ILLUSTRATION OF THE IPA

Zaiwa

Yao Lu[1,2,*] ⓘ, Lu Wang[3], Mudi Li[4] and Jiangping Kong[1,2]

[1]Laboratory of Language Sciences, Peking University, Beijing, China, [2]Department of Chinese Language and Literature, Peking University, Beijing, China, [3]International College for Chinese Studies, Nanjing Normal University, Nanjing, China, and [4]Department of Humanities, Dehong Normal University, Mangshi, China
*Corresponding author. Email: yaolu@pku.edu.cn

Zaiwa (ISO 639-3 code: atb; Glottocode: zaiw1241) belongs to the Burmese branch of the Tibeto-Burman languages, sharing many common features with the Burmese and Achang languages of the same branch. It is primarily spoken by a subgroup of Jingpo people, who identify as 'Zaiwa'. Beyond Zaiwa, the Jingpo people encompass four distinct subgroups, each conversing in unique linguistic variations, namely Jingpo (景颇), Langsu (浪速), Leqi (勒期), and Bola (波拉). Jingpo is distinctively affiliated with the Jingpo branch of the Tibeto-Burman languages, whereas the other three languages, including Zaiwa, are categorized within the Burmese branch (He, 2016). The majority of Zaiwa speakers are found in Luxi (潞西), Yingjiang (盈江), Longchuan (陇川), Ruili (瑞丽), Lianghe (梁河), and Wanding (畹町) counties within the Dehong Dai and Jingpo Autonomous Prefecture (德宏傣族景颇族自治州) of Yunnan province (云南省) as well as the Shan and Kachin states in Myanmar. Zaiwa is widely used in Zaiwa-dominant areas or communities with a significant Zaiwa presence. It is used not only in daily life contexts, such as among family members, villages, markets, and shops, but also in a range of social sectors, including in government and judicial offices, as well as on radio and broadcasting stations. Among the Jingpo languages, Zaiwa has the largest number of users. Individuals who speak Zaiwa often speak languages of other Jingpo subgroups in addition to Mandarin Chinese. Due to the extensive promotion and dissemination of Mandarin, particularly in educational and media contexts, Mandarin has emerged as the predominant second language for the youth within the community. Moreover, in neighboring regions or mixed communities where the Zaiwa subgroup is prominent, individuals from other ethnic groups such as the Achang, Han, Dai, and Lisu also frequently speak Zaiwa. According to the statistics from China's Sixth National Population Census in 2010, the total population of the Jingpo ethnic group is approximately 140,000. There were over 80,000 Zaiwa speakers within China, constituting more than 60% of the total Jingpo ethnic population in the country (He, 2016). Scholars such as Xu and Xu (1984), Dai (1989), Kong (2001), Pan (2014), He (2016), Lu and Kong (2019), and Lu et al. (2025) have conducted studies on the phonetics of Zaiwa.

Figure 1. (Colour online) Distribution of Zaiwa. The areas of Zaiwa are shaded pink. The map is drawn from C1-24 of *Language Atlas of China*, second edition.

Previous research has generally categorized Zaiwa into two principal dialects (He, 2016): the Bengwa dialect (迸瓦方言), which encompasses Wuchalu Township (五岔路乡), as well as Yingjiang County and parts of Xishan Township (西山乡) in Mang County (芒市), and the Longzhun dialect (龙准方言), which encompasses Zhefang (遮放) and Manghai (芒海) Townships as well as the southern sector of Xishan Township in Mang County. In addition, the Longzhun dialect spans across Longchuan and Ruili Counties. The present Illustration is based on data collected by a female native Zaiwa speaker from Ruili County. As shown in Figure 1, Ruili is located in the southwestern area of the Dehong Dai and Jingpo Autonomous Prefecture. It is adjacent to Mang County to the east, borders Longchuan County to the north, and shares its northwest, southwest, and southeast borders with Myanmar. As of September 2022, Ruili's total area included 944.75 square kilometers. By the end of 2021, the county's permanent resident population totaled 226,639. The female native Zaiwa speaker in our study was 26 years old at the time of recording. She was born and raised in Huyu Township of Ruili County, and had not spent long periods outside of the area. She completed her education at Dehong Teachers' College, specializing in Zaiwa and is presently employed by a Village Committee of the Ruili Government. The devices used during the recording sessions were a laptop computer, an external sound card, a mixing console, and a unidirectional collar clip microphone[1]. The software used was Adobe

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[1] Thinkpad X1 Carbon Gen 10, Beijing, China; Sound Blaster X-Fi Surround 5.1 Pro, Creative Labs, Singapore; Behringer XENYX 302USB Premium 5-Input Mixer, Beijing, China; ECM-44B, SONY, Tokyo, Japan

Audition 2023, with a sampling rate of 44.1 kHz and 16-bit resolution. Recordings were performed in a quiet room. Basic speech parameters were extracted using Praat (Boersma & Weenink, 2020). Chao's five-scale pitch system was applied to transcribe the tones throughout this article (Chao, 1980). Vowels with pressed voice appear with the "creaky-voiced" diacritic and the distinction between pressed and modal voice vowels will be described in detail in the Vowels section.

Consonants

As shown in the table below, the consonants of Zaiwa comprise 36 phonemes, including 22 simple consonants and 14 palatalized consonants. There are only voiceless obstruents, no voiced obstruents, and no consonant clusters. Plosives and affricates contrast in terms of aspiration. Aspirated consonants and fricatives cannot be combined with vowels with pressed voice. The approximant /ʋ/ has an allophone [w] that precedes the monophthong /a/. Since the fricative /f/ generally appears only in Chinese loanwords, such as /fa^{21}min^{21}/ 'invention', examples will not be provided in the following text.

	Bilabial		Labiodental	Alveolar		Postalveolar		Palatal	Velar		Glottal
Plosive	p	pʲ		t	tʲ				k	kʲ	ʔ
	pʰ	pʰʲ		tʰ	tʰʲ				kʰ	kʰʲ	
Affricate				ts		tʃ	tʃʲ				
				tsʰ		tʃʰ	tʃʰʲ				
Fricative			f	s		ʃ	ʃʲ		x	xʲ	
Nasal	m	mʲ		n	nʲ				ŋ	ŋʲ	
Approximant			ʋ			ɹ		j			
Lateral Approximant				l	lʲ						

The following minimal and near-minimal pairs illustrate the contrasts summarized above:

MANNER	CONSONANT	EXAMPLE	GLOSS
Plosives	p	pe^{35}[pə]	'fall off'
	pʰ	pʰe^{44}[pʰə]	'notch'
	pʲ	pʲe^{35}	'vomit'
	pʰʲ	pʰʲe^{44}	'to discuss'
	t	ta^{35}	'time' (measure word)
	tʰ	tʰa^{51}	'to argue, to rebuke'
	tʲ	tʲe^{51}	'illegitimate child'
	tʰʲ	tʰʲe^{21}	'peck'

	k	ko^{35}	'jump'
	k^h	k^ho^{44}	'right'
	k^j	k^ja^{21}	'joke'
	k^{hj}	$k^{hj}a^{21}$	'simply'
Affricates	ts	$tse^{51}[tsə]$	'items'
	ts^h	$ts^he^{51}[ts^hə]$	'ten'
	tʃ	$tʃo^{51}$	'russet sparrow'
	$tʃ^h$	$tʃ^ho^{51}$	'tube'
	$tʃ^j$	$tʃ^je^{35}$	'arrive'
	$tʃ^{hj}$	$tʃ^{hj}eʔ^{55}$	'peel'
Fricatives	s	so^{21}	'walk'
	ʃ	$ʃo^{21}$	'meat'
	x	$xe^{51}[xə]$	'swing, deny'
	$ʝ^j$	$ʝ^je^{51}$	'loose'
	x^j	x^je^{51}	'that'
Nasals	m	ma^{21}	'drowsy'
	m^j	m^ja^{21}	'disheveled'
	n	no^{51}	'pain'
	ŋ	$ŋo^{51}$	'I'
	n^j	n^je^{51}	'red'
	$ŋ^j$	$ŋ^jo^{51}$	'speak'
Approximants	j	ja^{21}	'cure'
	l	lo^{21}	'tiger, leopard'
	l^j	l^je^{35}	'come'
	ɹ	$ɹe^{35}$	'pain'
	ʋ	$ʋe^{35}$	'choke'

Plosives

There are 13 plosives in Zaiwa, all voiceless, at bilabial, alveolar, and velar places of articulation. All plosives contrast in terms of aspiration. Voice Onset Time (VOT) for unaspirated voiceless stops is shorter than that for aspirated voiceless stops, with a value of almost zero. Figure 2 presents a spectrogram of $/t^ha^{51}/$ 'to argue/rebuke' and $/ta^{35}/$ 'time' (measure word), demonstrating the difference in the VOT between the two. When pronouncing $/ta^{35}/$, the stop release and vocal fold vibration occur almost simultaneously, resulting in a VOT that is almost 0; whereas the VOT for $/t^ha^{51}/$ is approximately 96 ms. As shown in Figure 3, the VOT of unaspirated plosives, that is, /p t k/, is shorter with the release and voicing onset occurring within approximately 12 ms. By contrast, the VOT of aspirated plosives, that is, $/p^h\ t^h\ k^h/$, ranges from 100–160 ms. In addition to appearing in onset position, the unaspirated plosives /p/, /t/, and /k/ can also appear as stop codas followed by vowels and /ʔ/ can only appear in coda position.

Affricates

There are 11 affricates in Zaiwa. The spectrogram in Figure 4 shows that the aspirated affricate is acoustically comprised of stop release burst, frication and aspiration intervals whereas the unaspirated affricate has only release burst and frication intervals. As shown in Figure 5, the VOT of unaspirated affricates is much shorter than the aspirated affricates.
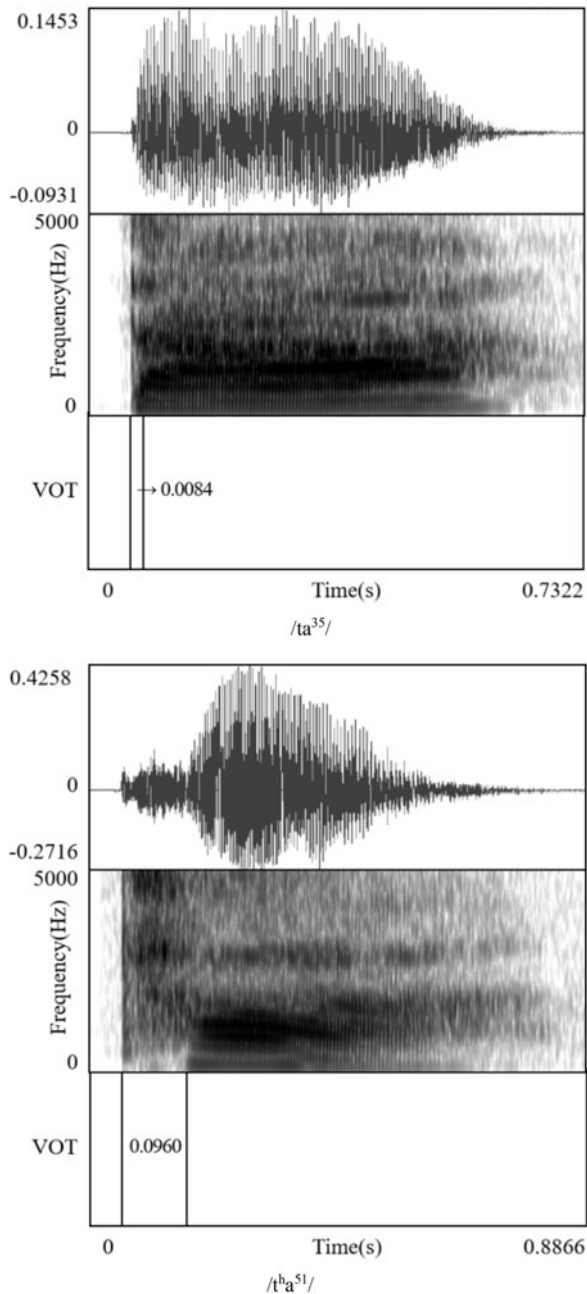
Figure 2. Waveforms and spectrograms for the minimal pairs /tʰa⁵¹/ 'argue, rebuke' and /ta³⁵/ 'time' (measure).

Fricatives

Five fricatives are produced at three articulation locations: alveolar, postalveolar, and velar. Fast Fourier Transform (FFT) spectra (made with a 23-ms window centered on the peak of noise intensity) of five fricative samples of Zaiwa are provided in Figure 6. The energy distributions of the five fricatives are different. /s/ has energy mainly concentrated between 8,000–12,000 Hz. The energy of /ʃ/ is primarily between 4,000–6,000 Hz, and that
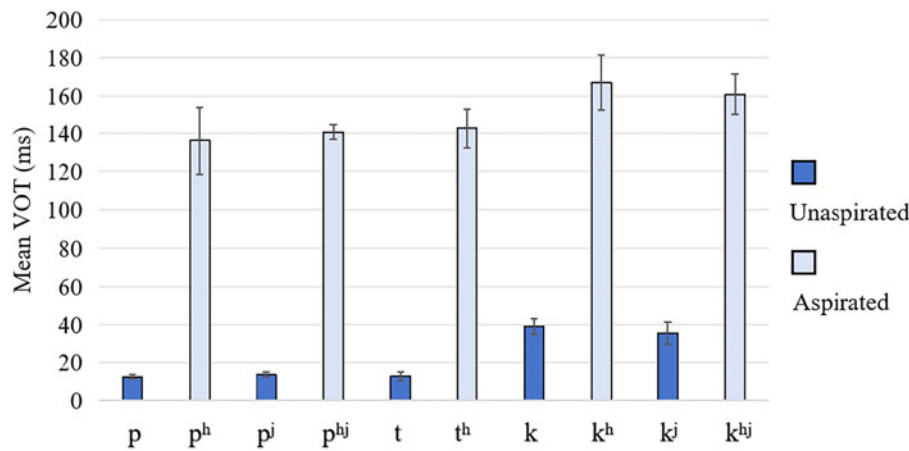
Figure 3. (Colour online) VOT of plosives in Zaiwa, where unaspirated and aspirated plosives are indicated by distinct colors. The mean and standard deviations were calculated using five tokens of each plosive from a single speaker.
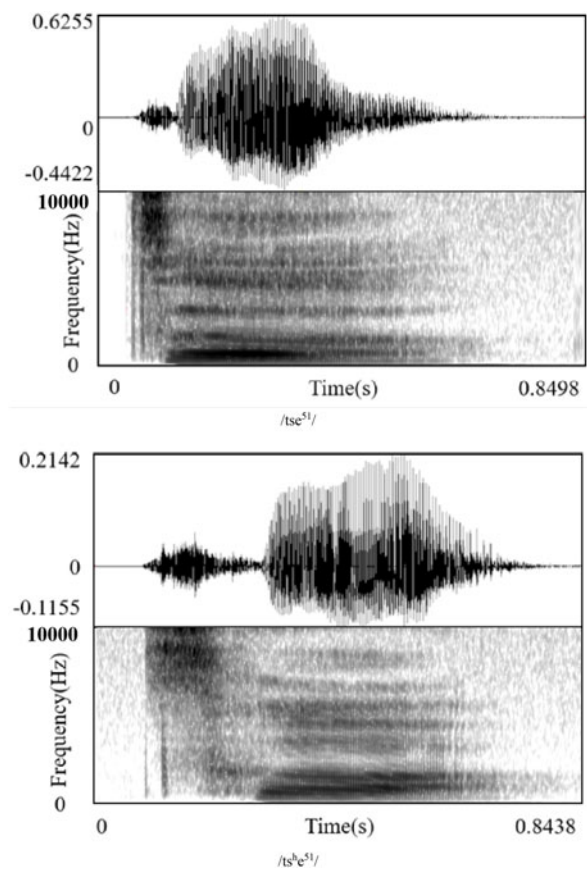

Figure 4. Waveforms and spectrograms for the minimal pairs /tse^{51}/ 'items' and /ts^{h}e^{51}/ 'ten'.
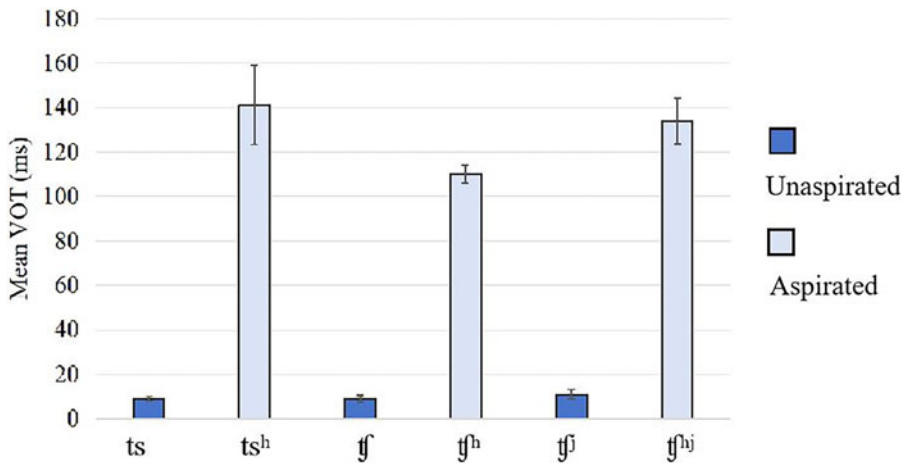
Figure 5. (Colour online) VOT of affricates in Zaiwa, where unaspirated and aspirated affricates are indicated by distinct colors. The mean and standard deviations were calculated using five tokens of each affricate from a single speaker.

of /x/ is between 2,000–4,000 Hz. The energy of /ɕʲ/ is primarily around 6,000 Hz and /xʲ/ is primarily around 4,000 Hz. Additionally, the peak frequency and center of gravity of palatalized fricatives' spectra are comparatively higher than those of their non-palatalized counterparts.

Nasals

The six nasals of Zaiwa include bilabial (/m/, /mʲ/), alveolar (/n/, /nʲ/), and velar (/ŋ/, /ŋʲ/). /m n ŋ/ can occur both in the onset and coda position, while palatalized /mʲ nʲ ŋʲ/ occur only in the onset position. Syllabic nasals also occur in certain words, for example, /m̩ ⁵¹/ for 'mm-hmm'.

Lateral approximants and approximants

There are two lateral approximants, /l lʲ/, and three central approximants, /ʋ/, /ɹ/, /j/ in Zaiwa. They are produced at three articulation locations: labiodental, alveolar, and palatal. Scholars (Xu & Xu, 1984) have described /ʋ/ and /ɹ/ as the voiced counterparts to the voiceless consonants /f/ and /ʃ/, respectively, labeling them as the voiced phonemes /v/ and /ʒ/. Subsequent studies, utilizing empirical analyses and comparative studies, have posited that the phonemes /ʋ/ and /ɹ/ in Zaiwa exhibit characteristics more akin to those of approximants (Pan, 2014). We posit the latter due to their phonetic characteristics. In our study, we also found that /ʋ/ and /ɹ/ are excited mainly by voicing, with only slight frication, as shown in Figure 7. Furthermore, we identified [w] as an allophone of /ʋ/. Hence, treating /ʋ/ as an approximant aligns more closely with the data observed. If /ʋ/ and /ɹ/ are treated as approximants, this can explain both the phonological configuration and the phonological evolution, and it also aligns more closely to the actual pronunciation.

Palatalized consonants

In Zaiwa, the bilabial plosive, alveolar plosive, velar plosive, postalveolar fricatives, velar fricatives, nasals, and lateral approximant each have their palatalized counterpart, namely,
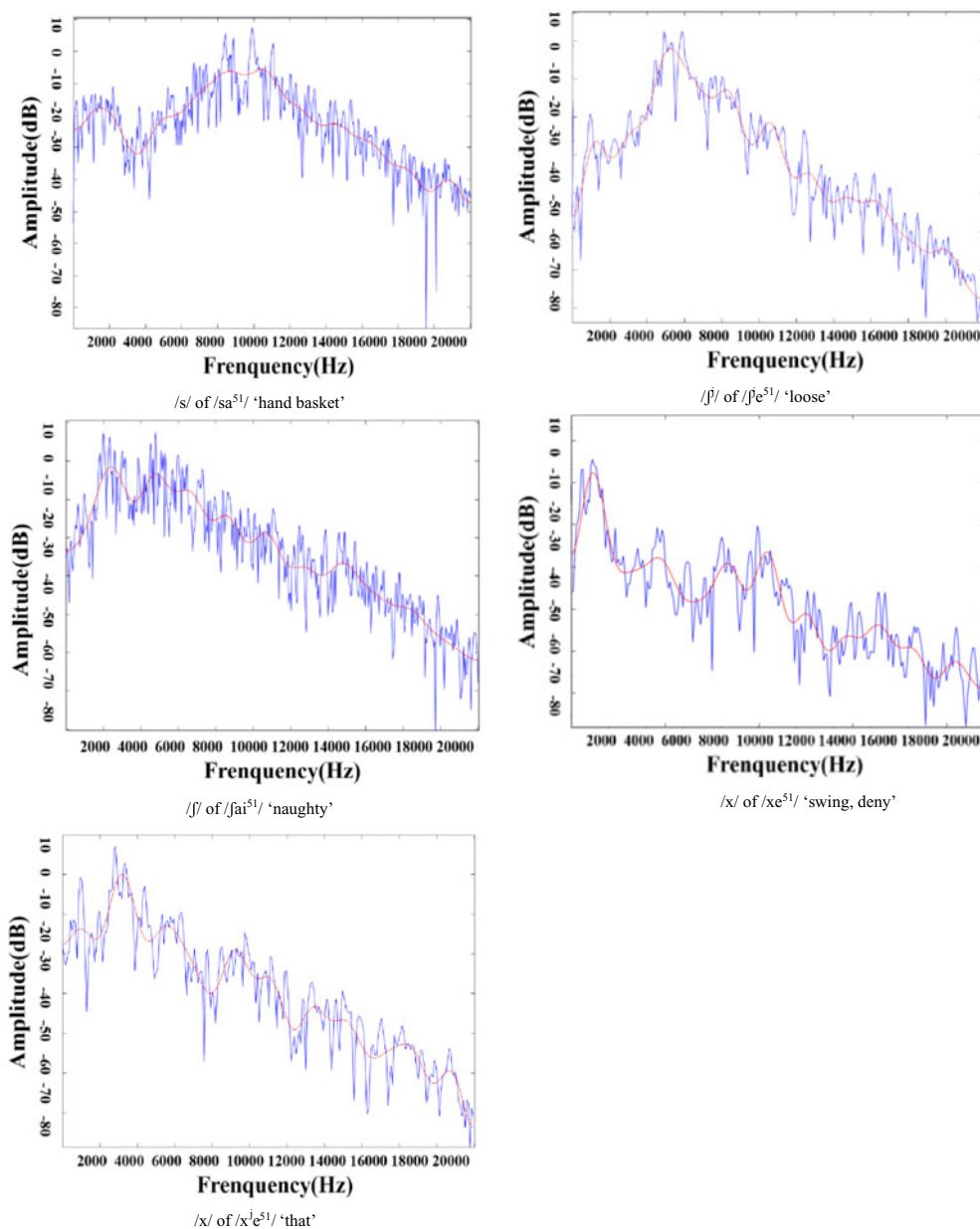
/s/ of /sa⁵¹/ 'hand basket'

/ʃ/ of /ʃai⁵¹/ 'naughty'

/ʃʲ/ of /ʃʲe⁵¹/ 'loose'

/x/ of /xe⁵¹/ 'swing, deny'

/x/ of /xʲe⁵¹/ 'that'

Figure 6. (Colour online) FFT (Fast Fourier Transform, blue) and logarithmic (red) spectra (Linear Predictive Coding, red) spectrum (made with a 23-ms window centered on the peak of noise intensity) of the frication in /sa⁵¹/ 'hand basket', /ʃai⁵¹/ 'naughty', /ʃʲe⁵¹/ 'loose', /xe⁵¹/ 'swing, deny', and /xʲe⁵¹/ 'that'.

/pʲ/, /pʰʲ/, /tʲ/, /tʰʲ/, /tʃʲ/, /tʃʰʲ/, /ʃʲ/, /kʲ/, /kʰʲ/, /xʲ/, /mʲ/, /nʲ/, /ŋʲ/, and /lʲ/. According to the spectrogram for plain /p/ in Figure 8(a), F1 remains stable at approximately 1,000 Hz, whereas F2 starts at 1,150 Hz and slowly rises to 1,350 Hz, and then remains stable. As can be seen in the spectrogram for palatalized /p/ in Figure 8(b), F1 starts at 400 Hz, gradually rises to 1,000 Hz, and remains stable, whereas F2 increases 3,000 Hz to 2,300 Hz and then remains steady. The dynamic trajectories of F1 and F2 are similar to the process from the high front
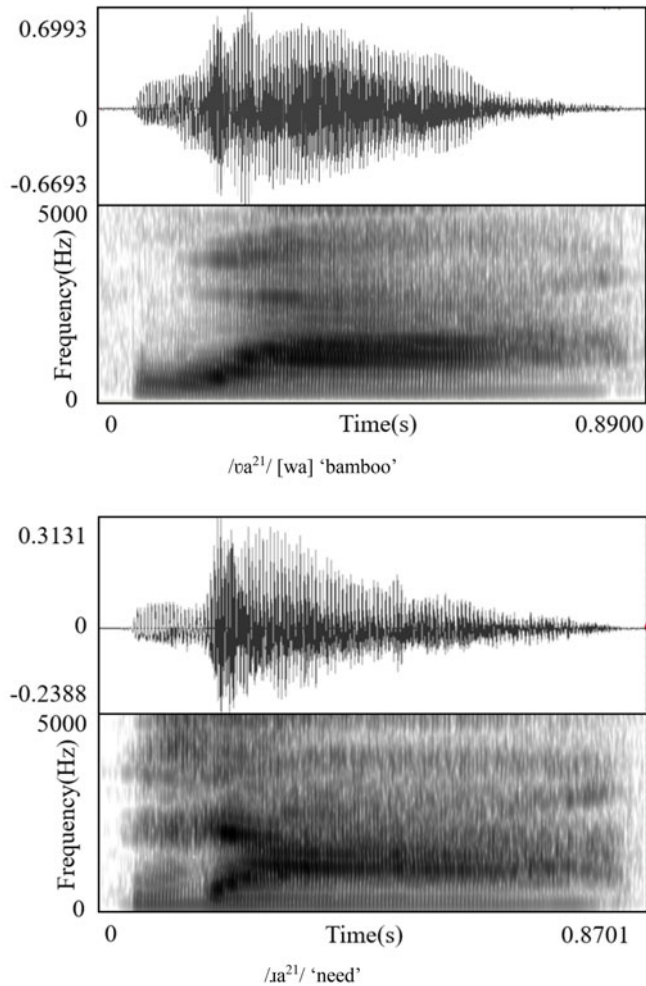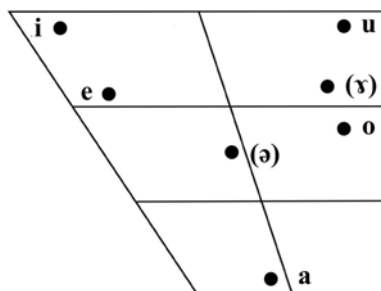
Figure 7. Waveforms and spectrograms for /ʋa²¹/ [wa] 'bamboo' and /ɹa²¹/ 'need'.

vowel to the low central vowel. As shown in Figure 9, we statistically analyzed the mean F2 onset of the plain consonants and corresponding palatalized consonants. The F2 onsets of palatalized consonants were significantly higher than those of plain consonants.

Vowels

Monophthongs

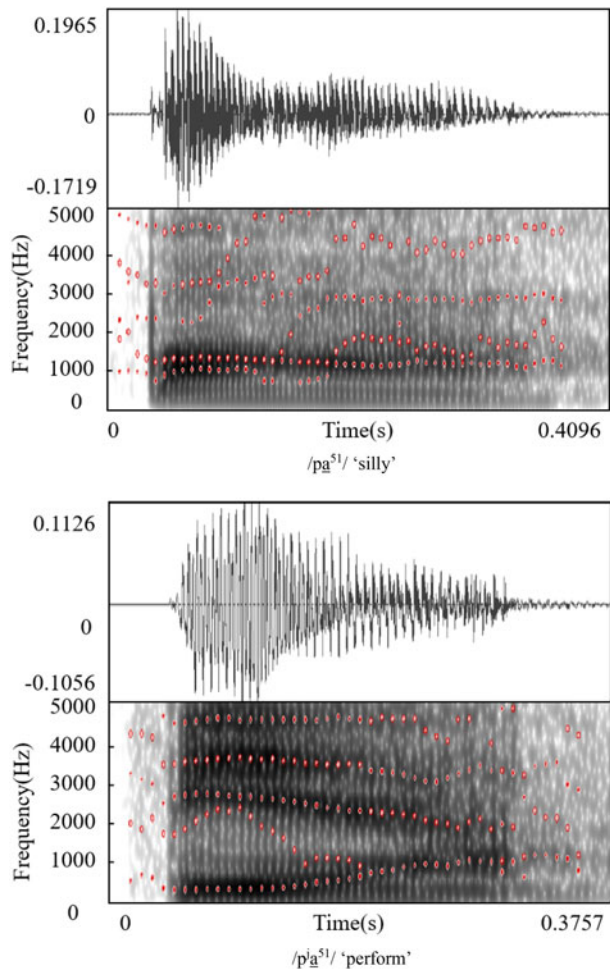| VOWEL	EXAMPLE	GLOSS
a	pa⁵¹	'fine, OK' (hortative)
e	pe⁵¹ [pə]	'completed action' (perfective aspect)
i	pɤ²¹	'help, please'
o	po⁵¹	'contain'
u	pu²¹	'sprout, clothes'
a̰	pa̰⁵⁵	'dam'
ḛ	pḛ⁵¹ [pə]	'military counselor'
ḭ	pʲḭ⁵¹	'transverse'
o̰	po̰⁵¹	'cheap'
ṵ	pṵ⁵⁵	'make protruding'

Figure 8. (Colour online) Waveforms and spectrograms for the minimal pairs /pa̰⁵¹/ 'silly' versus /pʲa̰⁵¹/ 'perform'. The red dotted lines represent the formants.
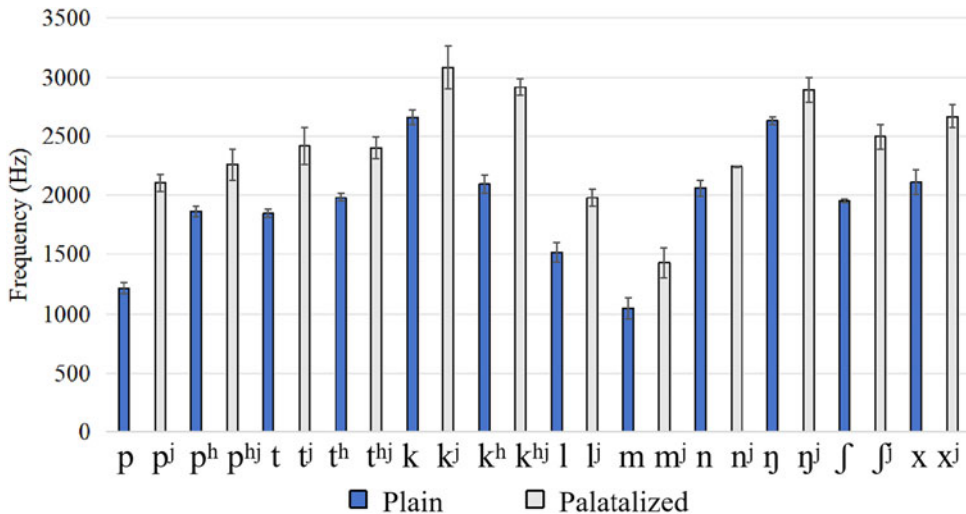
Figure 9. (Colour online) The mean F2 onset after plain versus palatalized consonants. The mean and standard deviations were calculated using eight tokens of each consonant from the single speaker.

Zaiwa has five vowel phonemes: /i e a o u/, further differentiated according to phonation (modal versus pressed voice), forming 10 monophthong vowels. Vowels /i i̠/ are high front vowels, /e e̠/ are mid-high front vowels, /a a̠/ are central low vowels, /o o̠/ are mid-low back vowels, and /u u̠/ are high back vowels. All 10 vowels can occur in closed syllables with nasal codas /m n ŋ/ and stop codas /p t k ʔ/. The vowel chart was plotted based on the relative F1 and F2 values of the vowel phonemes in Zaiwa, as shown in Figure 10. We chose 10 syllables with different consonants for each vowel and then used the Praat software to extract the values of the stable segment of the formants. Vowel [ɤ] is an allophone of /i/, /i̠/, and [ə] is an allophone of /e/ and /e̠/. In the subsequent sections, we will provide a detailed introduction to the conditions under which these two variants occur.

The phonemes /i/ and /i̠/ are realized as [ɤ] and [ɤ̠] after velar consonants /k/, /kʰ/, /x/, as well as bilabials, alveolars, and the approximant /ʋ/, whereas they remain unchanged following the palatalized counterparts of bilabial, alveolar, and velar consonants. The example includes /pik³¹/ realized as [pɤk³¹] 'to shoot'. The spectrographic analysis presented in Figure 11 for [pɤk³¹] 'to shoot' compared to /tʲik⁵⁵/ 'urgent, fast' distinctly shows that the separation between the formants F1 and F2 in [pɤk³¹] is markedly less than that observed in /tʲik⁵⁵/.

The phonemes /e/ and /e̠/ are realized as [ə] and [ə̠] following bilabial, alveolar, and velar consonants, the labiodental approximant /ʋ/, and in null onset positions, whereas they remain unchanged following the palatalized counterparts of bilabial, alveolar, and velar consonants. An example of this phenomenon is observed in /pe³⁵/, which is articulated as [pə³⁵] 'fall off'. In Figure 12, which shows spectrograms of [pə³⁵] 'fall off' to /tʲe³⁵/ 'send', we find that the separation between the formants F1 and F2 for [pə³⁵] 'fall off' is considerably narrower than that for /tʲe³⁵/ 'send'. Figure 13 shows the spectrogram of two syllables /me²¹/ 'green blue' and /mik²¹/ 'greedy', which are realized respectively as [mə²¹] and [mɤk²¹].

Vowel phonation

The distinction between vowels with pressed versus modal voice constitutes a pivotal feature within the phonology of Zaiwa. Through an analytical review of the manifestations and
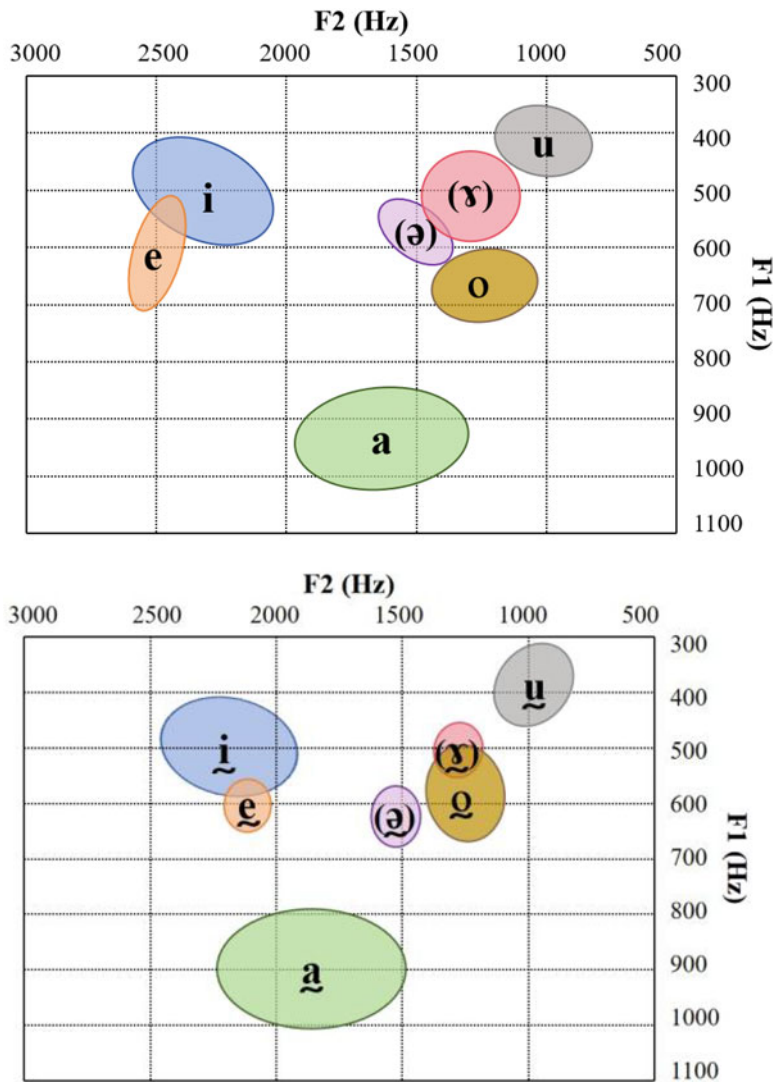
Figure 10. (Colour online) Formant plots for the monophthongs of Zaiwa, F1 and F2 of each vowel were based on mean formant values of 10 open syllables. The ellipses show the F1 and F2 values to two standard deviations.

combinatorial rules of vowels with pressed voice and modal voice across various Tibeto-Burman languages, Dai (1989) posited that the differentiation between vowels with pressed and modal voice represents a critical characteristic in a subset of Tibeto-Burman languages. Regarding the formation of the pressed and modal voice vowels, Dai (1989) pointed out that the opposition in the Tibeto-Burman language family of China was the result of convergence from two different paths: one derived from the voiced versus voiceless contrast in onset consonants (noted in languages such as Zaiwa and Jingpo), and the other from the contrast between checked and unchecked vowels (observed in languages like Yi, Lahu, Lisu, and Hani). For example, one of the falling tones in Lisu is represented as being 'checked' by a glottal stop (Tabain, 2019). The former involves changes in vowel quality influenced by the elements preceding the vowel, whereas the latter involves changes influenced by the
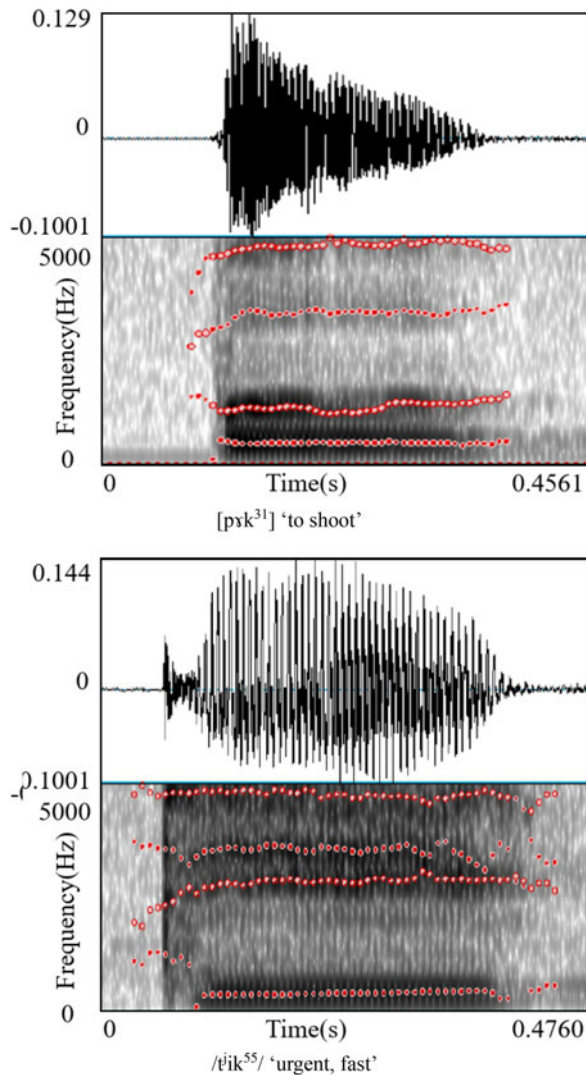
Figure 11. (Colour online) Waveforms and spectrograms for [pɤk³¹] 'to shoot' and /tʲik⁵⁵/ 'urgent, fast'. The red dotted lines represent the formants.

elements following the vowel. Both the consonants before and after the vowel influence vowel changes, driving vowels toward a pressed and modal opposition, albeit under different conditions. This is a distinctive feature of the evolutionary development of the vowel system within the Tibeto-Burman language family, separating it from other language families. From the perspective of phonation types, Kong (2001) indicated that the vowels with modal and pressed voice in Zaiwa belong to different phonation types. The vowels with modal voice are largely modal but with a slightly breathy voice quality, while the vowels with pressed voice have a form representing a highly complex form of creaky voice.

Thus, we calculated corrected H1∗–H2∗ using Matlab for five minimal pairs or near-minimal pairs of vowels with pressed and modal voice in Zaiwa. The findings are presented in Figure 14, and reveal that the difference of H1∗–H2∗ between vowels with pressed
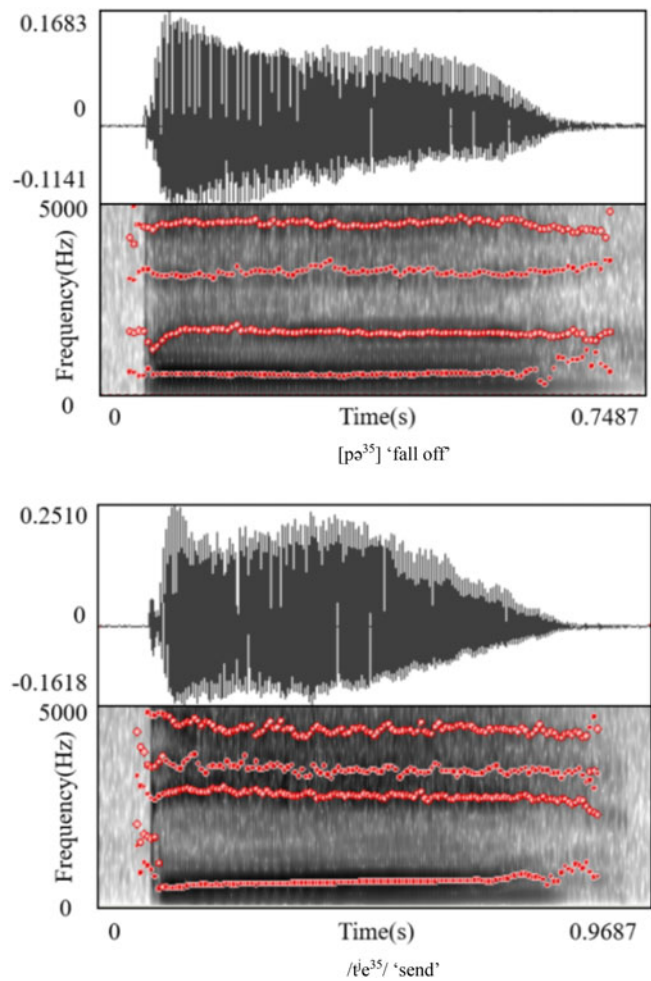
Figure 12. (Colour online) Waveforms and spectrograms for the minimal pairs [pə³⁵] 'fall off' versus /tʲe³⁵/ 'send'. The red dotted lines represent the formants.

and modal voice is large. This suggests that vowels with pressed voice are produced with constricted vocal folds.

Cooccurrence restrictions between consonants and vowels

Vowels with a modal voice can combine with all consonants, while vowels with a pressed voice can only combine with unaspirated plosives, unaspirated affricates, nasals, lateral approximants, and approximants.

	Vowels with modal voice	Vowels with pressed voice
Unaspirated plosives	pe³⁵ [pə] 'fall off'	pa̰m²¹ 'make damp'
Aspirated plosives	pʰe⁴⁴ [pə] 'notch'	

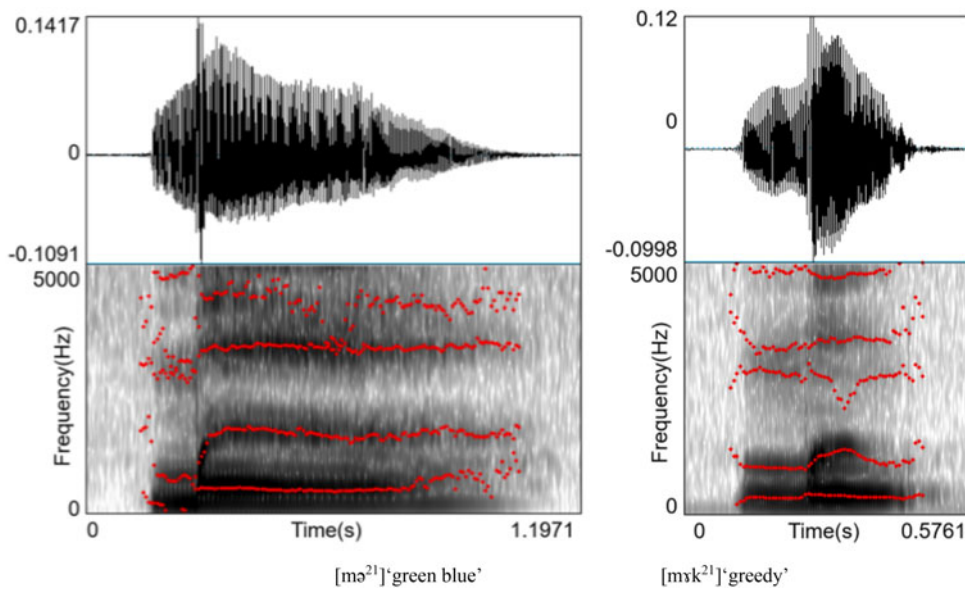| Unaspirated affricates	tʃo⁵¹ 'russet sparrow'	tʃo̰i²¹ 'beautiful'
Aspirated affricates	tʃʰo⁵¹ 'tube'	
Fricatives	se⁴⁴ [sə] 'know'	
Nasals	nʲe⁵¹ 'red'	na̰²¹ 'to confuse'
Lateral approximants	lʲe³⁵ 'come'	lo⁵¹ 'naughty'
Approximants	ɹe³⁵ 'pain'	ɹa̰t⁵⁵ 'sister-in-law'

Figure 13. (Colour online) Waveforms and spectrograms for [mə²¹] 'green blue' and [mɤk²¹] 'greedy'. The red dotted lines represent the formants.
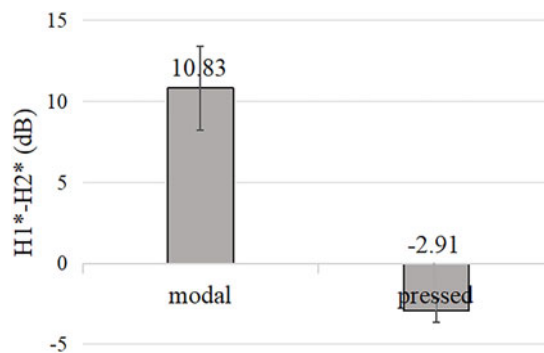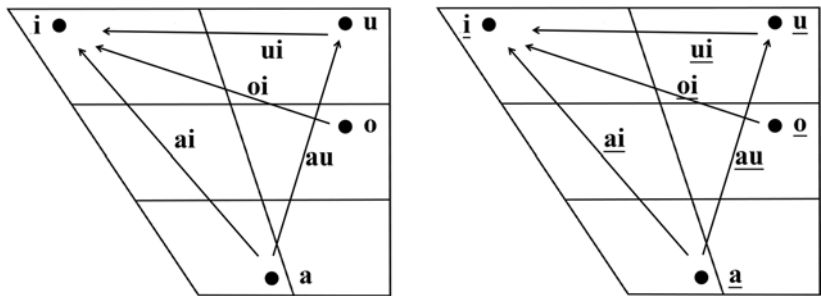

Figure 14. H1∗–H2∗ of vowels with modal and pressed voice. The means and standard deviations were calculated using five tokens of each phonation type from the single speaker.

Diphthongs

VOWEL	EXAMPLE	GLOSS
ai	pai^{51}	'fine, OK'
au	pau^{51}	'ridge'
oi	poi^{51}	'festival'
ui	pui^{51}	'to move, to spread out'
a̠i	pa̠i^{21}	'not authentic, not standard, out of tune'
a̠u	pa̠u^{51}	'bamboo raft'
o̠i	po̠i^{51}	'fawn on'
u̠i	pu̠i^{51}	'to move'

In Zaiwa, the primary vowels /a o u/ combine with the coda /-i, -u/ to form eight diphthongs with modal and pressed voice: /ai a̠i oi o̠i ui u̠i au a̠u/, all of which are rising diphthongs. Figure 15 shows that F1 and F2 of the diphthongs were measured at 20% and 80%, which indicates the onset and offset values of the diphthongs.

Tones

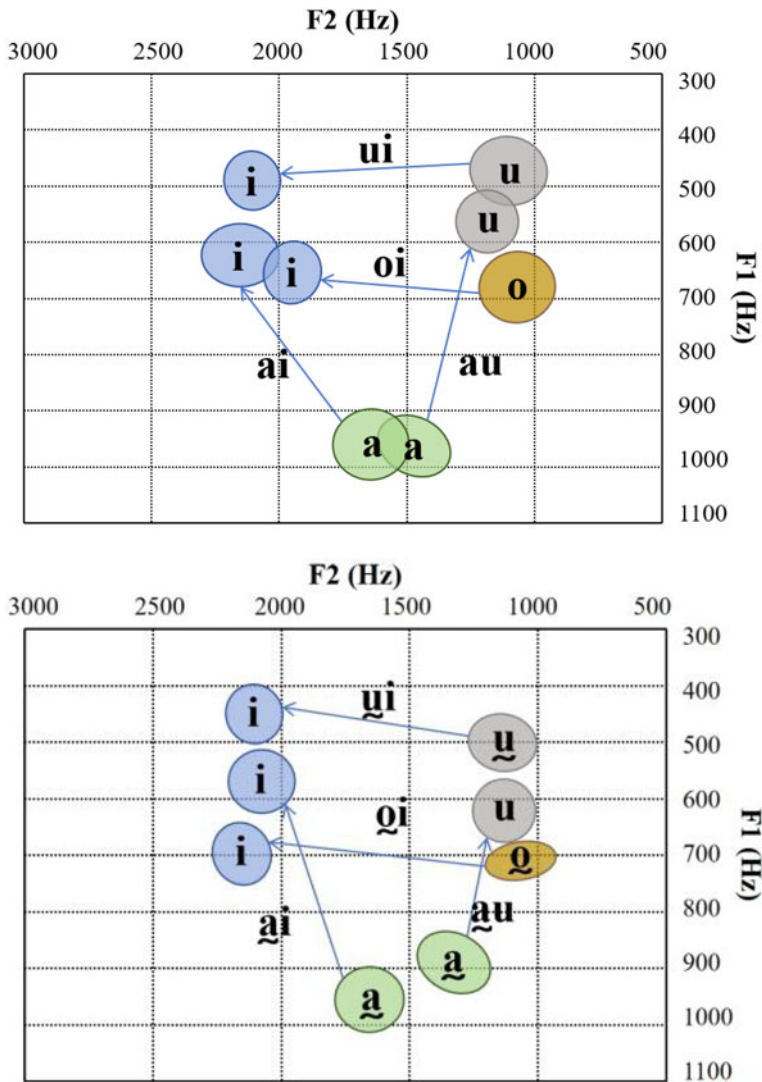| Tone1	21	unchecked	/pam^{21}/ 'damp'; /pa̠m^{21}/ 'make damp'
Tone2	31	checked	/pat^{31}/ 'strike, knock'; /mʲa̠p^{31}/ 'short'
Tone3	51	unchecked	/po^{51}/ 'contain'; /po̠^{51}/ 'embrace'
Tone4	44	unchecked	/pʰe^{44}/ [pə] 'notch'; /ma̠u^{44}/ 'cheat'
Tone5	55	checked	/kʰop^{55}/ 'hollow'; /pa̠t^{55}/ 'brew'
Tone6	35	unchecked; with limited distribution	/mau^{35}/ 'strange'

Figure 15. (Colour online) Formant plots for the diphthongs of Zaiwa, F1 and F2 of vowel were based on mean formant values of 5 syllables. The ellipses show the F1 and F2 values to 2 standard deviations.

The Zaiwa tone system is rather complex. Previous research by Xu and Xu (1984) suggested that Zaiwa has three tones, with values of 21, 55, and 51. Dai (1989) identified two methods for categorizing Zaiwa tones. The first approach aggregates tones based on their proximal tone values and consolidates checked and unchecked tones into a single tone category. This classification yielded three tones, marked as 21, 55, and 51, with the 21 and 55 categories each encompassing both checked and unchecked variations. The second approach separated checked from unchecked tones, thus leading to five tones: three unchecked (21, 55, 51) and two checked (21, 55). Vowels with stop codas /p t k ʔ/ can only combine with checked tones. He (2016) concurred with the existence of three tones within Zaiwa but argued for a revision of the tonal values to 22, 55, and 51. Furthermore, it has been shown in past studies that the high level tone 55 in Zaiwa changes to 35 for modal vowels preceded by unaspirated
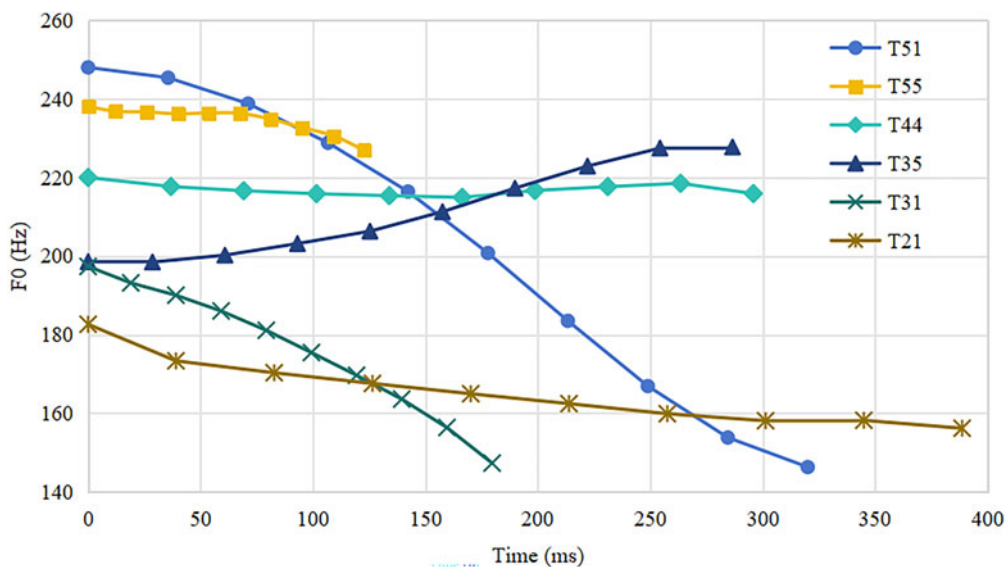
Figure 16. (Colour online) F0 contours of Zaiwa tones for the one speaker.

plosives and affricates, nasals, lateral approximants, or approximants. With other tones, vowels can either be pressed or modal in phonation. Lu & Kong (2019) observed that the Zaiwa tonal system has six tones for monosyllabic words, including two level tones, three falling tones and one rising tone, whose tone values are 55, 44, 51, 31, 21, and 35 respectively. As the phonation types of Zaiwa vowels vary between modal and pressed voice, and are closely integrated with tones, Lu & Kong (2019) also agreed with the limitations on the conditions under which the tone 35 appears in previous research.

Based on the study by Lu & Kong (2019) and the current survey, we undertook an acoustic analysis of the Zaiwa tones, whereby the fundamental frequency of each monosyllabic utterance was extracted to analyze the tones. When selecting monosyllabic words to determine tones, we preferred words starting with unaspirated stop consonants to facilitate the extraction of fundamental frequency data. The f0 values of each tone were extracted using Praat (Boersma & Weenink, 2020). Each tonal contour is obtained by averaging across six tokens. Tonal values were marked using the five-scale pitch system developed by Chao (1980), in which 5 was the highest and 1 was the lowest. As shown in Figure 16, there is a difference in the tone values between the checked and unchecked tones. Checked tone 55, marked by a stop coda of /p, t, k, ʔ/, was approximately one semitone higher in F0 than unchecked tone 55. The checked tone was approximated at 55, while the unchecked tone was at 44. Similarly, for tone 21, the checked tone characterized by a stop coda of /p, t, k, ʔ/ was approximately 31, whereas the unchecked tone was around 21. Additionally, due to the considerable duration difference between checked and unchecked tones, we posit that distinguishing between checked and unchecked tones aligns more closely with perception. Additionally, there is a significant difference in fundamental frequency between the high-level tone and its variant 35, leading us to conclude that they should be distinguished as two separate tones. We also found that the combination of tone 35 with consonants and vowels aligns with the findings of previous researchers.

We agree with Lu & Kong (2019), who posit that the tonal system of Zaiwa should be described as follows: Zaiwa has six tones, comprising two level tones, one rising tone, and three falling tones, with the tone values of 55, 44, 35, 51, 31, and 21, respectively. Among

Table 1. Syllable structure and examples of Zaiwa

Syllable structure	Example			
V^T	a^{21} 'no'	i^{21} 'pee'	i^{51} 'alcohol'	i^{44} 'two'
VV^T	ai^{21} 'serious'	au^{21} 'pan'		
VC^T	am^{51} 'jaw'	an^{44} 'saddle'	aŋ^{44} 'vat'	
	ap^{55} 'needle'	ut^{55} 'gong'	ok^{55} 'fraud'	uʔ^{55} 'migratory bird'
CV^T	pa^{51} 'fine, OK'	pa^{35} 'rake'	pe^{51} [pə] 'completed action'	pe^{35} [pə] 'fall off'
CVV^T	pau^{21} 'bug'	pau^{51} 'ridge'	pau^{35} 'only'	pa̰u^{51} 'bamboo raft'
CVC^T	pam^{21} 'damp'	pan^{21} 'flower'	kaŋ^{51} 'quench'	
	tap^{21} 'stick'	pat^{21} 'knock'	pʰak^{21} 'gap'	pʰa̰ʔ^{21} 'depressed'

these, tones 31 and 55 are checked tones, in that they only occur on syllables ending in a stop coda /p, t, k, ʔ/, while tones 21, 44 and 35 are unchecked tones, meaning that they cannot occur on syllables ending in a stop coda. The occurrence of rising tone 35 is conditional, requiring the consonant to be unaspirated plosives and affricates, nasals, lateral approximants and approximants, and the vowel to be in a modal voice, whereas the vowels in other tones can be in either a modal or pressed voice.

Syllable structure

There are seven syllable structures, namely V, VV, C, VC, CV, CVV, and CVC. Since type C consists only of syllabic /m/ and /n/, which are modal particles, it should be treated as extralinguistic and not part of the lexical phonology. As shown in Table 1, syllable types V and VV respectively represent all monophthongs and diphthongs as previously mentioned. In syllable types VC, CV, CVV, and CVC, the onset consonants include all consonants except for the glottal stop, and the coda consonants include the nasal sounds /m n ŋ/ and the stops /p t k ʔ/.

Transcription of the recorded passage

The passage used for the recordings is the story 'The Wind and the Sun', which is transcribed using the consonants, vowels, and tones of Zaiwa described above. The transcription below is broad phonemic. The symbol indicates a minor intonational break (corresponding to final lengthening), while denotes a major intonational break preceding a pause, following the International Phonetic Alphabet conventions. The transcription of each sentence is presented in three versions: the first line is an IPA transcription; the second, in italics, is a Zaiwa writing system transcription; and the third is the interlinear morphemic glossing. Abbreviations used in interlinear glossing follow the Leipzig Glossing Rules (LGR, https://www.eva.mpg.de/lingua/pdf/Glossing-Rules.pdf). The non-standard abbreviation (not included in the LGR) is: PREP = preposition. Additionally, a free English translation is also provided in quotations.

lai^{51} mo^{44} eʔ^{55} pui^{51} mo^{35} mo̰^{51} mʲi^{21}

LAIMO   *EQ*   *BUIMO*   *MVOMYI*

wind   and   sun   story

The Wind and the Sun story.

lai⁵¹ mo³⁵   eʔ⁵⁵   pui⁵¹mo³⁵ | o⁴⁴   pʰaʔ³¹tʃɿ⁵¹
Laimo   *eq*   *buimo* | *o*   *paqzhvi*
wind   and   sun   who   ability

tʃe³⁵   kat⁵⁵   le³⁵   tai⁵¹ kʰʲiŋ⁵¹lu̥m²¹   ma³⁵gɔ⁵¹ ||
zhe   *gat*   *le*   *dai-qinglvum*   *magvo* ||
COMP.   big   come   say-compete   PART

The wind and the sun were arguing about who was stronger.

xʲi⁵¹   u²¹ tso²¹   ma³⁵ | kʰʲo⁵¹kuŋ²¹   mi³⁵ |
xi   *u-zo*   *ma* | *qogung*   *mi* |
This   time   TOP   way   LOC

me²¹pu²¹   tʰuʔ⁵¹ tʰuʔ⁵¹   vut³¹   ma⁵¹ |
mebu   *tuqtuq*   *wut*   *ma* |
clothes   thick   wear   NMLZ

pʲu⁵¹   so²¹   le³⁵   lo³⁵   pe⁵¹ ||
byu   *so*   *le*   *lo*   *be*
person   walk   come   PART   PFV

At this time, there came a traveler wearing a thick coat.

xau⁵¹mu⁵¹   pui⁵¹mo³⁵   ki²¹   lai⁵¹mo³⁵   ɹe³⁵   tai²¹   pe²¹ka²¹|
Haumu   *buimo*   *gi*   *laimo*   *re*   *dai*   *bega* |
so   sun   SBJ   wind   OBJ   say   PFV

a²¹ tʃʲaŋ³⁵   le³⁵   kʰʲiŋ⁵¹lu̥m²¹   ʋu³⁵ko²¹|
azhang   *le*   *qinglvum*   *wugo* |
then   come   competition   try

o³⁵   xʲi⁵¹   kʰʲo⁵¹so²¹   paŋ²¹   e³⁵   me⁵¹pu²¹ |
o   *xi*   *qoso*   *bang*   *e*   *mebu* |
who   this   walk   PL.nmlz   GEN   clothes

vo³⁵   kʰʲut⁵⁵ pʲa̰m⁴⁴   na̰ŋ⁵¹   tʃʲaŋ⁴⁴ |
wo   *qutbyvam*   *nvang*   *zhang* |
could   take off   CAUS   SUB

xau⁴⁴ juʔ³¹   phaʔ³¹ tʃɿ⁵¹   kat³¹   toŋ⁵¹   son⁴⁴ ko²¹ ||
hauyuq   *paqzhvi*   *gat*   *dong*   *songo* ||
that   ability   big   APO   count as

So the sun said to the strong wind, 'Let's have a contest and see who can prevail, whoever of the two of us is able to make the traveler take off his coat would be considered the stronger one'.

lai⁵¹ mo³⁵   ki   soʔ⁵⁵la²¹ nṳt⁵⁵ mo³⁵   mut³¹ ta̰ŋ²¹ ka̰t³⁵   tʃʲaŋ⁴⁴ |
Laimo   *gi*   *soqlanvutmo*   *mutdvanggvat*   *zhang* |
wind   SBJ   a big bite   blow   SUB

kʰʲo⁵¹ so²¹   paŋ³⁵   ki²¹   mə⁵¹pu²¹   pu²¹liŋ⁵¹   ʃe⁵¹
qoso   *bang*   *gi*   *mebu*   *buling*   *she*
walk   PL.nmlz   GEN   clothes   collar   PART

tʃe³⁵   sai⁵¹   laŋ³⁵ to̰ʔ³¹   pe⁵¹ ||
zhe   *sai*   *langdvoq*   *be* ||
more   make   pull up   PFV

Then the wind blew as hard as he could, but the stronger the wind blew, the more closely the traveler folded his collar around himself.

tʃe³⁵ tʰaŋ⁴⁴ ma³⁵ | lai⁵¹ mo³⁵   ki²¹
Zhetangma | *laimo*   *gi*
in the end   wind   SBJ

sum⁵¹   jin³⁵   ɹa⁵¹   tsi²¹   ke²¹ a²¹lo⁵¹ ||
sum   *yin*   *ra*   *zi*   *ge-alo* ||
fail   admit   PART   only   PART

In the end, the wind had to admit defeat.

xau^{51} t^{h}aŋ^{51} ma^{35} |

Hautangma |

then

pui^{51}mo^{35}	ki^{21}	pui^{51}	x^{j}eŋ^{51} x^{j}eŋ^{51}	tso̰^{51}		ka̰t^{55}	tʃ^{j}aŋ^{35}	
buimo	*gi*	*bui*	*hengheng*	*zvo*		*gvat*	*zhang |*
sun	SBJ	sun	shine	illuminate	big	SUB	

la^{21} k^{hj}iŋ^{21} tʃ^{j}aŋ^{35}		k^{hj}o^{51} lai^{51} su^{51}	pu^{21}	k^{hj}ut^{21}	pe^{51} ||
laqingzhang |	*qolaisu*	*bu*	*qut*	*be ||*
a while	traveler	clothes	put off	PFV

Then the sun shone out warmly, and the traveler took off his coat after a while.

tʃe^{35} t^{h}aŋ^{51} ma^{35}		pui^{51} mo^{35}	ki^{21}	oŋ^{21}	p^{j}uʔ^{51}	pe^{51} ||
Zhetangma |	*buimo*	*gi*	*ong*	*byuq*	*be ||*
In the end	sun	SBJ	win	RES	PFV

In the end, the sun won.

References

Boersma, Paul & David Weenink. 2020. Praat: Doing phonetics by computer. Version 6.1.28. http://www.praat.org/ (last accessed 27 September 2025).

Chao, Yuen. 1980. A system of 'tone-letters'. *Fangyan* [Dialects] 2, 81–83.

Dai, Q. 戴庆厦. 1989. Zaiwayu Shengdiao Yanjiu 载瓦语声调研究 [Research on the tones of Zaiwa]. *Zhongyang Minzu Xueyuan Xuebao《中央民族学院学报》*[Journal of Minzu University of China] 1, 61–66.

Edmondson, Jerold A., John H. Esling, & Li Shaoni. 2021. Jianchuan Bai. *Journal of the International Phonetic Association* 51(3), 490–501.

Esposito, Christina M., & Sameer U. D. Khan. 2020. The cross-linguistic patterns of phonation types. *Language and Linguistics Compass* 14(12), e12392.

Gordon, Matthew & Peter Ladefoged. 2001. Phonation types: A cross-linguistic overview. *Journal of Phonetics* 29(4), 383–406.

Hanson, Helen M. 1995. Glottal characteristics of female speakers. Ph.D. dissertation, Harvard University, Cambridge, MA.

Hanson, Helen M. 1997. Glottal characteristics of female speakers: Acoustic correlates. *Journal of the Acoustical Society of America* 101, 466–481.

He, L. 2016. *Zaiwayu Yuyin Yanjiu* 载瓦语语音研究 [Research on the phonetic system of Zaiwa]. PhD. Dissertation, Shanghai Normal University.

Institute of Linguistics, Chinese Academy of Social Sciences, Institute of Ethnology and Anthropology, Chinese Academy of Social Sciences, Research Centre of Language Information and Science, City University of Hong Kong. (2012). *Language atlas of China*, second edition. Beijing: The Commercial Press.

Kong, J. 孔江平. 2001. *Lun Yuyan Fasheng*《论语言发声》[On language phonation]. Beijing: Central Minzu University Press 中央民族大学出版社.

Kreiman, Jody, Yen-Liang Shue, Gang Chen, Markus Iseli, Bruce R. Gerratt, Juergen Neubauer, & Abeer Alwan. 2012. Variability in the relationships among voice quality, harmonic amplitudes, open quotient, and glottal area waveform shape in sustained phonation. *The Journal of the Acoustical Society of America* 132(4), 2625–2632.

Lu, Y., 陆尧 & J. Kong. 孔江平. 2019. Zaiwayu Shengdiao de Shengxue ji Ganzhi Yanjiu 载瓦语声调及声学感知研究 [Acoustic and perceptual studies on the Zaiwa tones]. *Minzu Yuwen*《民族语文》[Minority languages of China] 1, 55–65.

Lu, Y., C. Liang, & J. Kong. 2025. Contribution of f0 and phonation to tone perception in the Zaiwa language. *Journal of Phonetics* 110, 101413.

Pan, X. 潘晓声. 2014. Yimianyu zhong de Jinyin yu Zhuocayin 彝缅语中的近音与浊擦音 [Some voiced fricatives and approximants with friction in the Lolo-Burmese languages]. *Minzu Yuwen*《民族语文》[Minority languages of China] 3, 54–58.

Samlan, Robin, Brad H. Story, & Kate Bunton. 2013. Relation of perceived breathiness to laryngeal kinematics and acoustic measures based on computational modeling. *Journal of Speech Language & Hearing Research* 56, 1209–1223.

Tabain, Marija, David Bradley, & Defen Yu. 2019. Central Lisu. *Journal of the International Phonetic Association* 49(1), 129–147.

Titze, Ingo R., Ronald J. Baken, Kenneth W. Bozeman, Svante Granqvist, Nathalie Henrich, Christian T Herbst, et al. 2015. Toward a consensus on symbolic notation of harmonics, resonances, and formants in vocalization. *The Journal of the Acoustical Society of America* 137(5), 3005–3007.

Trubetzkoy, N. S. 2012. *Introduction to the principles of phonological descriptions*. New York: Springer Science & Business Media.

Xu, X., 徐悉艰 & G. Xu 徐桂珍. 1984. *Jingpoyu Jianzhi (Zaiwayu)*《景颇语简 志（载瓦）》[A sketch of the Zwaiwa language]. Beijing: Nationalities Press 民族出版社.

Zhang, Zhaoyan. 2016. Mechanics of human voice production and control. *Journal of the Acoustical Society of America* 140, 2614–2635.