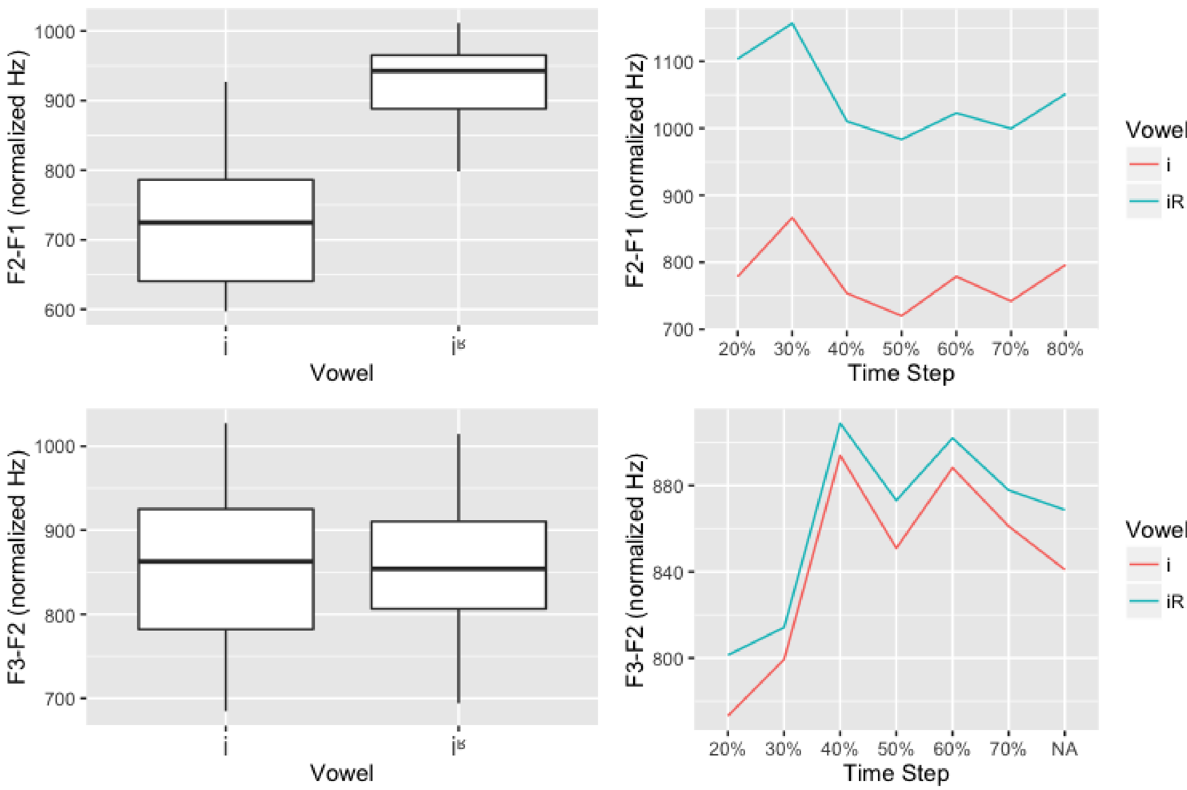


Figure 6.4. F2-F1 and F3-F2 differences at midpoint (left) and over time (right) in scaled Hertz values for [i] and [iʁ]

6.3.3 High front rounded vowels [y] and [yʶ]

The uvularized high front rounded vowel [yʶ] occupies an F1xF2 space entirely bounded by that occupied by its plain counterpart [y], as shown in Figure 6.5 on page 110. This is perhaps not surprising since [y] occupies a relatively wide portion of the F1xF2 vowel space, overlapping with both the high front vowel [i] and the high back vowel [u]. As we can see from Figure 6.5, [yʶ] is a bit lower overall than [y] and it occupies a more compact area of the vowel space. At the bottom of Figure 6.5, we see that F3 is a bit raised in [yʶ], when compared with [y].

The salient distinction between [y] and [yʶ] may not in fact come from the F1xF2 space, but from the effect on F3. The uvularized [yʶ] has a markedly higher F3 than the plain [y], as seen at the bottom of Figure 6.5, which plots F3 on the vertical axis.

Differences in formant values between [y] and [yʶ] are shown for all three formants in Figure 6.6 on page 111, with the left side showing midpoint ranges, and the right side showing the change in mean values over time. Figure 6.7 on page 112 shows the F2-F1 and F3-F2 values (midpoint and over time). None of the differences observed between [y] and [yʶ] are significant. This is likely due to the relatively small number ($n = 54$) of [yʶ] tokens when compared with the [y] tokens ($n = 377$) in the data set, owing to the unexpectedly large inter-speaker variation observed in the word *ʁzyʶ* 'excrement,' in which many speakers say [ʁzy], rather than [ʁzyʶ].

6.3.4 High back rounded vowels [u] and [uʶ]

In comparing [u] and [uʶ], we can see from the F1xF2 plot in Figure 6.8 on page 114 that there is significant overlap between the two, but there are some differences. While plain [u] is more diffuse, uvularized [uʶ] has more concentrated values further back (i.e., has a lower overall F2). F2 differences can be seen in the middle plots in Figure 6.9 on page 115; F2 is significantly lower in [uʶ] when compared with [u] ($p < .05$). We also see that F2 rises throughout [uʶ], while it is relatively stable throughout [u]. F3 appears to be slightly higher for [uʶ] as compared with [u], as shown in Figures 6.8 and 6.9, though this is not a statistically significant difference. F1 differences are small and not significant.

When comparing the formant differences, we find that F2-F1 is significantly lower in [uʶ] than in [u] ($p < .05$), while F3-F2 is significantly higher in [uʶ] than in [u] ($p < .05$). This suggests that the

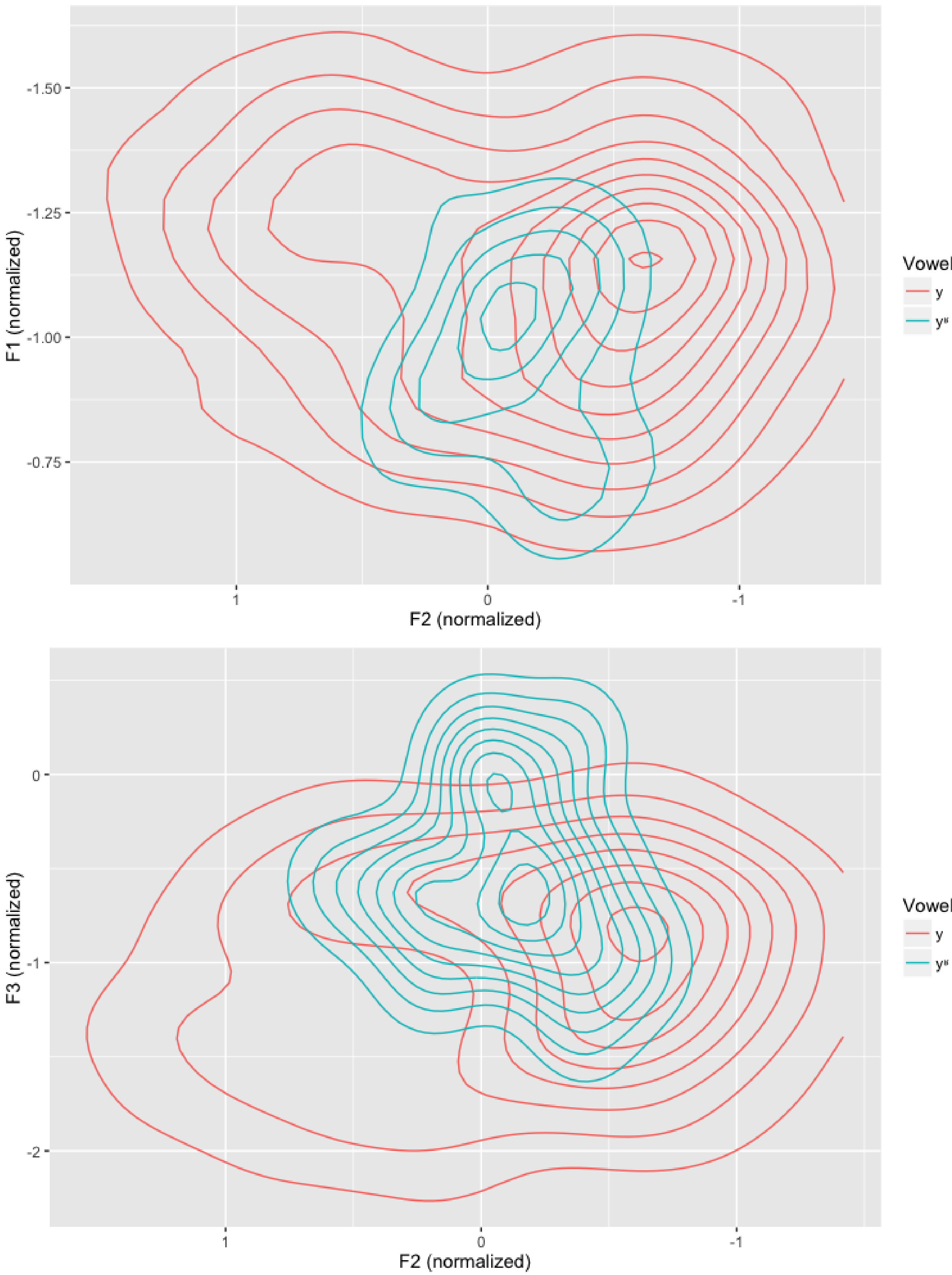


Figure 6.5. F1xF2 and F2xF3 density plots for [y] and [yʶ]

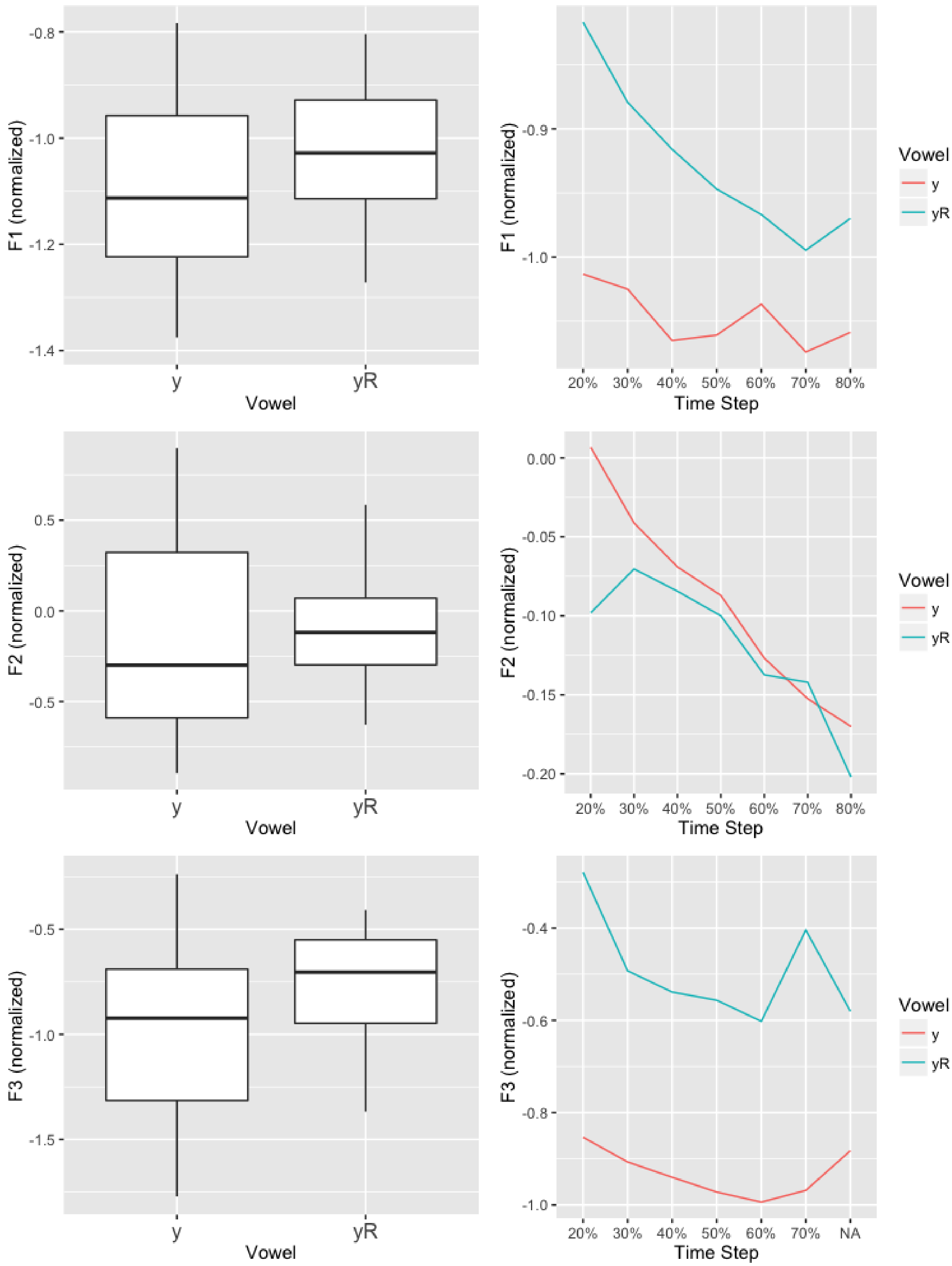


Figure 6.6. Formant values at midpoint (left) and formant values across time (right) in Lobanov normalized values for [y] and [yʁ]

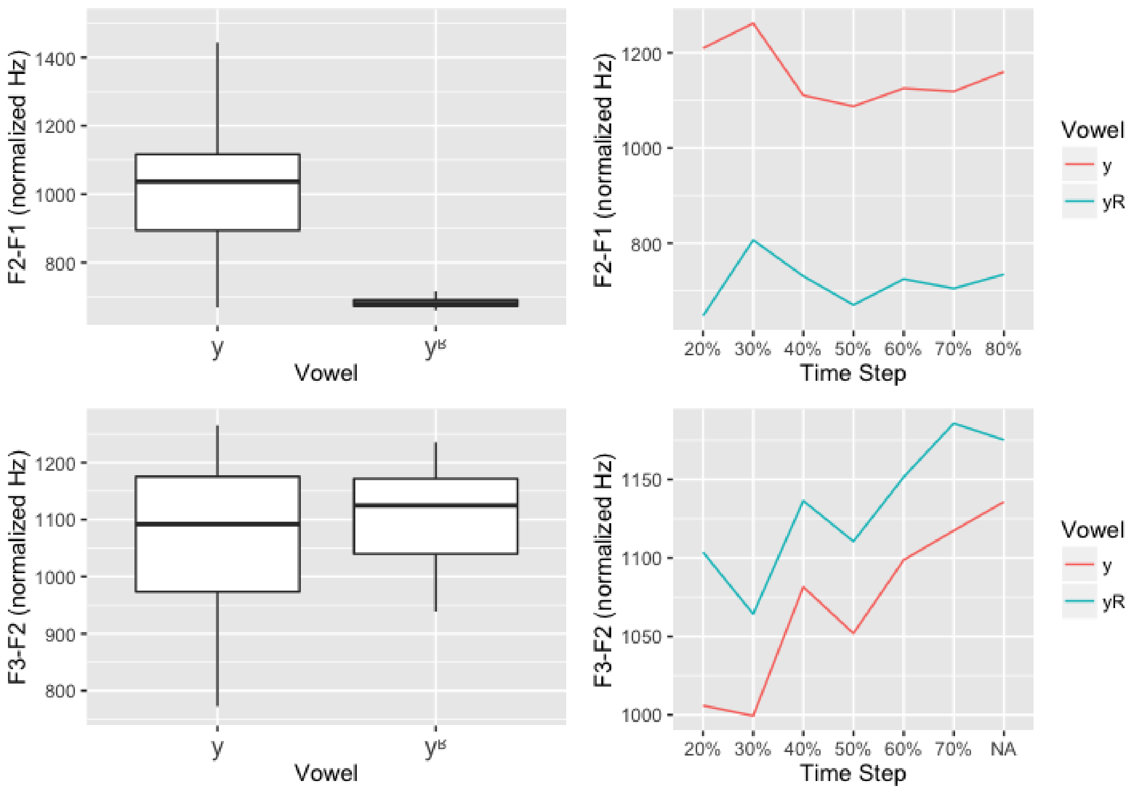


Figure 6.7. F2-F1 and F3-F2 differences at midpoint (left) and over time (right) in scaled Hertz values for [y] and [yʁ]

lowering of F2 (i.e., backing) plays a significant acoustic role in the discrimination between [uʶ] and [u], and indicates a retracted tongue during the production of this vowel.

6.3.5 Mid central vowels [ə] and [əʶ]

The mid central pair [ə] and [əʶ] are observed to occupy overlapping, yet distinct regions of the center of the F1xF2 vowel space, as can be seen in the top of Figure 6.11 on page 117. Visually, we can see that the major distinction between the two vowels is backness, i.e., that [əʶ] is farther back than [ə]. In Figure 6.12 on page 118, we observe that indeed the greatest separation in the class between formants is in F2. In fact, the effect of uvularization on F2 in this pair is approaching significance ($p = 0.05$). We also observe a steep increase in F2 over time for [əʶ] while [ə] is fairly stable. Differences between the midpoints of these pairs in F1 and F3 are small and not significant.

The lowering of F2 shrinks the space between the first two formants enough to make F2-F1 significantly lower for [əʶ] when compared with [ə] ($p < 0.05$), as shown in Figure 6.13 on page 119. It also increases the difference between F2 and F3 enough that F3-F2 differences between this pair are approaching significance ($p = 0.06$).

6.3.6 Low-mid back rounded vowels [ɔ] and [ɔʶ]

Although there is no phonological evidence for phonemically uvularized */ɔʶ/, we see that the uvularized allophone [ɔʶ] has many of the same acoustic attributes distinguishing it from plain [ɔ] as we see in other pairs with a phonemic counterpart. In Figure 6.14 on page 120, we see from the F1xF2 plot on top that [ɔʶ] is distinctly further back than [ɔ], while vowel height differences are negligible. Differences in F3 are also negligible. This is corroborated by the boxplots in Figure 6.15: only F2 differences are distinct and they are also the only statistically significant differences ($p < 0.05$).

When we compare the differences between formants, as in Figure 6.16 on page 122, we see that F2-F1 is also higher in [ɔʶ] than in [ɔ] at a significant level ($p < 0.05$), although it is unclear how this difference grows for the uvularized vowel when the values for F2 are lower and thus closer to F1. The differences between the second and third formants are noticeable, though not as pronounced, and are putatively the result of a lowered F2 and a raised F3, both of which are observed in Figure 6.15, though only F2 differences are statistically significant. These F3-F2 differences are approaching statistical significance ($p = 0.079$).

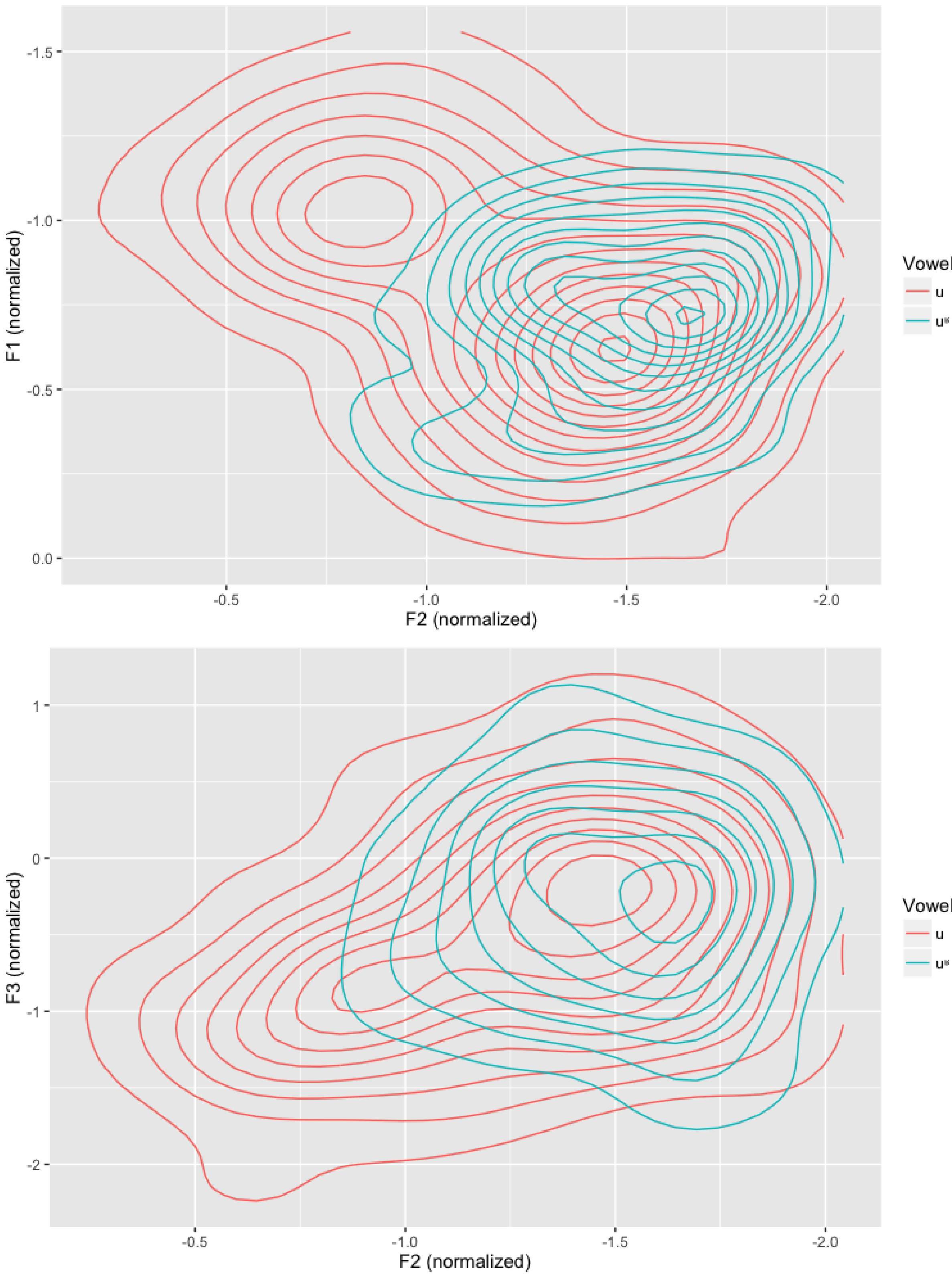


Figure 6.8. F1xF2 and F2xF3 density plots for [u] and [uˠ]

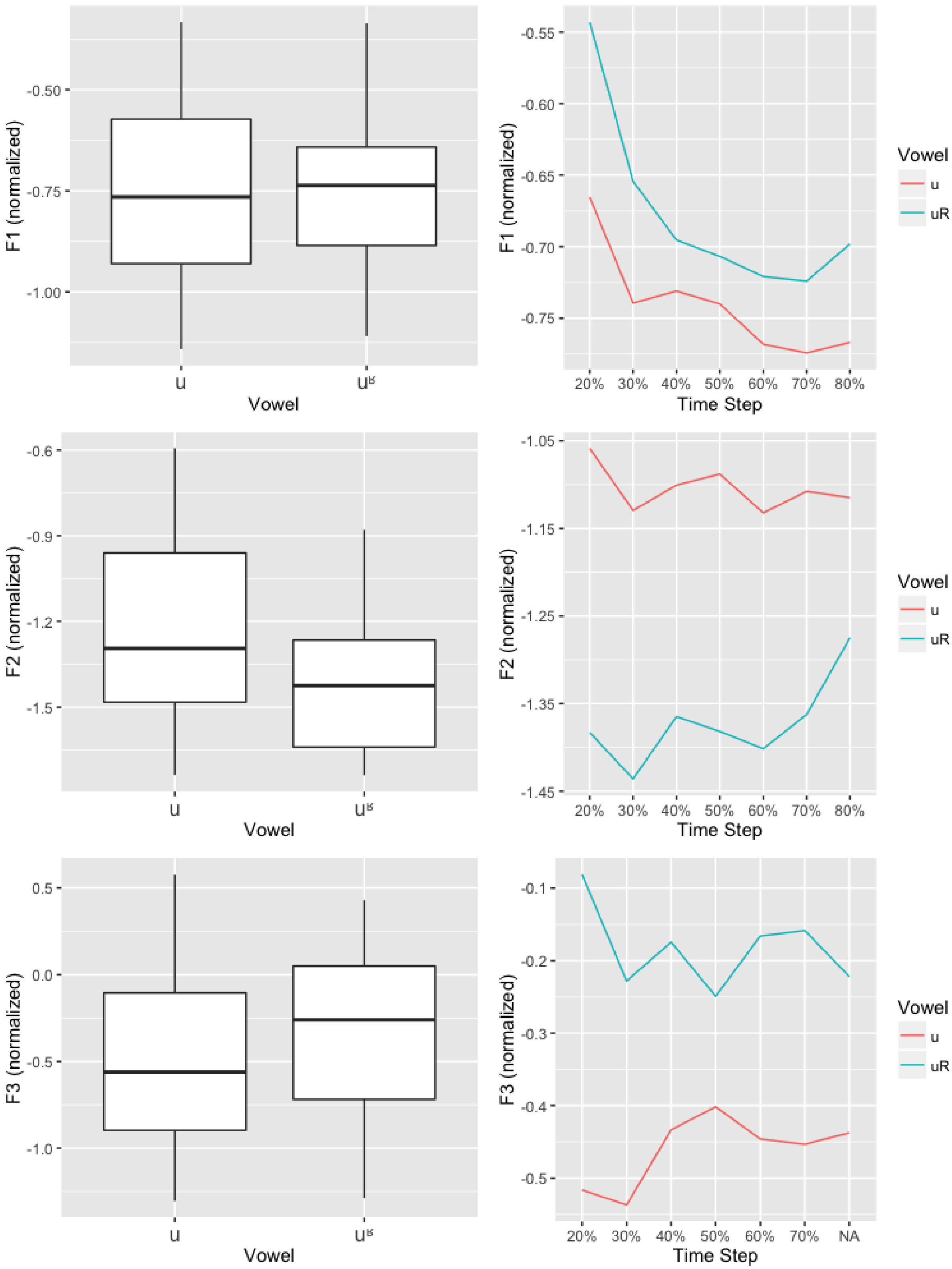


Figure 6.9. Formant values at midpoint (left) and formant values across time (right) in Lobanov normalized values for [u] and [uʶ]

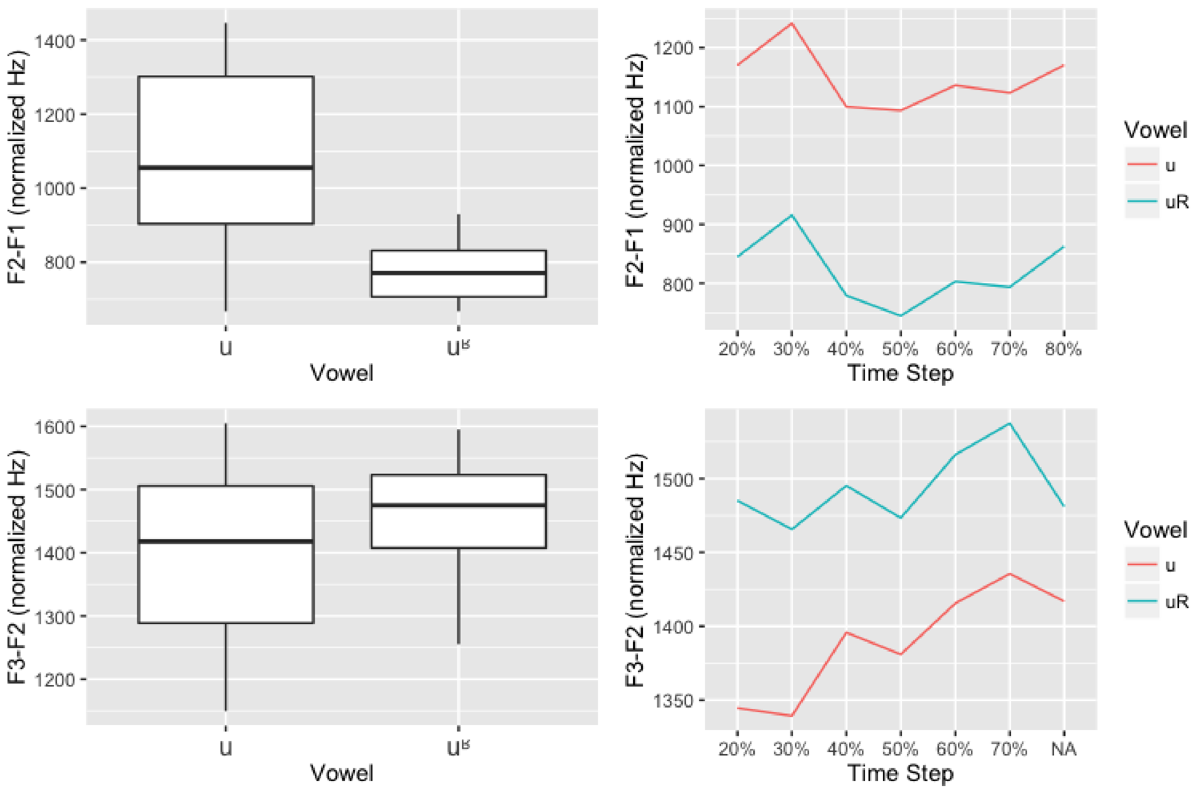


Figure 6.10. F2-F1 and F3-F2 differences at midpoint (left) and over time (right) in scaled Hertz values for [u] and [uʁ]

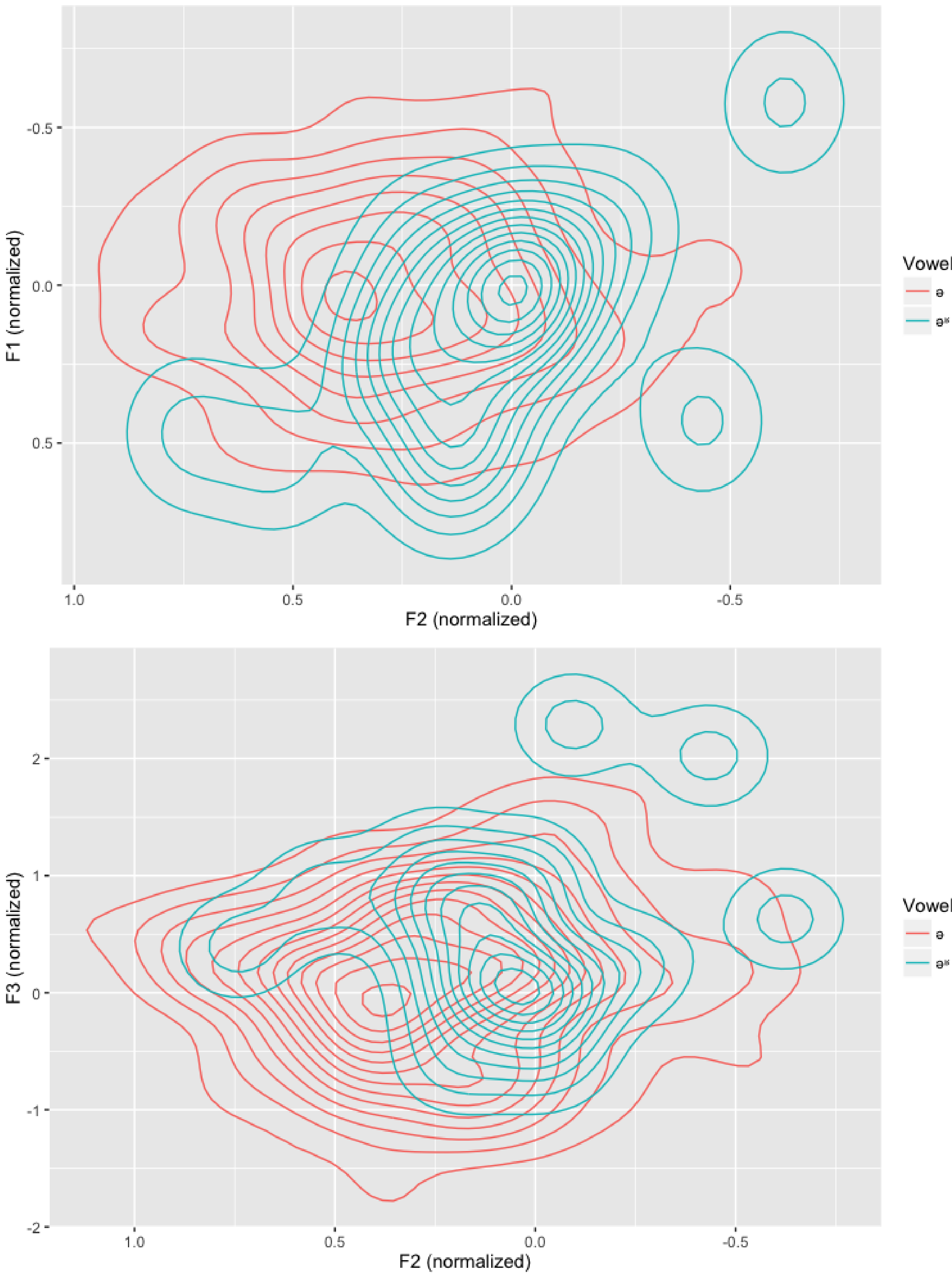


Figure 6.11. F1xF2 and F2xF3 density plots for [ə] and [əʶ]

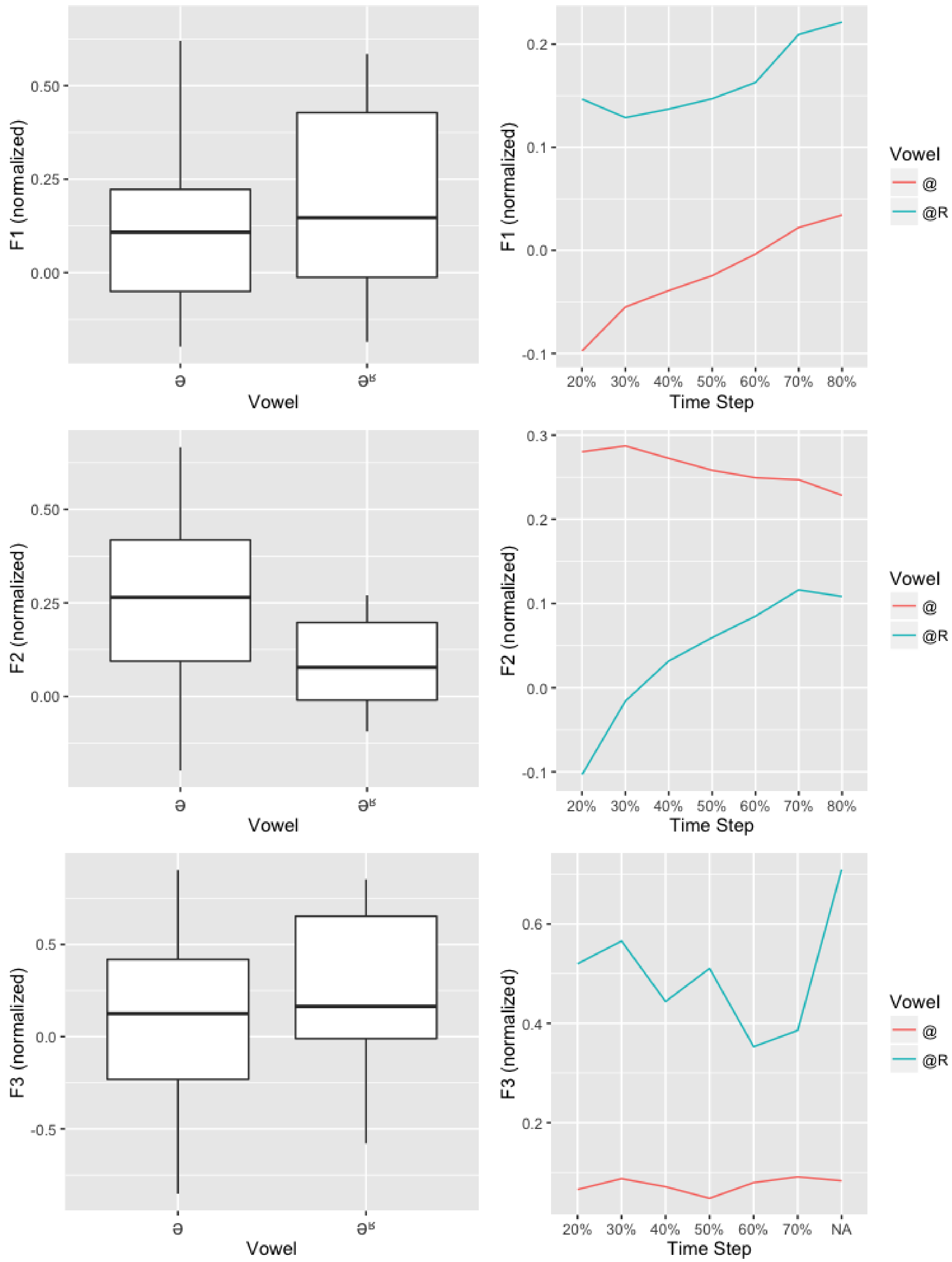


Figure 6.12. Formant values at midpoint (left) and formant values across time (right) in Lobanov normalized values for [ə] and [əʶ]

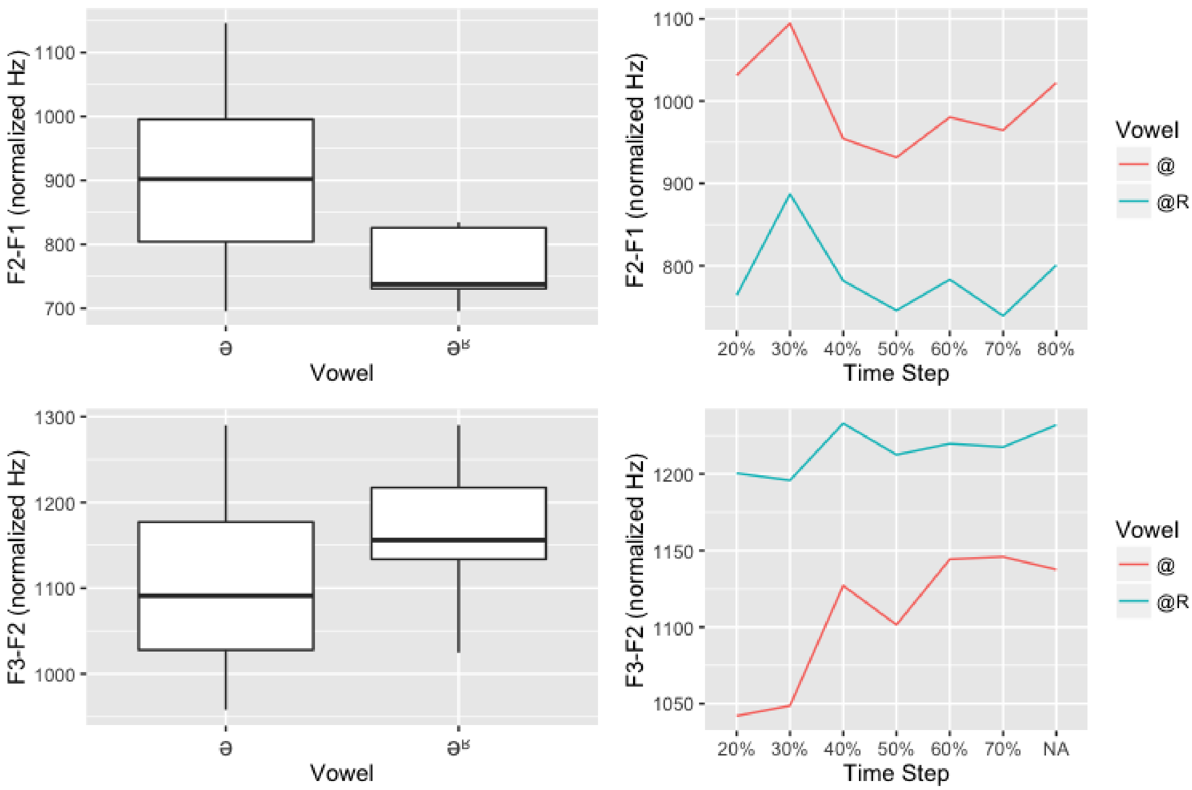


Figure 6.13. F2-F1 and F3-F2 differences at midpoint (left) and over time (right) in scaled Hertz values for [ə] and [əʁ]

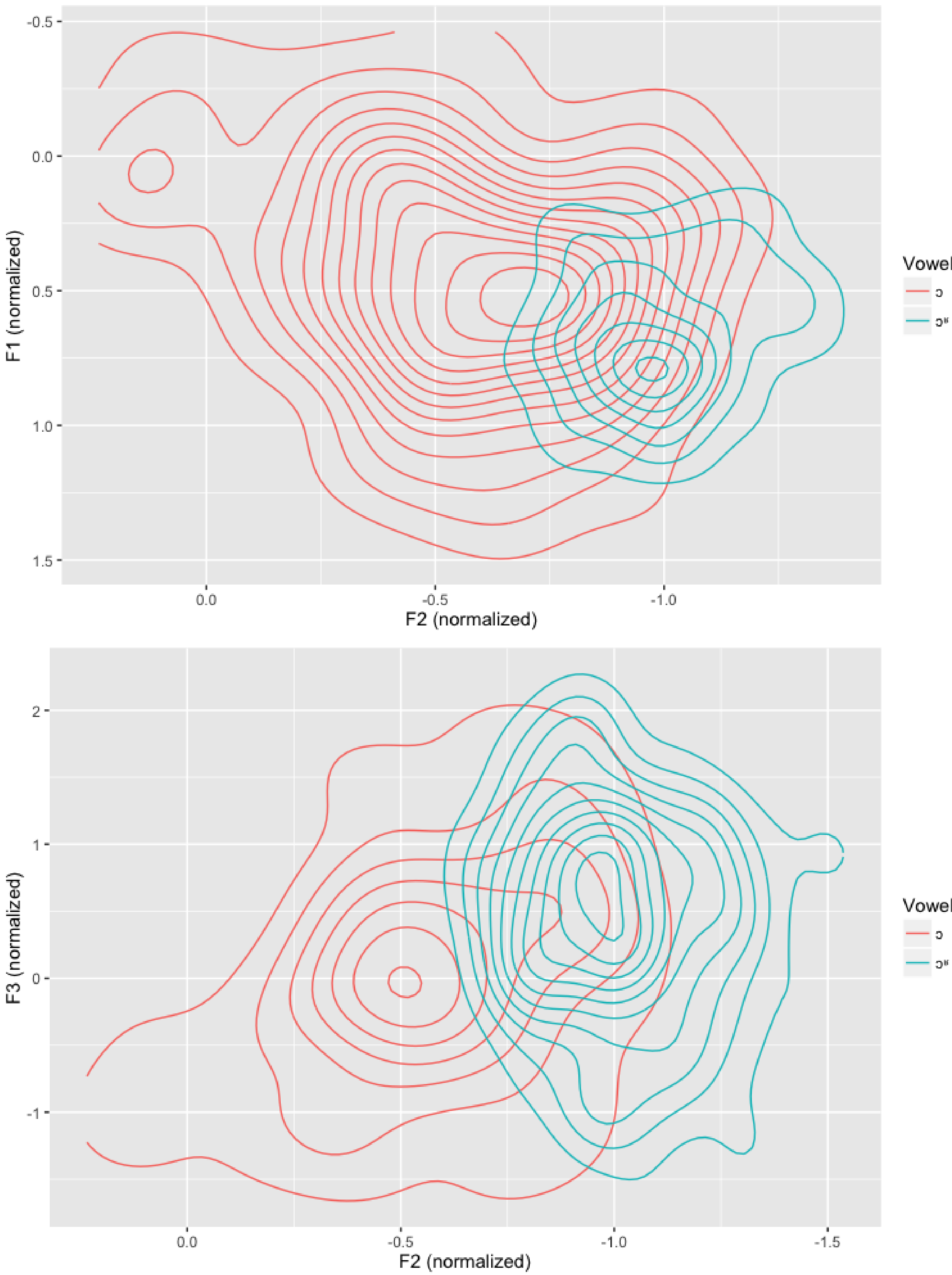


Figure 6.14. F1xF2 and F2xF3 density plots for [ɔ] and [ɔʶ]

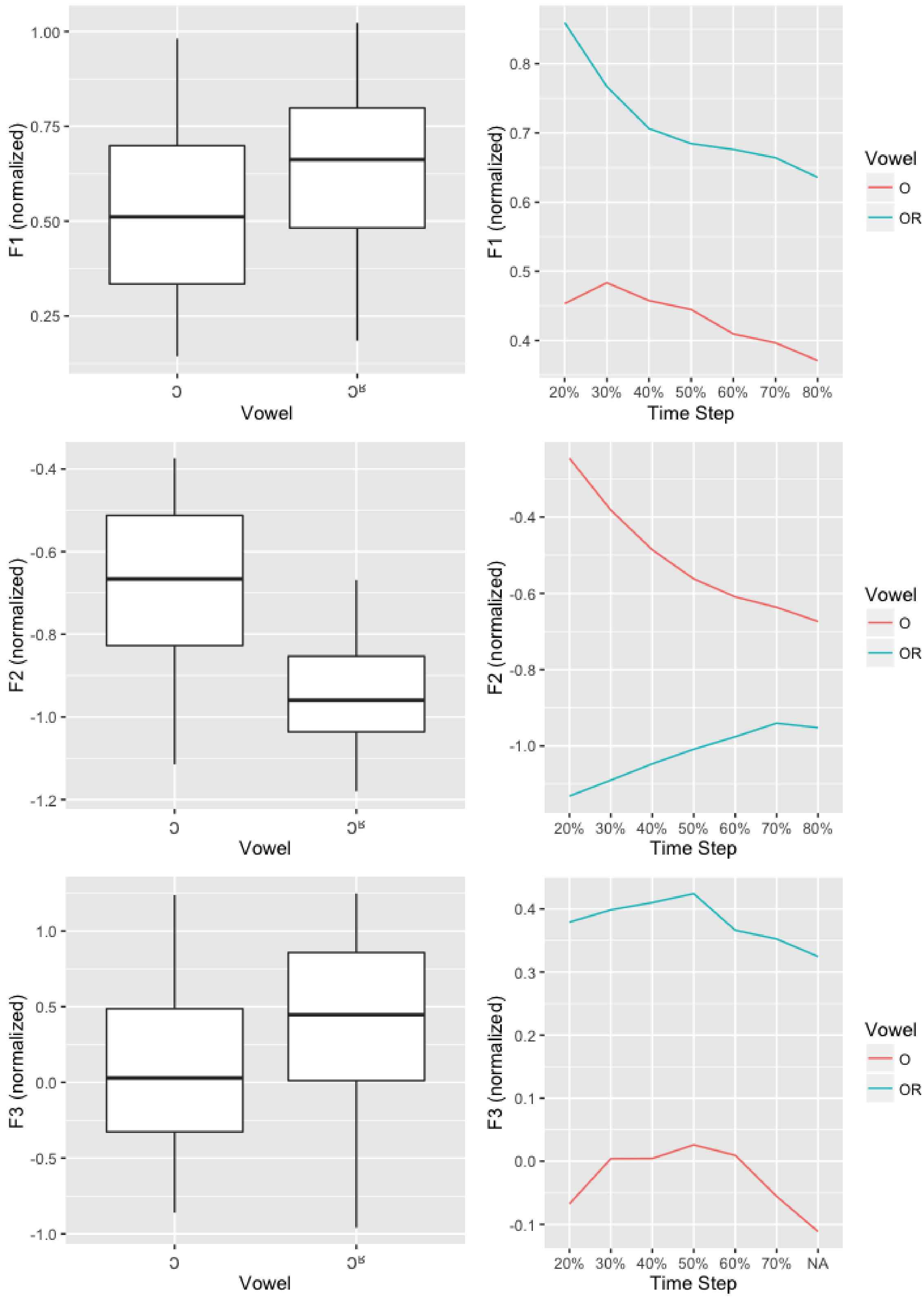


Figure 6.15. Formant values at midpoint (left) and formant values across time (right) in Lobanov normalized values for [ɔ] and [ɔʶ]

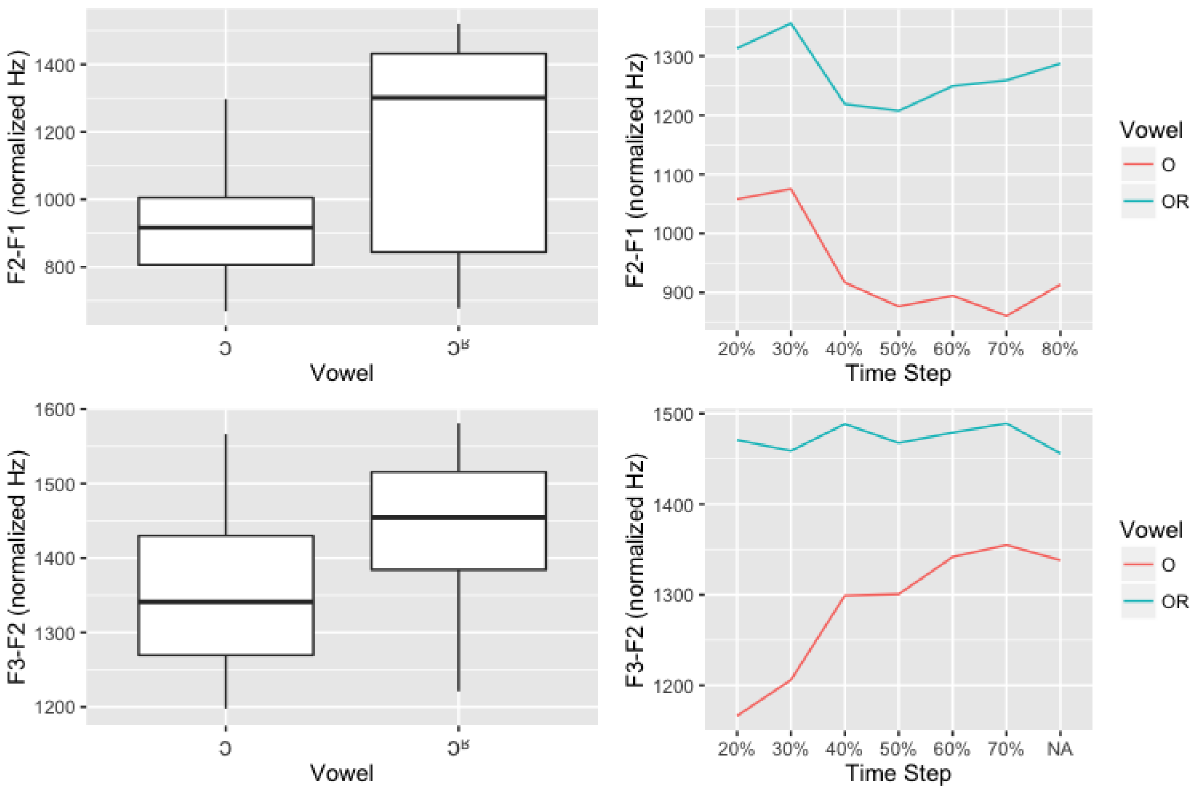


Figure 6.16. F2-F1 and F3-F2 differences at midpoint (left) and over time (right) in scaled Hertz values for [ɔ] and [ɔʁ]

6.3.7 Low central vowels [a] and [aʶ]

The two low vowels [a] and [aʶ], plotted in Figure 6.17 on page 124, occupy perhaps the most separate F1xF2 spaces, though the uvularized [aʶ] exhibits a high degree of variation, and can overlap significantly with plain [a]. Of all the vowel pairs in this language, [aʶ] is observed to exhibit the most backing when compared with its plain counterpart. The variation observed in [aʶ] makes the mean difference in F2, though noticeable lower than [a] as seen in the middle of Figure 6.18, not statistically significant.

The differences between the second and third formant are significantly greater in [aʶ] than in [a] ($p < 0.05$), as seen in Figure 6.19 on page 126. The space created by the lowering of F2 (i.e., backing) is correlated with uvularization in this vowel pair.

6.4 Discussion

In examining the effect of uvularization on different vowels in Nyagrong Minyag, we find that the most salient acoustic cue of uvularization is a drop in F2, which correspondingly affects the spaces between the formants, as measured by F2-F1 and F3-F2. According to perturbation theory (Chiba & Kajiyama 1941, Mrayati et al. 1988), constrictions in the vocal tract affect formants by lowering when the constriction is near a point of maximum velocity for that formant, and raising when the constriction is near a point of maximum pressure for that formant. The second formant has points of maximum velocity near the lips and the pharyngeal cavity; the third formant has a point of maximum pressure between the tongue back/root and the uvula. Therefore, a secondary articulation in the uvular region would likely produce a drop in F2 and a rise in F3. In our acoustic study of Nyagrong Minyag, we find statistically significant F2 lowering in the uvularized vowels [uʶ], [əʶ], [ɔʶ] and an F2 lowering trend in the other uvularized vowels [iʶ], [yʶ], [aʶ] though without statistical significance. We do not find any statistically significant effects on F3 when measured alone, but we do note that the space between the second and third formants, i.e., F3-F2, increases as a result of uvularization. F3-F2 is significantly higher in [uʶ] and [aʶ], and is approaching significance in [əʶ] and [ɔʶ].

As a secondary articulation, we assume that the constriction under investigation here is primarily in the uvular region for the phonological reasons mentioned previously. Although the present study does not include any articulatory investigations, we can hypothesize about these articulations from other relevant studies. In the nearby related language Qiang, Evans et al. (2016) use ultrasound

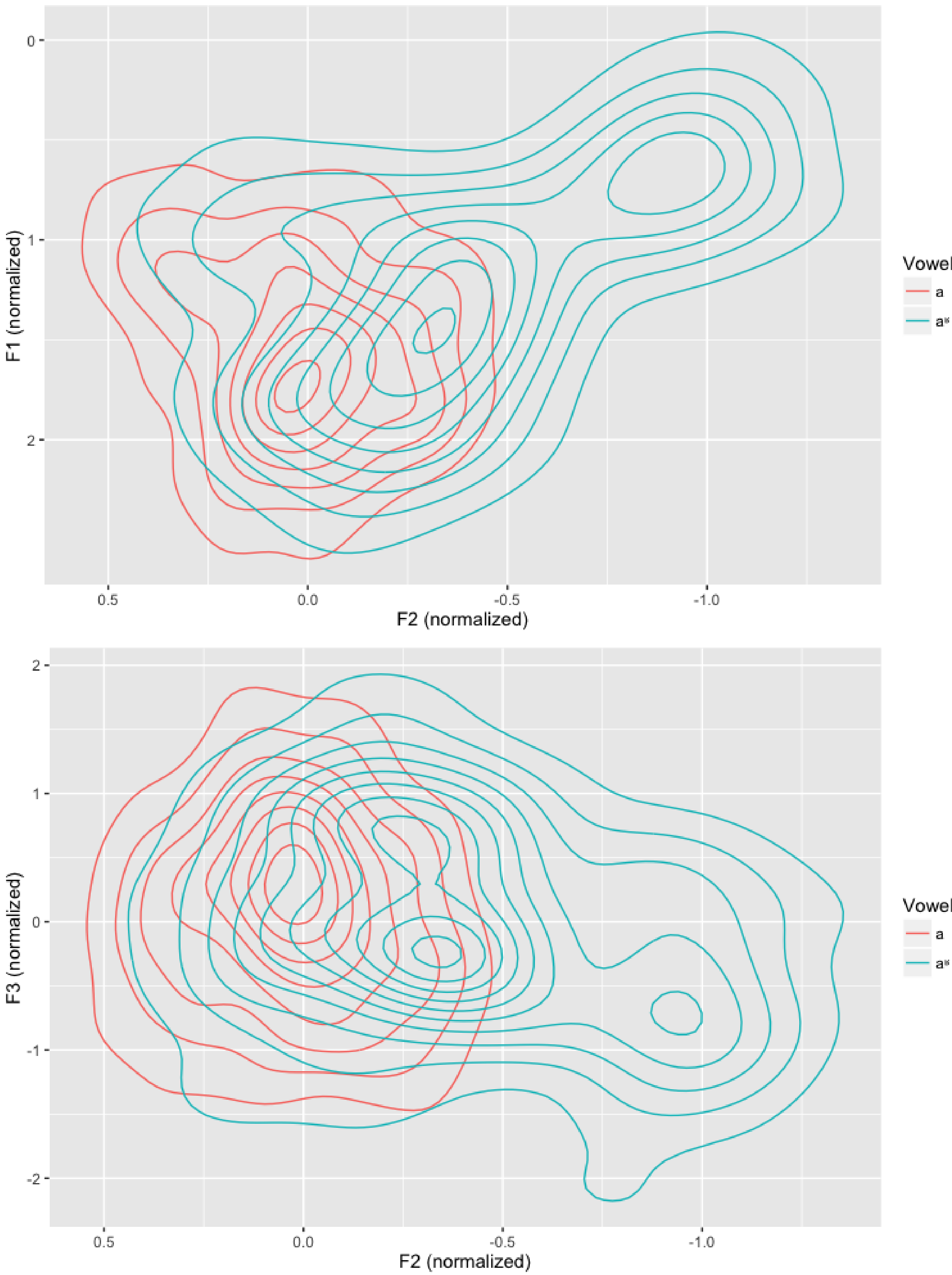


Figure 6.17. F1xF2 and F2xF3 density plots for [a] and [aʁ]

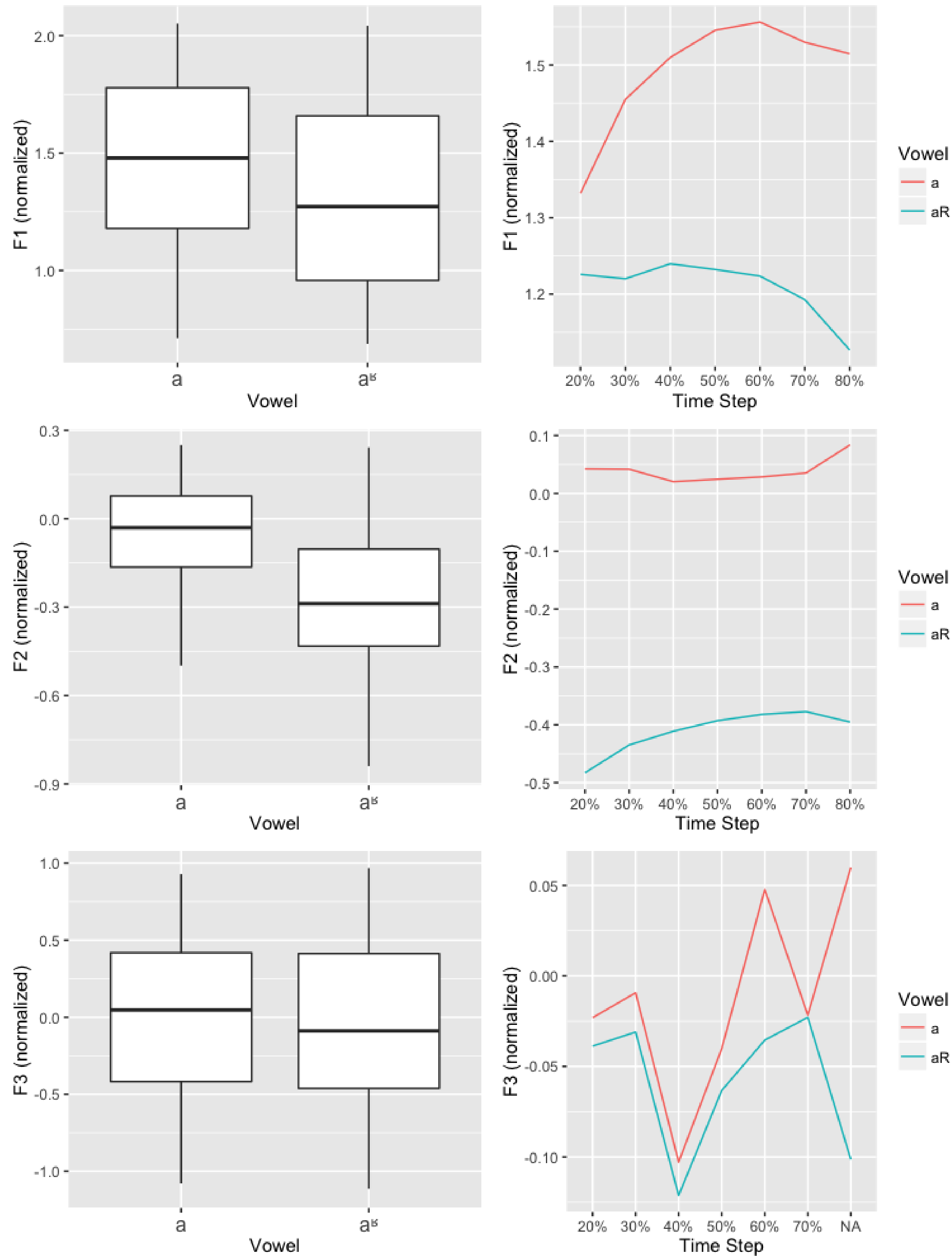


Figure 6.18. Formant values at midpoint (left) and formant values across time (right) in Lobanov normalized values for [a] and [aʁ]

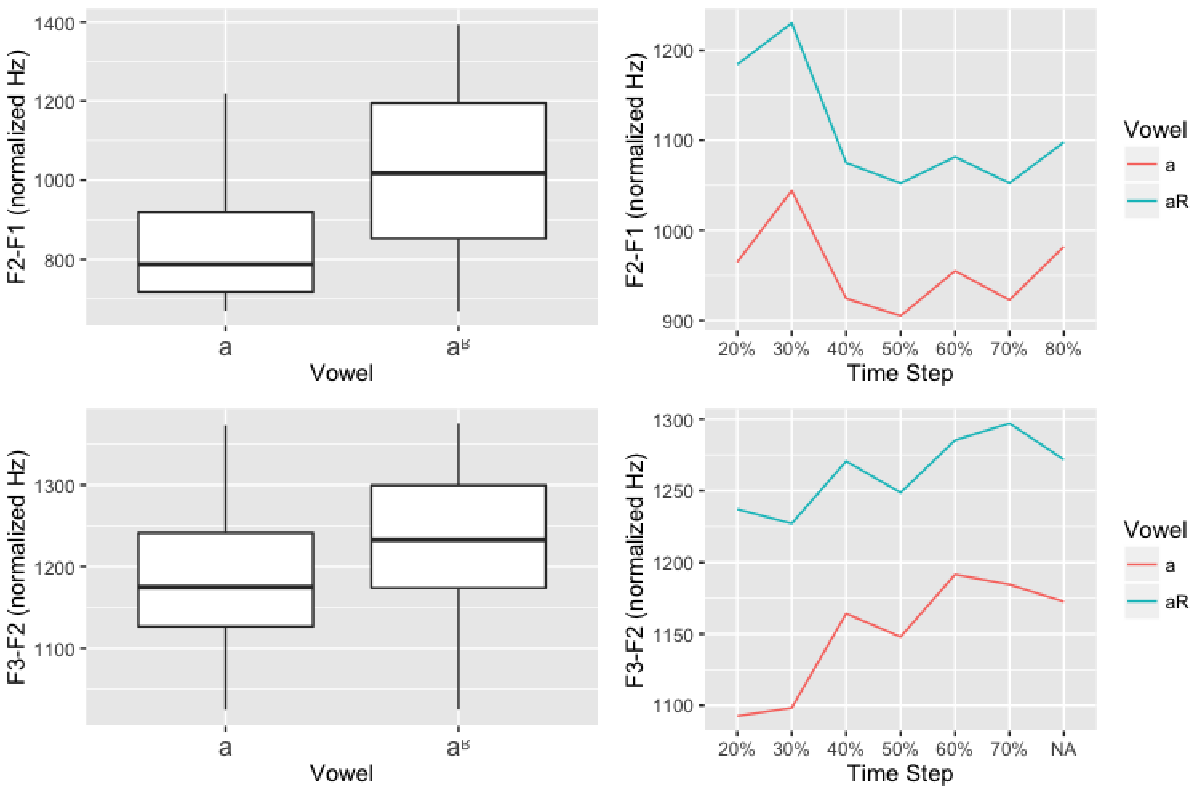


Figure 6.19. F2-F1 and F3-F2 differences at midpoint (left) and over time (right) in scaled Hertz values for [a] and [aʁ]

to show that in uvularized vowels the highest point of the tongue is retracted when compared with the highest point of the tongue in plain vowel counterparts. Shahin (2011), from studies of Arabic and St'át'imcets, claims that uvularization is accompanied by upper pharyngeal constrictions as well. Such a constriction would line up with an observed drop in F2, which we observe in Nyagrong Minyag. Further studies would benefit from articulatory imaging using an instrument like a portable ultrasound that would help illuminate the nature of the tongue movement during uvularization.

The extent to which the vowel trajectories inform us about the nature of uvularization in this language remains to be seen. It is perhaps possible that a vowel which is inherently uvularized has more of the acoustic cues of uvularization (i.e., drop in F2 and greater F3-F2) throughout its production than a vowel which is phonologically conditioned from a preceding uvular, in which we would expect a gradual rising in F2 and lowering of F3-F2, or from a vowel that is phonologically conditioned from a following uvular, in which we would expect to see a gradual lowering of F2 and increase of F3-F2. As this study does not contain enough words with these kinds of contrasts from multiple speakers, we will not be able to settle that question here, but it will remain an area for future acoustic investigation.

Overall, this chapter has given further evidence of uvularization as a secondary articulation on vowels. Phonological reasoning and acoustic evidence from Nyagrong Minyag further strengthen the argument of Evans et al. (2016) that uvular approximation should be included among the secondary articulations recognized by the International Phonetic Alphabet. Such a recognition would aid research into uvularization as a phonetic or phonological phenomenon in other languages or speech varieties. Furthermore, many Rgyalrongic languages, including the Horpic languages to which Nyagrong Minyag belongs, have been described as having phonemically contrastive velarized vowels (Sun 2000b, 2004, 2005b, Lin et al. 2012). The evidence provided in this chapter suggests that the vowel systems of these closely related languages may need to be reexamined.

Chapter 7

Conclusion

7.1 Summary

In this dissertation, I have presented a detailed treatment of the sound system of Nyagrong Minyag, a Horpic language of the Sino-Tibetan family, spoken in western China. The goals of this dissertation are to contribute to the documentation of this understudied and endangered language and to provide thorough phonetic and phonological analyses of rare phenomena such as aspirated fricatives and uvularized vowels, as well as precise phonetic details about the large inventory of sounds. This dissertation contributes to the documentation of Nyagrong Minyag, to the study of phonetics and phonology, provides data for comparative studies of Sino-Tibetan languages, and helps ground future work on the documentation and preservation of this language.

In Chapter 1, I explain the geographical, linguistic and socio-cultural context in which Nyagrong Minyag is spoken. Previous research on this and nearby, related languages is reviewed. In this chapter, I clarify what is meant by the term Nyagrong Minyag, disambiguating it from other languages, and I examine the mutual intelligibility, or lack thereof, with other languages, and its genetic relationship within the Sino-Tibetan family. Considerable discussion centers around the vitality of Nyagrong Minyag. I explain that this language is at the bottom of a prestige hierarchy which includes local and literary varieties of Tibetan and Mandarin Chinese. This situation is causing a shift from Nyagrong Minyag to Nyagskad, the local Tibetic language, which has become the local lingua franca and has replaced Minyag in many formal and informal domains. The system of formal education also serves to increase the prestige of Literary Tibetan and Chinese, and further dim the prospects of future maintenance of this language. Finally, the construction of a hydroelectric dam will cause all speakers to be relocated, which will likely further disrupt the transmission of this language to younger generations.

This endangerment situation has sparked an interest in language and cultural documentation, which it is hoped will help preserve Nyagrong Minyag for future generations. This documentation project is the larger context in which this dissertation is situated.

Chapter 2 describes the methods used to gather and analyze data for this study. The design of certain aspects of the study, such as audio recordings of word lists and other speech events, and the recruitment of participants are discussed. I describe methods for extracting acoustic data from the audio recordings and quantitative methods for handling the acoustic data, such as vowel normalization and statistical tests. I also describe the design of static palatography sessions for revealing details of articulation. This chapter provides descriptions of phonetic methods which are useful in the investigation of under-documented languages.

Chapter 3 provides evidence for the 42 consonants and seven plain vowels that make up the phonemic inventory of Nyagrong Minyag. Details of articulation for consonants are shown with palatographic evidence, and these details help illuminate the differences between the many phones, especially those in the coronal region. In particular, it is shown (through preliminary palatography with one speaker) that most of the alveolars are laminal, that the trill is dental, and that the three sets of affricates are denti-alveolar, alveolo-palatal and post-alveolar. The allophony and distribution of velar, uvular and glottal consonants are also shown. Plain vowels are shown in phonological and acoustic space, and vowel alternations are explained.

Chapter 4 explores the syllable, with special attention to initial clusters, since Nyagrong Minyag allows for great complexity in the onset and no underlying codas. Phonological analysis is used to determine which phonemes are present in initial clusters. Variation observed in these clusters is explained through phonetic reasoning. In this chapter, I make use of palatographic and acoustic evidence (i.e., spectral properties of fricatives and the formants of the preceding vowel) to compare and contrast consonants in clusters.

Chapter 5 explores phonological and phonetic questions that arise with respect to the fricatives and affricates in Nyagrong Minyag. Regarding the affricates, linguography allows for the three places of articulation to be further distinguished by lingual characteristics: [ts] is laminal, flat; [tɕ] is (apico-) laminal, domed; and [tʂ] is apical, flat. Acoustic differences are also found in the center of gravity of the frication portion of each affricate and the F2 locus (raising after [tɕ]). Close observation of the articulatory details has allowed for the discovery of an unexpected asymmetry between the alveolo-palatal affricates and the palato-alveolar fricatives. Finally, aspirated fricatives, which are typologically rare, are examined from an acoustic perspective. I find that center of gravity changes from the frication to the aspiration portion of the fricative and that f_0 is lower after aspirated fricatives than unaspirated fricatives, while the effect on higher formants is inconclusive. The presence of these aspirated fricatives present problems for feature-based theories of phonology that rely on the feature [spread glottis] to characterize aspirated consonants.

Chapter 6 provides evidence for a secondary uvular approximation on vowels and other sonorants, in which the back of the tongue retracts toward the uvula. This feature can spread from uvular consonants, but I also show evidence for phonemically contrastive uvularized vowels. Nyagrong Minyag contains five uvularized vowel phonemes /iʁ yʁ uʁ əʁ aʁ/ alongside seven non-uvularized vowels. Acoustically, these uvularized vowels are found to have a lowered F2 and higher F3-F2 compared with their non-uvularized counterparts. These acoustic characteristics correlate with vowel backness. This chapter provides further evidence for uvularization to be recognized by the International Phonetic Alphabet as a secondary articulation.

7.2 Future efforts

Some questions remain about the phonetics and phonology of Nyagrong Minyag that can be investigated in a few ways. First, in order to confirm observations about the details of articulation, palatography with more speakers is needed. This would help clarify, for example, whether there is an asymmetry between the affricate series /tɕ tɕʰ dʑ/ and fricative series /ʃ ʃʰ ʒ/ or whether other speakers have them in the same place of articulation (although acoustic and auditory analysis have helped confirm the descriptions given here). Additional studies could also show whether some descriptions of other phones are consistent with all speakers; for example, it could be known whether all speakers have a dental trill [r̪]. More palatography may also help reveal the nature of variation in some of the pre-initials.

Second, well-designed perception experiments would aid in the identification of which acoustic cues are most salient for listeners. For example, in studying the aspirated fricatives, one could create stimuli that isolate certain cues, such as the raising or lowering of pitch in the vowel, or the difference in center of gravity between the frication and aspiration portions of the fricative. An experiment could then be run in which Nyagrong Minyag speakers would listen to the stimuli and identify whether they hear a word with an aspirated fricative or a minimally contrasting word with an unaspirated fricative (e.g., *ʃə* ‘tooth’ or *ʃʰə* ‘ghost’). Depending on which stimuli were presented, conclusions could be drawn about which acoustic cues are most salient. Similarly, one could design a perception experiment around the acoustic cues for uvularized vowels (i.e., lowered F2 and/or raised F3) to compare with plain vowels.

Finally, ultrasonic investigations could produce revealing studies of articulator movement, which would help clarify some of the segments, variation and secondary articulation observed in Nyagrong Minyag. For example, an ultrasound could be used to visualize the movement of the tongue during uvularized vowels/syllables. If the movement of the tongue is more similar to that in a uvular approximant than in, say, a velar approximant, it would help confirm the status of this secondary articulation as uvular approximation. Furthermore, ultrasonic studies of pre-initial fricatives could help reveal differences in the gestures of the tongue between *x-* and *r-* and incline more research toward gesture-based theories to describe this part of the language’s phonology.

In closing, the overall goal of this work has been to contribute to the documentation of Nyagrong Minyag, an endangered language. It is my hope that this will be a foundational document in the further exploration and documentation of this language. The quantitative analysis of rare linguistic phenomena, such as aspirated fricatives and uvularized vowels, can contribute valuable data to cross-linguistic explorations of these and other phenomena. The phonological and phonetic analyses presented here can provide material that can be used to further refine the sound correspondences in the Sino-Tibetan language family. Most importantly, I hope that this document will aid the creation of more resources (pedagogical or grammatical), which will support the future maintenance of Nyagrong Minyag by its speakers.

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