



Register, tone, and consonant-vowel coarticulation

Marjoleine Sloos¹, Yunyun Ran^{1,2}, Jeroen van de Weijer²

¹Fryske Akademy (Royal Netherlands Academy of Sciences), The Netherlands

²Shanghai International Studies University, China

msloos@fryske-akademy.nl, patience0130@163.com, jeroen@shisu.edu.cn

Abstract

Although partial coarticulation of consonants and vowels is common, coarticulation in which consonantal features are realized for the *complete* duration of the vowel are rarely reported (except for vowel nasalization). Such extreme consonant-vowel coarticulation may occur if a fricative or affricate is followed by a vowel with the same voicing and place of articulation, causing frication during the entirety of the vowel. This paper illustrates and discusses fricative-vowel coarticulation in Huangyan Taizhou, a Wu Chinese dialect, where this only occurs in the low tonal register.

Consonant-vowel coarticulation in general appears to be a remarkably strong tendency of Huangyan Taizhou (HT). First, fricative-vowel coarticulation involves a larger number of vowels and consonants than reported for other languages in which fricative vowels occur, viz. three different consonants and three vowels. Second, HT also has two other processes of extreme coarticulation of consonants and vowels. The first is a historical process in which a nasal and the following vowel were coarticulated and eventually merged, resulting in syllabic nasals with a tonal specification. Like fricative-vowel coarticulation, these syllabic nasals only occur in the low register. A more common process of extensive coarticulation also occurs in HT, namely, vowel nasalization, which is unrelated to tone and register.

In this paper, we present these different forms of extreme coarticulation in HT, discuss their possible underlying mechanisms and why they are related to register.

Index Terms: fricative-vowel coarticulation, register, nasalization, syllabic nasals, Huangyan Taizhou, Wu dialect, Chinese.

1. Consonant-vowel coarticulation

The fluent connection of speech gestures naturally leads to coarticulation between speech sounds. Coarticulation of a consonant and a vowel typically has a limited duration and impact on the sounds involved. However, in some cases the spreading of consonantal features overlaps with the full duration of the vowel, either as progressive or regressive assimilation, and leads to clearly distinct sounds. The most well-known example of consonant-vowel assimilation may be vowel nasalization, in which the [nasal] feature of a preceding or following nasal spreads onto the vowel, which changes from oral into nasal or nasalized.

Other consonants tend not to spread features to adjacent vowels to such an extent. However, there are some reports of fricatives spreading their frication to the following vowel, resulting in a so-called fricative vowel (also referred to as syllabic sibilants). Fricative-vowel coarticulation has been reported for the Bantoid language Mambila [1, 2], Standard Chinese, and the Wu Chinese dialect of Suzhou ([3], [4], [5]), and seems widespread in Chinese dialects in general [4].

The context for fricative-vowel coarticulation seems much more restricted than nasalization, since the sources above suggest that the consonant and vowel involved need to be homorganic, and since frication only affects high vowels. The most commonly observed fricative vowels result from sibilant (alveolar or retroflex) fricatives and affricates extending their frication onto the following vowel (which is then called apical). This is the type that is commonly observed in Chinese dialects. The amount of frication varies across different Chinese dialects, which is reflected in a variety of terms and different symbols used to indicate this vowel frication [6: fn 8].

Besides apical and retroflex vowels, fricativization can affect other vowels as well. Sometimes, rounding is involved, like in /sy/ in the Suzhou Wu Chinese dialect ([4], [5]). Labial fricative-vowel coarticulation also marginally occurs, e.g. in a number of Grassfields Bantu languages in which labial or labiodental consonants spread their frication onto a following /i/ or /u/ [1, 2]. Cross-linguistically, only high vowels appear to undergo frication because these vowels have a narrow constriction, which, all else being equal, leads to a relatively high amount of turbulence [7]. This turbulence may cause extremely high vowels to undergo frication, even if they are not preceded by a fricative at all [8].

This paper describes fricative vowels in HT and will show that turbulence caused by the narrow constriction is not the only source of fricativization of vowels. If constriction were the only cause of frication in high vowels, all high vowels could be affected. But, crucially, fricative vowels in this dialect only occur in the low register. We will discuss the reason for this restriction and also relate fricativization to other consonant-vowel coarticulation processes in this language.

Consonant-vowel coarticulation in HT is extensive in different respects. First, it occurs in at least three different processes, namely, vowel nasalization, fricative-vowel coarticulation, as well as nasal syllabification. Second, fricative-vowel coarticulation involves more consonants and vowels than reported for other languages. Third, frication lasts for the entire duration of the vowel, which is not the case in e.g. Standard Chinese [9]. We will also show that the three different processes are in different developmental stages. Fricative-vowel coarticulation is variable and phonetic. Vowel nasalization has been partly phonologized, but seems part of a change in progress. Nasal syllabification is a historical process which probably has been lexicalized.

The remainder of this paper is organized as follows. Section 2 provides some background information on HT. Section 3 describes the acoustic properties of fricative vowels, the historical development of syllabic nasals, and vowel nasalization in Huangyan Taizhou. Section 4 discusses and concludes.

2. Huangyan Taizhou dialect

Huangyan (黄岩话 [xuánjénwà]) is a variety of Taizhou, a Wu dialect spoken in Zhejiang Province, south from Shanghai in China. Wu dialects form the second largest dialect group in China (after Mandarin). In 2011, the population of Huangyan District was 632,000. Like most Wu dialects, HT has two registers, which can be defined as particular sets of consonants, vowels, and tones that can (co)occur in a syllable ([3], [10], [11], [12: pp. 229–232]). In the upper register, tones start in the high part of the pitch range, obstruents are voiceless, no sonorant onsets occur, and vowels have modal voicing. In the lower register, tones start in the low part of the pitch range, obstruents have (breathy) voiced phonation, sonorant onsets occur, and vowels have breathy voicing. Huangyan has an eight-tone system, with four tones in both registers [13].

- | | |
|-----------------|-----------------|
| 1. High dipping | 5. High level |
| 2. Low falling | 6. Low dipping |
| 3. High falling | 7. High checked |
| 4. Low level | 8. Low checked |

Sometimes, tones undergo register shift, which may lead to different combinations of tones and segments [10]. Huangyan probably also underwent such a shift, given the co-occurrence of initial nasals and high falling tones (see section 3.3). In the next section, we will show some language-specific properties of the register distinction, namely, that fricative vowels and syllabic nasals only occur in the low register.

3. CV coarticulation in Huangyan

3.1. Methodology

The data discussed in this paper are from a young male speaker, age 24, who speaks Huangyan dialect on a daily base with family and friends. We recorded him in a silent office at Shanghai International Studies University. For this paper, we analysed an extended version of the North Wind and the Sun story, the citation forms of the words used in that story, and a separate word list. In total, we analysed 486 words.

3.2. Results

3.2.1. Fricative vowels

Since fricative vowels are the result of coarticulation of consonant and following vowel, they have the acoustic properties of both. That is, fricative vowels are vowels and as such have clear formant structure, but they also have frication [5]. The following main acoustic properties are observed for fricative vowels:

- The formant structure is comparable with that of normal vowels, but F2 is lower ([5], [8]) indicating the fricative vowel is less fronted, and F1 is lower too, indicating that the fricative vowel is higher ([8] for Suzhou Wu)
- There is no indication of a palatal release of the consonant in the formants [5]
- The location of the peak intensity is variable, can be at the beginning, in the middle or at the end of the vowel, probably due to a high degree of turbulence [5]

For HT, we observe that fricatives may spread their frication feature to the following vowel for its entire duration. This only occurs in the low register, and only if the vowel is homorganic

with the preceding consonant. All high vowels /i y u/ can be subject to frication. The shared feature can be [labial] or [alveolar]. That is, frication occurs in the following sequences:

- [zɿ] and [zy], in which the shared feature is [alveolar]
- [βu], in which the shared feature is [labial]

Figures (1-3) show the acoustic properties of the fricative vowels. The spectrograms show that the fricative vowels retain the frication of the preceding fricative. The oscillograms show that the amplitude more or less gradually changes from consonant to vowel. The intensity contour is variable, cf. the observations in [1, 2].

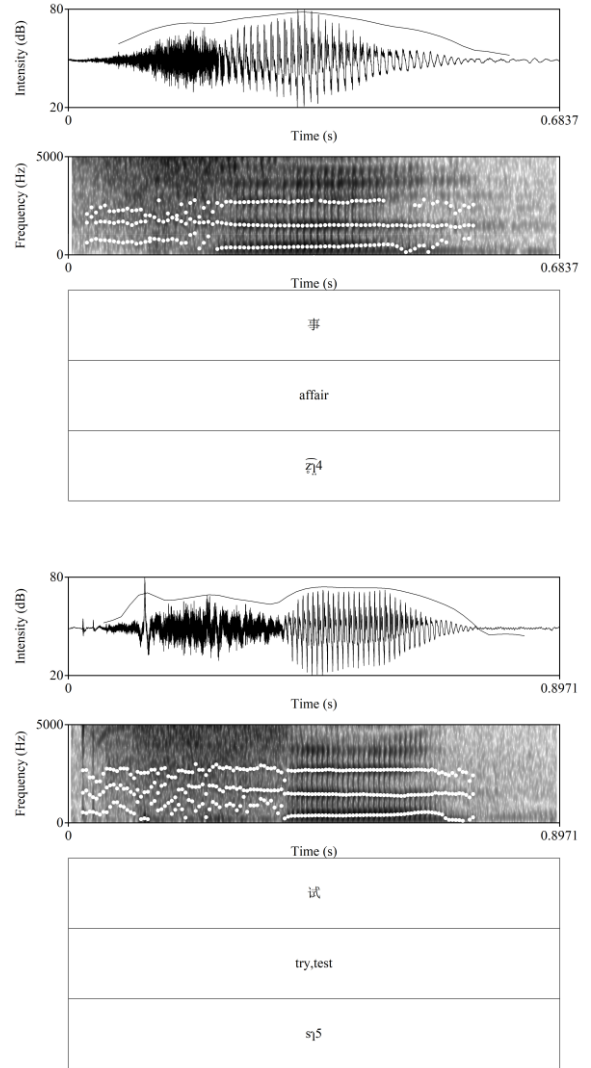


Figure 1: The spectrograms, formants, waveforms and intensity contours of the fricative vowel and non-fricative counterpart /ɿ/ in HT in 事 [ʒi⁴] ‘affair’ and 试 [sɿ⁵] ‘try, test’.

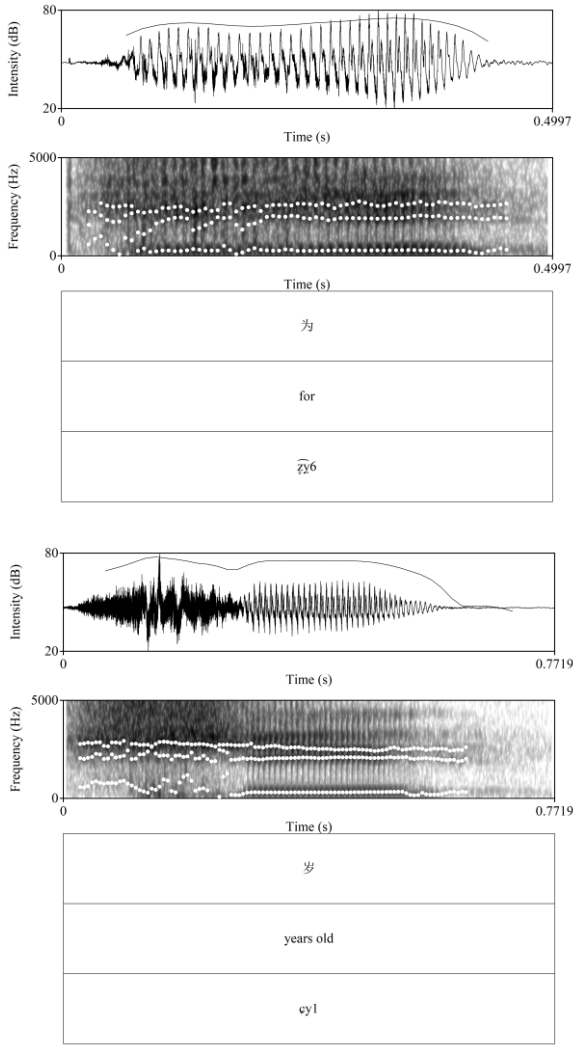


Figure 2: The spectrograms, formants, waveforms and intensity contours of the fricative vowel and non-fricative counterpart /ʃ/ in HT in 为 [z̥y̯⁶] ‘for’ and 岁 [ɕy̯¹] ‘years old’.

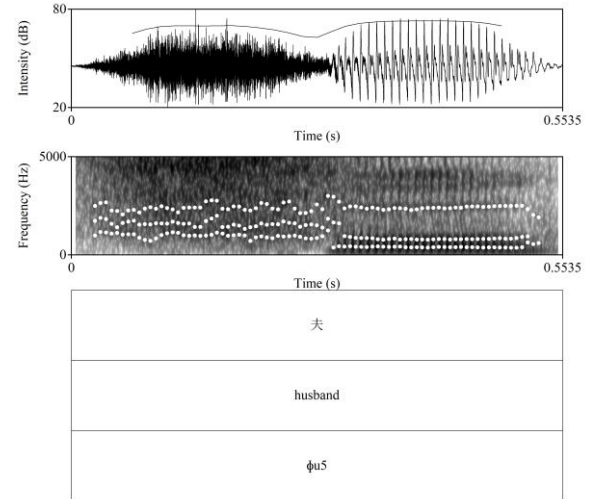
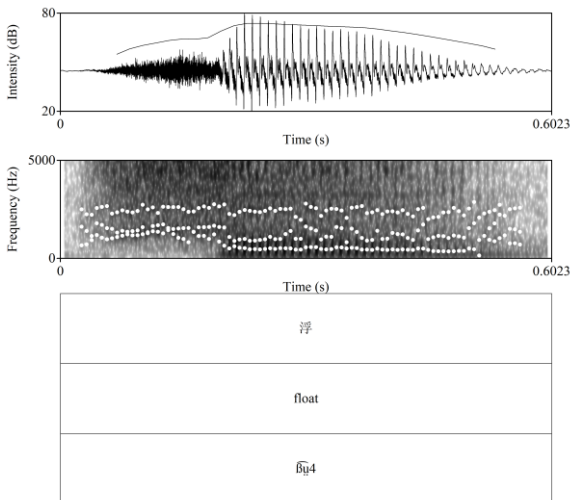


Figure 3: The spectrograms, formants, waveforms and intensity contours of the fricative vowel and non-fricative counterpart /ʃ/ in HT in 浮 [β̥u̯⁴] ‘float’ and 夫 [φu̯⁵] ‘husband’.

As we pointed out in section 1, the narrow constriction of the vowel leads to more turbulence which makes it susceptible to coarticulation with the preceding fricative. Why do fricative vowels only occur in the low register? Apparently, the high turbulence is not enough to cause fricativization in the high register. Low register obstruents differ from high register obstruents in their phonation: low register consonants have a breathy release and the following vowels are also breathy ([10], [14]), which means that the vocal folds are relatively slack. Slack vocal folds lead to a decrease of the subglottal airflow and an increase of the oral airflow. Examples of this can be found in unrelated languages like Hindi and Igbo ([15]), and Javanese. In Javanese, for instance, the mean intraoral pressure in breathy stops was 637 Pa as contrasted with 568 Pa in their modal counterparts [16]. The increase of oral pressure may be necessary to avoid instable voice quality caused by the slack vocal folds [17: p. 302]). The aerodynamics of breathy sounds are described as “random distribution of noise in the regions of the upper formants of the following vowel, but with voice also present, and comparatively greater concentration of acoustic energy at the fundamental frequency than at the second harmonic” [15]. This description of breathy consonants is remarkably similar to the description of fricative vowels in [1, 2]. Whereas the narrow constriction of high vowels is not enough to cause fricativization of vowels in HT, the conspiracy with breathy voicing, which also leads to higher air pressure—hence even more turbulence—does cause fricativization in HT.

3.2.2. Syllabic nasals

Another consonant-vowel coarticulation pattern in HT occurred as a historical process, and is related to tone. This resulted in lexical words consisting of a single syllabic nasal, such as:

無 m² ‘no’ 五 ŋ¹ ‘five’
二 n⁴ ‘two’

There were 20 instances of syllabic nasals in our data. Syllabic nasals are observed in a large number of Chinese dialects. Most of these dialects have only a two-way contrast; only two other

Wu dialects (namely, Suzhou and Ningbo) are known to have a three-way contrast in syllabic nasals like HT [18].

The syllabic nasals derive from post-nasal vowel deletion, in which the tone is transferred to the nasal. Vowel syncopation after nasals is not unique; in some Bantu languages vowels are also deleted after nasals [19]. Nasal syllabification in Chinese dialects differs from that in Bantu languages, however, since it only occurs if the nasal and the vowel share the same place of articulation, i.e. it is subject to the same condition as fricativization (section 3.1).

- labial: mu > m̥
- coronal: ni > n̥
- velar: ŋu > ŋ̥

Like in fricativization, the vowels involved in this process are all high (close) vowels. We suggest that if the oral constriction during the vowel is minimized and the nasal feature (through lowering of the velum) is retained, the result is a syllabic nasal.

Syllabic nasal formation is expected to occur only in the low register, since sonorant onsets do not occur in the high register (section 1). However, syllabic nasals also occur with the high falling tone 1. Actually, nasal onsets and other sonorant onsets also occur with the high falling tone. Since sonorant onsets and nuclei do not occur with the low level tone 4, it seems plausible that a register flip occurred in the historical development of this dialect. Register shifts or flips are not uncommon in Chinese dialects [10: p. 10], and have also been reported for Shanghaiese Wu, for instance (see also [20]).

3.2.3. Nasalization

The third type of extensive consonant-vowel coarticulation in Huangyan Taizhou is vowel nasalization. Different from fricativization and syllabic nasal formation, vowel nasalization is unrelated to register or tone, as the following examples show:

- 酌 t^hɔ¹ ‘pour wine’
 狂 guǎ² ‘crazy’
 方 fā³ ‘square’
 望 m^wǎ⁶ ‘look over’

In many Chinese dialects, coda nasals are deleted with concomitant vowel nasalization [21]. Vowel nasalization is the first stage of sound change, as in as in 尝 zān² ‘taste’. Subsequently, nasals can be deleted, like in 狂 guǎŋ² → guǎŋ̃² → guǎ̃² ‘crazy’; and eventually even nasalization may be lost, resulting in an oral vowel as in 弯 wēn² → wē̃² → wē² ‘bend’. In HT, we observe all stages: a common pattern in Chinese dialects [21], which could be an indication of language change in progress.

We observe that not all vowels are equally often subject to nasalization. Vowel nasalization cross-linguistically tends to affect low back vowels most and high front vowels less so ([21], [22]). From an articulatory point of view, this distribution is expected because of the tendency to lower the velum in low vowels, inducing nasal airflow ([23], [24: p. 185] and references cited there). This pattern can also be observed in HT; the low back vowel is consistently nasalized as [ã]. High vowels are rarely nasalized, whereas much variation occurs in the low central vowel /a/ and mid vowels /e/.

Table 1: *The number of occurrences of nasal and oral vowels based on the identity of the vowel.*

	i	e	ɛ	ə	ɑ	a	ə	o	ɔ
Oral	28	0	2	4	1	7	5	17	3
Nasal	2	1	2	1	18	9	1	1	1

This pattern could be another indication of ongoing change.

4. Discussion

HT shows three patterns of consonant-vowel coarticulation, namely, fricativization of vowels, syllabic nasal formation, and vowel nasalization. We observed similar patterns for syllabic nasal formation and vowel frication: the process only occurs if the consonant and the vowel share a place of articulation, if the vowel is high, and if the register is low. However, the articulatory mechanisms that cause the coarticulation are different. Fricativization occurs through high oral pressure, due to both the narrow constriction of the high vowel as a type of compensation for the slack vocal folds used in the low register. Syllabic nasal formation occurs if the oral closure of the nasal is not released when the vowel starts and the velum remains lowered. The distribution of syllabic nasals is therefore the same as that of initial nasals, i.e. the originally low register.

It seems that the three processes (vowel frication, vowel nasalization and syllabic nasal formation) are all processes of language change which are in different stages. Syllabic nasal formation is a historical process and seems lexicalized. Nasalization is part of a process in which eventually the nasal is deleted. It affects low back vowels first and high front vowels last. Huangyan presents examples of all intermediate stages, but nasalization currently hardly affects high vowels. Whether vowel frication is part of language change is unclear. [8] argues that syllabic fricatives in Chinese (and also in Swedish and Grassfields Bantu) can be derived from raising the high vowels in a context-free chain shift. Whether this is also the case in HT warrants further research. A different possible scenario is that fricative vowels are not the endpoint of a process of sound change, but only an intermediate stage between fully vocalic and non-vocalic realizations. In many descriptions of Wu dialects, syllabic consonants are only reported as [sz tsz], which suggests that these sounds are perceived as consonants rather than vowels. This too is speculative and requires further investigation into fricative vowels cross-linguistically.

We conclude with the observation that HT is extremely tolerant toward consonant-vowel coarticulation, given the number of different processes in which consonants and vowels are coarticulated and given that frication and nasal syllabification occur(red) in more contexts than have been reported for other related and unrelated languages or dialects.

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