Rhoticization as a Secondary Articulation in Stops: Evidence from Prinmi

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Abstract: Drawing data from Prinmi (a Tibeto-Burman language of China), this paper studies the use of rhoticization as a secondary articulation in producing two sets of stops, bilabial and velar, in some dialects of Prinmi. Since it has not been discussed in Ladefoged and Maddieson's [11] survey of the sounds of the world's languages or mentioned in Ladefoged [10], the finding of this paper may be regarded as a contribution to broadening our knowledge of linguistic sounds in the frontier of phonetics.

Keywords: Secondary articulation, plosives, Tibeto-Burman, minority languages of China

1. INTRODUCTION

When I first studied the periodic table of the chemical elements in the middle school, I was amazed by its ability to predict existence of unknown chemical elements. In linguistics the table for (pulmonic) consonants in the chart of the International Phonetic Alphabet, to some extent, also conveys a similar kind of predictability about existence of consonants in human speech. As shown in Table 1, the shaded areas in the table are deemed impossible while non-shaded voids could be filled, e.g. the formal recognition of the labiodental flap in 2005. In the frontier of phonetics, new sounds with different combinations of articulatory gestures may emerge as we conduct more research on lesser known and under-described languages, cf. Ladefoged & Maddieson [11].

China, with a linguistic diversity beyond our current level of knowledge, represents untapped resources for linguistic research. Based on fieldwork data from Prinmi (普米语, a Tibeto-Burman language unique to China), this paper discusses the use of rhoticization as a secondary articulation in producing plosives. I will first provide background information on Prinmi and remark briefly on consonant clusters in known Prinmi dialects. Then I compare acoustic properties of such consonant clusters as [$\mathrm{p^h}$ɹ] and [$\mathrm{k^h}$ɹ] in English with

Table 1: Pulmonic consonants in the IPA chart (2005).

	Bilabial	Labiodental	Dental	Alveolar	Postalveolar	Retroflex	Palatal	Velar	Uvular	Pharyngeal	Glottal
Plosive	p b			t d		ʈ ɖ	c ɟ	k ɡ	q ɢ		ʔ
Nasal	m	ɱ		n		ɳ	ɲ	ŋ	ɴ		
Trill	ʙ			r					ʀ		
Tap or Flap		ⱱ		ɾ		ɽ					
Fricative	ɸ β	f v	θ ð	s z	ʃ ʒ	ʂ ʐ	ç ʝ	x ɣ	χ ʁ	ħ ʕ	h ɦ
Lateral fricative				ɬ ɮ							
Approximant		ʋ		ɹ		ɻ	j	ɰ			
Lateral approximant				l		ɭ	ʎ	ʟ			

similar sounds [pʰʴ] and [kʰʴ] in Xinyingpan Prinmi. On the ground of the acoustic evidence, I submit that Xinyingpan Prinmi has developed, in addition to the plain sets of bilabial and velar stops, two sets of corresponding rhoticized stops.

2. CONSONANT CLUSTERS IN PRINMI

Spoken mainly in Lanping and Ninglang in northwestern Yunnan as well as in Muli and Jiulong in southwestern Sichuan, Prinmi is a Tibeto-Burman language of the Qiangic branch, according to Lu [13]. About one third of its speakers have the official nationality status as *Pǔmǐ* (all living in Yunnan), and the remainder the status as Tibetan. In the survey of seven villages scattered in the Prinmi-speaking area, Lu [14] classifies nearly all Prinmi dialects spoken in Yunnan into Southern Prinmi. Since the inventory of consonants varies among Prinmi dialects of Yunnan (see Lu [14]; Matisoff [16]; Ding [5]), I will refer to a particular variety of Prinmi by its village name.

Studies by Lu [13] on Qinghua and by Matisoff [16] on Dayang report that Lanping Prinmi has a number of consonant clusters such as fricative-plus-stop and stop-plus-retroflex. Ding [3; 5] finds that the former type does not occur in Xinyingpan Prinmi (spoken in Ninglang, Yunnan) while the latter type is realized phonetically as stops with double articulation. However, no acoustic evidence was provided for the 'rhoticized' plosives in these works.

Details of combination in the plosive-plus-retroflex type differ between Lanping and Xinyingpan Prinmi, as shown by representative examples in Table 2. The set with bilabial stops is shared between them, but Lanping dialects lack the set with velar stops, most of which become retroflex stops/affricates (cf. Matisoff [16]). Rhoticization, characterized by occurrence of an alveolar approximant, is found only with velar and bilabial stops in Xinyingpan Prinmi.

Lu [13; 14] regards retroflex stops as allophones of homorganic retroflex affricates in Prinmi and dependence of the fricative's voicing on the stop is conspicuous in his transcription of these consonant clusters. In the case of Xinyingpan Prinmi a similar voicing dependence on the stop also holds, but this phonetic detail will not be transcribed explicitly in the examples. It should be pointed out that the correspondence between the voiceless alveolar approximant and fricative applies at a more generally level in the phonological system of Xinyingpan Prinmi and Lanping Prinmi. It is regularly observed in words such as /ɹ̥a^{13}/ ↔ /ʂa^{13}/ 'to laugh'.

Furthermore, the tonal representation of the Prinmi examples in this paper will be provided at the phonetic level, where every syllable is marked by two numerals indicating the starting and ending point of its pitch, respectively. Such representation does not imply that Prinmi possesses a syllable-tone system, as argued against in Ding [3; 4; 5; 6; 7].

Table 2: Complex consonants with plosive-plus-retroflex in Prinmi.

Xinyingpan	Qinghua	Meaning
pʰʴĩ^{55}	pʰʂə̃^{55}	'white'
pʴɛ^{13}	pʂɛ^{13}	'to snap (vi.)'
bʴɛ̃^{13}	bʐə̃^{13}	'rope'
kʰʴə^{55}	ʈʰʂʐ̩^{55}	'foot'
kʴə^{55}	ʈʂʐ̩^{55}	'gall bladder'
gʴə^{13}	ɖʐʐ̩^{13}	'star'

Ladefoged and Maddieson [11] consider affricates as 'an intermediate category between simple stops and a sequence of a stop and a fricative'. In this connection, the initials of the words from Qinghua in Table 2 can all be treated as complex consonants involving more than one articulation manner rather than two consonants in clusters.

Xinyingpan Prinmi has only six complex consonants (other than affricates), all shown in Table 2. These rhoticized stops have basically disappeared in the speech of those born after 1970s. The simplification is different in nature from contextual cluster reduction, a common phonological process such as 'hands' /hændz/ → [hænz] in English, cf. Wheeler [18].

3. ACOUSTIC ANALYSIS OF COMPLEX CONSONANTS

Consonant clusters made up of a stop and a rhotic are common in many European languages, e.g. English and Portuguese. Instead of taking an isolated study of Prinmi, it will be more enlightening to pursue acoustic comparison of the complex consonants in Prinmi with similar consonant clusters such as [p^hɹ], [bɹ], [k^hɹ] and [gɹ] in English.

3.1 Consonant clusters in English

Shown in (1) are consonant clusters in English comparable to those in Xinyingpan Prinmi.

(1)	print [p^hɹɪnt]	spring [spɹɪŋ]	bring [bɹɪŋ]
	cream [k^hɹi:m]	scream [skɹi:m]	green [gɹi:n]

These consonant clusters are remarkable in that the rhotic approximant may serve as the center for phonemic contrast against stop-plus-lateral clusters, as shown in (2). Such minimal pairs do not exist in Prinmi.

(2)	pray [p^hɹej]	vs.	play [p^hlej]
	grew [gɹu:]	vs.	glue [glu:]

Two native speakers of English were invited to record a list of 18 monosyllabic words, many (but not all) of which form minimal pairs like those exemplified in (2). They were instructed to utter the word list as clearly as possible, and each word was pronounced twice in the recording. The word list was recorded directly with Praat, developed by Boersma & Weenink [2].

Speaker A, a female professor in her 60s, grew up in Zimbabwe and was monolingual in English as a young child. Speaker B, a male instructor of English in his 30s, was born and raised in Ontario, Canada. Data from these two speakers thus represent two different varieties of English, in which the phonetic status of the consonant clusters under investigation is assumed to be the same.

3.1.1 The segment [ɹ] in [p^hɹ] and [bɹ]

Waveforms of the minimal pair of words 'play' and 'pray' uttered by speaker A are presented with segmentation in Figure 1. The non-overlapping part of the lateral [l] in 'play' is approximately 40 milliseconds, whereas the rhotic [ɹ] in 'pray' lasts for about 50 milliseconds. Spectrograms for the same pair of words produced by speaker B are shown in Figure 2, where the words were pronounced at a slower speed and the duration of the rhotic (about 80 milliseconds long) and of the lateral, as well, is thus longer.

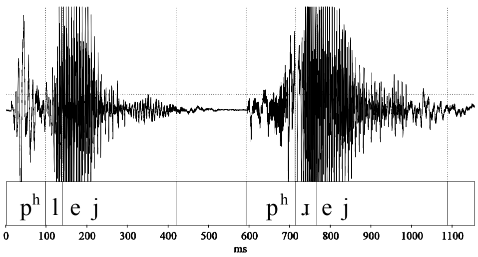

Figure 1: Waveforms of the words 'play' and 'pray' by Speaker A

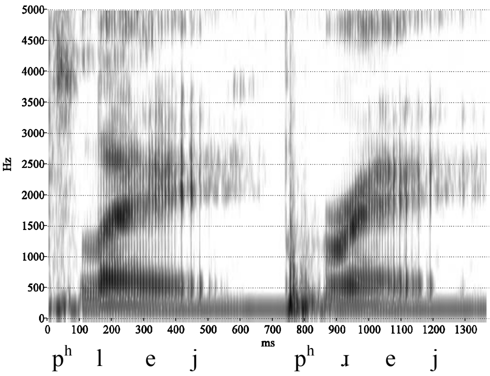

Figure 2: Waveforms of the words 'play' and 'pray' by Speaker B

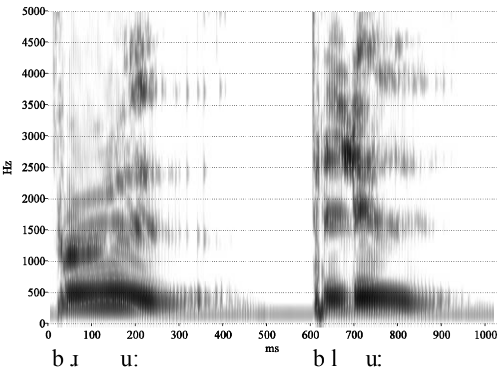

Figure 3: Waveforms of the words 'brew' and 'blue' by Speaker A

In terms of formants, we can see that the rhotic approximant in English is characterized with the third formant (F3) in the frequency range between 1500 Hz and 2250 Hz (cf. Lindau [12]). This is illustrated nicely by speaker B's utterance of the word 'pray' in Figure 2 (which also shows clearly the first and second formants in the lower ranges). The distinct F3 of the rhotic, with a slightly higher frequency under a female's voice, is also found in the word 'brew' shown in Figure 3.

3.1.2 The segment [ɹ] in [kʰɹ] and [gɹ]

The distinctive F3 of the rhotic approximant following a velar stop is found in about the same range. It falls between 1500 ~ 2000 Hz in speaker B's pronunciation of the word 'crew' in Figure 4, whereas it ranges between 1800 ~ 2300 Hz in the word 'grew' produced by speaker A in Figure 5. The non-overlapping part of its duration measures approximately 65 milliseconds and 85 milliseconds in the two words, respectively.

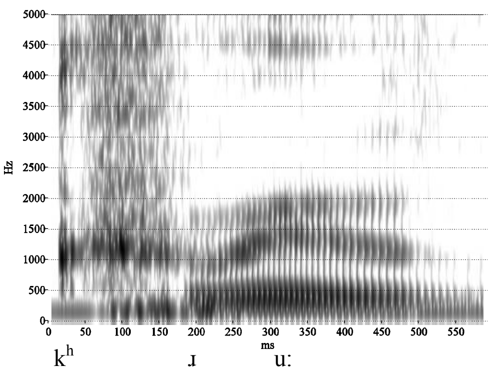

Figure 4: Waveforms of 'crew' by Speaker B

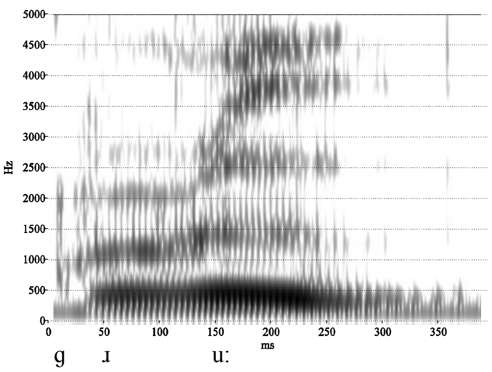

Figure 5: Waveforms of 'grew' by Speaker A

From these acoustic properties of the rhotic approximant in the consonant clusters, its phonetically independent status in English is confirmed. The rhotic is a genuine member of the consonant cluster, capable of carrying minimal phonemic contrast in the language.

3.2 Stop-plus-rhotic in Prinmi

As has been described above, Xinyingpan Prinmi has six complex consonants involving a rhotic approximant after bilabial or velar stops. Based on whether a Prinmi dialect has the set of complex velar stops, it is possible to identify a group of Prinmi dialects, the Kr-Prinmi.

Under this criterion, Xinyingpan, Xichuan (both spoken in southern Ninglang) and probably others in the adjacent area belong to the Kr-Prinmi dialect group. From my observation on other Kr-Prinmi dialects, it appears that the phonetic status of the rhotic element in the complex consonants is similar in this dialect group as a whole. Data from Xichuan Prinmi will also be consulted in the acoustic analysis below.

The Prinmi data come from a general collection of fieldwork data recorded in 1994 and 1995 in Yunnan using Matisoff's [15] 'culturally appropriate lexicostatistical model for Southeast Asia'. The list consists of about 200 words. Prinmi consultants were instructed to repeat each item twice when they recorded the word list onto tapes.

The complete word lists were elicited on different occasions from three speakers, all male and trilingual in Prinmi, Mandarin, and Nosu (a Yi language). Speaker α, a polyglot in several Tibeto-Burman languages, was in his late 50s at the time of recording. He was originally a native of Baomaping, the largest Prinmi community in the neighborhood of Xinyingpan, but had moved to and settled in Xinyingpan for decades. Speaker β was in his 20s. Born in Xinyingpan, he spoke a variety of Prinmi of the younger generation, in which the complex consonants alongside other linguistic features had gradually undergone various degrees of simplification. Speaker γ was in his 30s, a native of Xichuan with good competence in Prinmi.

Items selected for this study from the word list include the following (the slash indicating dialectal variation):

(3) p^{hɹ}ĩ^{55} ti^{55} / p^{hɹ}ĩ^{55} mi^{55} 'white'
k^{hɹ}a^{13} 'to shoot'
k^{hɹ}ə^{55} 'foot'

Although the full set of complex consonants is unavailable from the word list, a few words with the aspirated bilabial stop and velar stop are found. To my best knowledge, voicing of stops does not constitute a condition on the segmental status of the following rhotic approximant. Hence the generalization based on analysis of complex consonants involving an aspirated voiceless stop will be equally applicable to other homorganic complex stops.

3.2.1. [ɹ] as a secondary articulation in [p^{hɹ}]

The phonetic difference between a plain stop and a complex one containing [ɹ] is transparent when comparing their spectrograms. Speaker α's utterances of [p^{h}jɑ^{13}] 'water leech' and [p^{hɹ}ĩ^{55} ti^{55}] 'white' are analyzed in Figures 6 and 7, respectively. Studying the part of spectrogram before the vowel in these words, we can observe the presence of a special formant, the darkened spots, in the frequency range of 1500 ~ 2250 Hz in Figure 7, which is lacking in Figure 6. The special formant represents the occurrence of the rhotic sound in [p^{hɹ}ĩ^{55} ti^{55}] / [p^{hɹ}ĩ^{55} mi^{55}] 'white' and can be seen even more clearly in Figure 8, where the same word by speaker γ is analyzed.

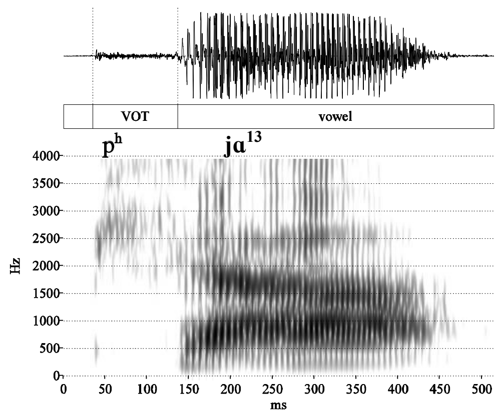

Figure 6: Waveform and spectrogram of 'water leech' by Speaker α

Since the words in Figures 6 and 7 both start with an aspirated voiceless bilabial stop, this facilitates demarcation of the initial part before the vowel, i.e. the voice onset time (VOT). With about 100 milliseconds, the VOT in the word [p^{h}jɑ^{13}] 'water leech' is slightly longer than the approximate 80 milliseconds in the word [p^{hɹ}ĩ^{55} ti^{55}] 'white'. The length difference is attributed to the number of syllables in the words. Taking the syllable as a unit, a monosyllabic word is considerably longer than a syllable in a disyllabic word.

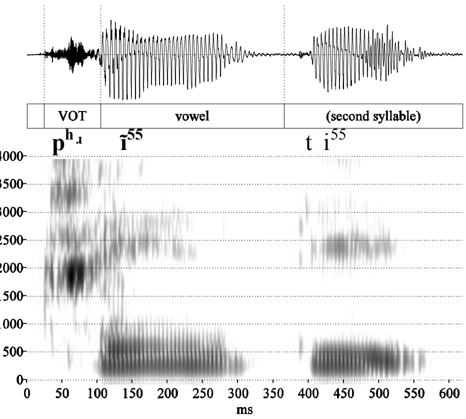

Figure 7: Waveform and spectrogram of 'white' by Speaker α

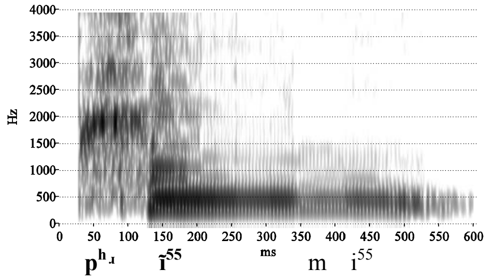

Figure 8: Spectrogram of 'white' by Speaker γ

What is remarkable about the VOT shown in Figure 7 is that the special formant representing the rhotic occurs only within the VOT. The same phenomenon holds true also in Figure 8 (utterance of the same word by speaker γ). These acoustic analyses unveil that the rhotic sound after the stop is produced in Xinyingpan and Xichuan Prinmi within the interval between the release of the bilabial stop and the beginning of the vowel in the syllable. As such, the rhotic element can only be co-articulated with the bilabial stop.

3.2.2. [ɹ] as a secondary articulation in [$k^{hɹ}$]

Let us examine the spectrogram in the beginning part of the first syllable in [k^ha^{11} ti^{55}] 'bitter' in Figure 9 and the initial part of spectrograms for the word [$k^{hɹ}a^{13}$] 'to shoot' in Figures 10 and 11. We see the special formant of the rhotic has darkened much of the VOT in the range of approximately 1500 Hz ~ 2000 Hz. Because the plain velar stop occurs in a disyllabic word, its VOT (around 125 milliseconds) is shorter than that of the complex one in a monosyllabic word (about 160 milliseconds) in Figure 10.

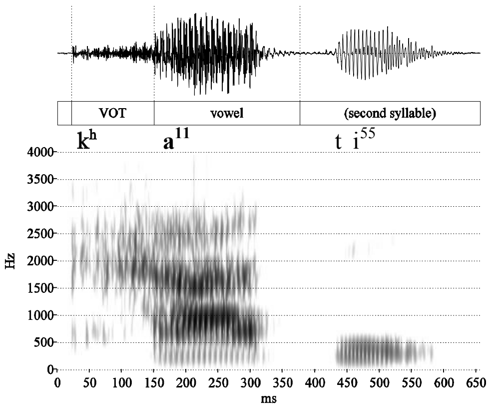

Figure 9: Waveform and spectrogram of 'bitter' by Speaker α

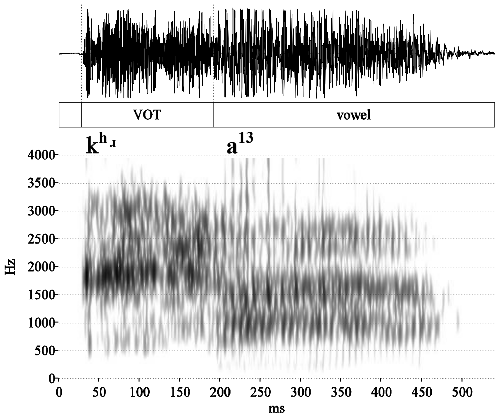

Figure 10: Waveform and spectrogram of 'to shoot' by Speaker α

The length of the VOT is irrelevant to the co-articulation of the rhotic approximant within it. When the sound wave is played on the computer from a point extremely close to the end of the VOT, the velar stop is still audible under the exhausted aspiration. That is, we can extract an unaspirated voiceless velar through manipulation of the sound waves when much of the VOT is excluded to yield the following:

(4) k^ha^{55} ti^{55} → ka^{55} ti^{55} 'bitter'
$k^{hɹ}a^{13}$ → $k^{ɹ}a^{13}$ 'to shoot'

However, it is not possible to select a certain part of the sound waves in Figures 10 or 11 to render a syllable starting with the alveolar approximant without the velar stop.

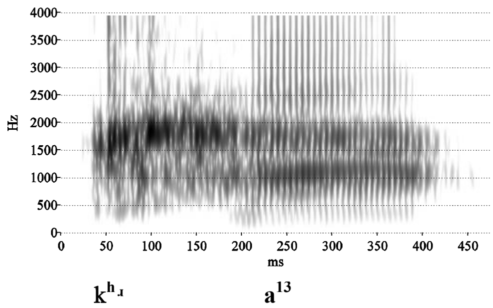

Figure 11: Spectrogram of the word 'to shoot' by Speaker γ

4. DISCUSSION

The acoustic studies of the complex consonants above have evinced that rhoticization of bilabial stops and velar stops exists in Xinyingpan Prinmi. Although words containing these consonants are rather few in Prinmi and they usually do not contrast phonemically against corresponding plain stops in the form of minimal pairs, these rhoticized stops do represent a phonetically distinct type of complex consonant that has not been discussed in the phonetic literature, e.g. Ladefoged & Maddieson [11], International Phonetic Association [9] and Ladefoged [10], or in the phonological literature such as Blevins [1] and Hansson [8] for studying consonants with a secondary articulation from an evolutionary perspective.

Constrained by available data suitable for acoustic analysis, I have focused on the case of aspirated stops. Incidentally, serendipity has arisen, as the VOT readily measurable in aspirated stops allows an unambiguous display of the co-occurrence of the rhotic element with the stops. Without such blending, the rhotic approximant would be able to claim its own segmental status and become a separable member of the consonant cluster.

When the clusters [pʰɹ] and [kʰɹ] in English are compared to the rhoticized stops [pʰʴ] and [kʰʴ] in Xinyingpan Prinmi, the alveolar approximant in both languages is shown to feature a distinctive formant between the range of 1500 ~ 2250 Hz. Nonetheless, the rhotic in English enjoys its own allocation of time in the syllable and thus can be separated from the preceding stop, see Figures 2 and 4. Note that the VOT of the stops in these instances is of substantial length, around 100 milliseconds in minimum. Articulatory overlaps in transition from one segment to another are inevitable, but they do not deprive the rhotic of its phonetic independence in English. Its own space and timing slot in the syllable can be pinpointed and measured in the sound wave.

In contrast, the rhotic element in Xinyingpan Prinmi exists only simultaneously with the stops. It does not take place in a sequence of articulatory events between the stop and the vowel in the syllable. Rather, it is part of the onset, contributing an additional articulation feature to the stop. In other words, these complex consonants in Xinyingpan Prinmi are phonetically, and synchronically, rhoticized stops, even though the rhoticized velar stops are good reflexes (or even relics) of the consonant clusters *kr and *gr in Proto-Tibeto-Burman, as reconstructed by Matisoff [17].

5. CONCLUSION

In discussing multiple articulatory gestures, Ladefoged and Maddieson [11] note that drawing a distinction between a consonant cluster with an approximant and a consonant with the approximant as a secondary articulation can be useful, albeit difficult in practice. Through acoustic comparison of similar complex consonants such as [pʰʴ] and [kʰʴ] in Xinyingpan Prinmi to clusters like [pʰɹ] and [kʰɹ] in English, this paper provides strong evidence for recognizing rhoticization as a secondary articulation in producing bilabial stops and velar stops. Unlike that in a consonant cluster, where every consonant has its own articulation time, the rhotic approximant in Xinyingpan Prinmi is co-articulated with the stop preceding it. It is usually articulated with a slight delay after the release of the stop, and it has, being subsumed entirely into the stop, lost its own voicing feature. Hence the role of the rhotic has been reduced to introducing a secondary articulation to the stop.

Available data suggest that Prinmi is rather conservative phonologically in that crucial phonemic contrasts are generally maintained even between major dialect groups, e.g. the preservation of minimal pairs that contrast between different tonal categories, see Ding [7]. However, in terms of phonetic details more dialectal variations can be expected, for keeping phonetic features of a language intact is not necessary for retention of phonemic categories. Thus it will be worth pursuing further phonetic studies of Prinmi dialects and also other minority languages/dialects of China, which has remained virtually a virgin land for phoneticians.

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