言語研究（*Gengo Kenkyu*）**168**: 57–76（2025） doi: 10.11435/gengo.168.0_57

Phonetics of Voiceless Laterals in Five Southern Bantu Languages

【Invited Article】

Seunghun J. Lee
International Christian University & University of Venda

Daisuke Shinagawa
ILCAA, Tokyo University of Foreign Studies

Abstract: Voiceless lateral fricative [ɬ] is commonly found in Southern Bantu languages, even though it is reported to be an uncommon sound from cross-linguistic perspectives. This paper draws data from five Southern Bantu languages (Siswati, Southern Ndebele, Xitsonga, Sesotho, and Northern Sotho) and reports acoustic characteristics of lateral fricatives. The results demonstrate that duration and intensity do not differ among the languages. Concerning the four spectral moments, Siswati shows higher center of gravity and lower skewness compared to other four languages, showing that lateral fricatives do not have uniform phonetic realizations. The paper then focuses on lateral fricatives in Siswati and Southern Ndebele because they both belong to the Nguni group, and they are spoken in the vicinity of each other. The lateral fricative is acoustically placed between alveolar and palatal fricatives in Siswati, but between alveolar and velar fricatives in Southern Ndebele. Our analysis suggests that the production of lateral fricative in Siswati and Southern Ndebele may differ due to the fricative inventory in each language; velar fricatives in Southern Ndebele allow more acoustic space for the realization of lateral fricatives, but palatal fricatives in Siswati rather limit the acoustic space. This paper also discusses how the phonetic findings connect with the diachronic studies on lateral fricatives.*

Key words: lateral fricatives, spectral moments, Southern Bantu languages

1. Introduction

The voiceless lateral fricative is a hybrid sound that combines the laterality with frication while being produced as voiceless. Compared to commonly found liquids such as laterals or rhotics, the lateral fricative is uncommon, which is usually found in specific clusters of languages in Africa, numerous Tibeto-Burman languages in

* This work was mainly supported by JSPS KAKENHI Promotion of Joint International Research (Fostering Joint International Research (B)) 21KK0005 (JSAntu). This study was also supported by JSPS KAKENHI (B) 23K25319 (PACroBaT, and the ILCAA joint research projects 'Phonetic typology from cross-linguistic perspectives (phase 2) (jrp000294)' and 'Diachronic Perspectives on Language Description and Typology in Bantu (jrp000292)'. We thank the participants who shared their languages during the recording sessions. We also thank members of the JSAntu project and PhonTyp2 project for their comments and suggestions.

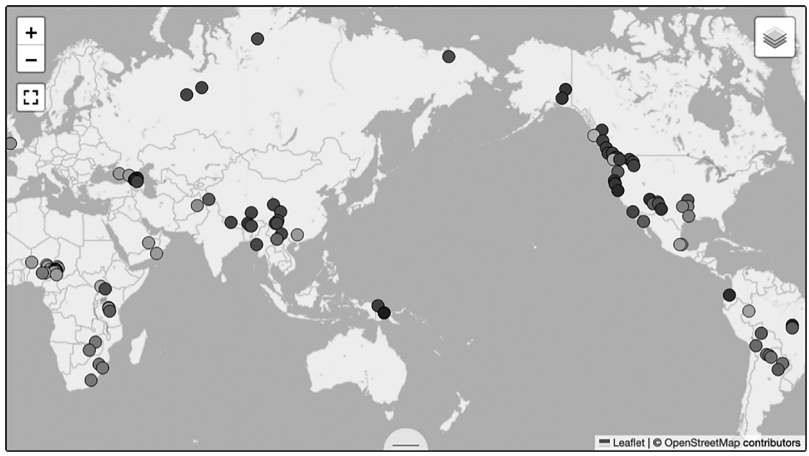


Figure 1 Distribution of sample languages with lateral fricatives in Phoible 2.0 database (https://phoible.org/parameters/1F0C89A7E99CD5113AA994AD2CC86CBC#3/-12.55/16.87)

the Himalayas, and the indigenous languages of the Americas. The Phoible website (https://phoible.org/) lists 149 languages (out of 2186 distinct languages) with the voiceless lateral fricative as shown in Figure 1.

Focusing on Sub-Saharan Africa, three geographical centers where languages with voiceless lateral fricatives are distributed can be identified as shown in Figure 2. One is the Chad basin area located at the intersection of the boundaries of Chad, Niger, Nigeria and Cameroon, where a number of Chadic languages, mostly belonging to Biu-Mandara branch, are identified as having phonemic lateral fricatives. Another area is the vast stretch of the East African rift valley, where languages with various phylogenetic profiles are reported to have lateral fricatives in their phonemic inventory, including the Kuliak language Nyang'i, the Central Sudanic Olu'bo, the Cushitic Iraqw, and two language-isolates, Sandawe and Hadza, as well as the two languages in a specific group of Bantu languages, Davida and Saghala (cf. Beer *et al.* forthc., Gunnink & van der Vulgt (2024)).[1] The last one is the southeastern part of Bantu area, where several of Southern Bantu languages, which belong to Zone S (see Appendix for the list of the languages) in the standard referential classification based on Guthrie (1967–71), have lateral fricatives in their phonemic inventories. It is this language group that the present study focuses on to analyze their phonetic variation of voiceless lateral fricatives (A list of the Zone S languages is provided in Appendix).

[1] According to the notes in Gunnink & van der Vulgt (2024), lateral fricatives in Davida are the result of the general spirantization process usually called 'Bantu spirantization' (cf. Schadeberg 1994/95, Bostoen 2008), while those in Saghala seem to have originated from Cushitic influence through contact.

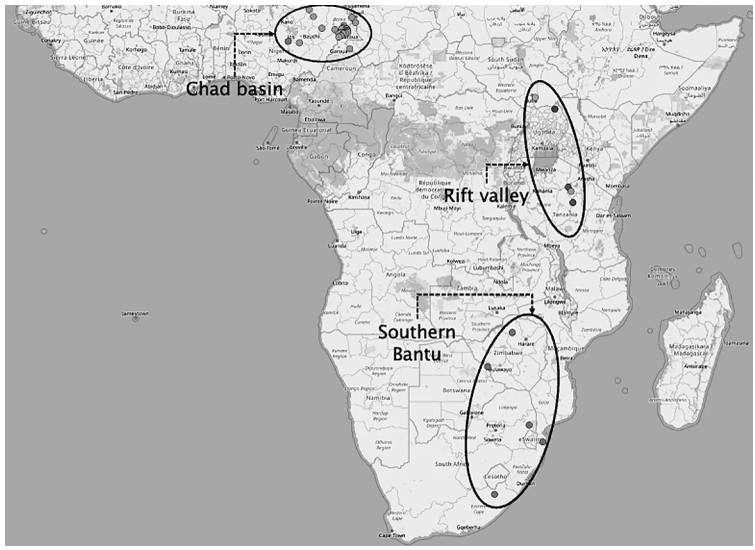


Figure 2 Distribution of languages with lateral fricatives in Sub-Saharan Africa as reported in Phoible (enlargement of Figure 1)

1.1. Lateral fricatives in Bantu languages

Partly due to the restricted distribution, detailed phonetic studies of the voiceless lateral fricatives are scarcely available in the literature of Bantu linguistics. The data sources cited in the Phoible 2.0 database for the reference to the lateral fricatives are either (mostly introductory chapters of) reference grammars of each sample language, such as Fortune (1955) for Shona [S10]; Doke (1961) and Rycroft & Ngcobo (1979) for Zulu [S42]; Sibanda (2004) for Zimbabwean Ndebele [S44]; Hargus (1999) for Rhonga [S54], or a comprehensive introduction of the Zone S languages with descriptive information about their consonant inventories, namely Gowlett (2003) for Xhosa [S41] and Copi [S61]. Significant exceptions in the classic literature that provide detailed phonetic descriptions about segmental features are a series of descriptive work by Clement Doke, namely the detailed phonetic description of Zulu (Doke 1926), the phonetics-based comparative studies of Shona varieties (Doke 1931), and the comparative description covering an entire range of Guthrie's (1967–1971) zone S groups: Shona [S10], Venda [S20], Sotho (Guthrie's 'Sotho-Tswana') [S30], Nguni [S40], Tsonga [S50] and the Inhambane (Guthrie's 'Chopi') [S60], which includes a chapter of comparative phonetics and phonology (Doke 1956). Even so, the studies have not yet covered results based on instrumental studies. Shinagawa and Lee (2024), as a recent contribution from the area of phonetic and phonological typology, provide a group-internal typological overview of lateral fricatives in selected zone S languages: Northern Sotho [S32], Southern Ndebele [S407], Xhosa [S41], Zulu [S42], and Swati [S43]. They show implicational relationships between syllabic positions and the occurrence of lateral

fricatives.

From a cross-Bantu perspective, Sands and Maddieson (2019), in their introductory chapter on Bantu phonetics, address the fact that lateral fricatives as cross-linguistically uncommon sounds are attested in a number of southeastern languages including Sotho-Tswana, Xhosa, and Zulu, posing the question about whether they had been developed language internally, i.e. as a result of shared innovation, or introduced through contact with phylogenetically external non-Bantu languages. Gunnink *et al.* (2023) have made a path-breaking contribution in deciphering an unsolved process which leads to the emergence of cross-linguistically rare sounds which are neither attested in any other groups of Bantu languages in the region, nor frequently found in neighboring non-Bantu languages. As part of their proposal of the novel phylogeny of the southern Bantu languages based on lexicostatistic analysis, Gunnink *et al.* (2023) present the distribution of lateral fricatives i.e., /ɬ/ and /ɮ/, and lateral affricates including /tɬ/, /dɮ/, as well as /kʟ/, all of which are identified as the reflexes of the Proto-Bantu palatals *c and *j, and accordingly examine possible scenarios of their historical emergence and development. Gunnink and van der Vulgt (2024) further investigate the process of the development based on their literature-based corpus and propose a comprehensive overview of the development process of the lateral obstruents across zone S languages (See 4.2 for the detail of their hypothesis. See also van der Vulgt & Gunnink (2024) for the discussion of the specific case of Nguni languages).

From an areal typological viewpoint, Clements and Rialland (2008) propose that the presence of ejective and aspirated stops, clicks, and slack voiced stops are typological features that are phonation based. They suggest that lateral affricates and fricatives could also be a typological feature that characterizes the 'South (of Africa)' as a phonological zone, where Khoisan and Southern Bantu languages are included. Naumann and Bibiko (2015) further investigate typological features that delineate the phonological zone from others and claim that lateral obstruents can be regarded as a typological feature that specifically defines Southeastern Bantu languages rather than 'South' as a phonological zone in general. Their claims are based on extensive data from the 'South' languages including three families of Khoisan languages (i.e., Khoe-Kwadi, Kx'a, and Tuu) and Bantu languages spoken in the geographical region (K10, K30, K40, R20, R30, R40, and all groups of Zone S), as well as other exemplary languages with various phylogenetic profiles spoken in Sub-equatorial Africa.

1.2. Structure of this paper

The goal of this paper is comparing acoustics of lateral fricatives in five Southern Bantu languages: Xitsonga [S53], Siswati [S43], S. Ndebele [S407], N. Sotho [S32], and Sesotho [S33]. In section 2, a cross-linguistic overview demonstrates that acoustic parameters used to measure the lateral fricatives are frication duration and four spectral moments (M1: center of gravity, M2: standard deviation, M3: skewness, M4: kurtosis). Previous studies on southern Bantu languages have only described the lateral fricative in Zulu [S42], a Nguni language that is not ana-

lyzed in this paper. Section 3 provides a summary of data analyzed in this paper, and reports results of the lateral fricatives. Lateral fricatives in Siswati display differences with other lateral fricatives. As such, we further analyze the patterns in Siswati and S. Ndebele, both of which are Nguni languages, but with a different series of fricatives. The following section 4 offers discussion points concerning the lateral fricatives in the Bantu context, both phonetically and diachronically. Section 5 concludes the paper with additional notes for further research and future perspectives.

2. Phonetic studies of lateral fricatives: a cross-linguistic overview

Lateral fricatives are reported in multiple languages, but not always with phonetic studies. For example, in the Chad basin area, Kraft (1971: 272) reports that lateral fricatives are observed in West Chadic languages including Ngizim, Karekare, Maha (Maaka), Geji/Gezawa, Buli, Dirya/Diryawa (Diri), Seya/Seyawa (Saya), Dwot (Dos), Palci (Polci), Miya/Miyawa, and Burma. He proposes that lateral fricatives are historically reconstructed as *s or *tl (see also Newman (1977) for further arguments). Lateral fricatives are also reported in languages of the Americas such as Nuuchahnulth, a Wakashan language, (Carlson, Esling and Fraser 2001) and Jicarilla Apache, an Athabaskan language (Tuttle and Sandoval 2002).

Phonologically, lateral fricatives do not always have a voiced non-fricative pair /l/ as it is the case in Nivaĉle (Gutiérrez 2019: 404), which presents a marked example of having a lateral fricative /ɬ/ and the complex lateral segment /kl/ in the absence of the sonorant lateral /l/. Lateral fricatives have contrastive aspiration in a Xinzhai variety of Hmu (Liu *et al.* 2020: 243, 246, 248), which has a lateral fricative and an aspirated lateral fricative in addition to a lateral approximant: [la^{11}] 'vegetable garden', [ɬa^{11}] 'rich', and [ɬ^{h}a^{11}] 'to cut'. The aspirated voiceless lateral fricative has an aspiration that follows the frication noise, similar to the aspirated fricative [s^{h}] in Korean (Cho, Jun and Ladefoged 2002) as well as Burmese and Jinghpaw (Kurabe and Lee 2024).

The UCLA Phonological Segment Inventory Database (UPSID, Maddieson 1984) is a useful tool to survey sound patterns. Using UPSID, Maddieson (1980) surveys patterns of liquids from 321 languages, in which 9% of them (n = 36) have a voiceless lateral fricative. A follow-up cross-linguistic study (Maddieson and Emmorey 1984) reports acoustic measurements of lateral fricatives from 27 speakers of five languages: Zulu (n = 3), Navajo (n = 9), Taishan Chinese (n = 8), Burmese (n = 4) and Tibetan (n = 3). The general tendency of the realizations in these languages includes the following features: the onset of the voicing is delayed, the amplitude is higher, and the energy at higher frequencies are greater in voiceless lateral fricatives compared to voiceless lateral approximants. The Navajo lateral fricatives show similar amplitude to the following vowel.

The presence of anticipatory voicing is not required. Holton (2001) reports that lateral fricatives ("fortis lateral fricatives" by Holton), do not have any voicing portion (p. 406) in Tanacross Athapaskan. Schötz *et al.* (2014) compares the duration measurements of lateral fricative [ɬ] and [s] in Estonian Swedish, in which they

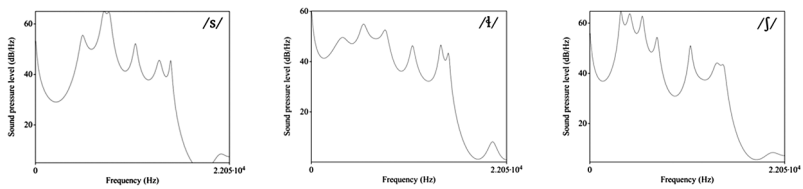
found that the lateral fricative has a similar duration as [s], but has an anticipatory voicing at the offset of the fricative.

Welsh is a better studied language concerning the phonetics of lateral fricatives; examples are shown in Table 1. The initial and medial [ɬ] are both twice as long as [l], and it has no anticipatory voicing. The [ɬ] has a higher F2, and noise concentration in the range of 5000–7000 Hz.

Table 1 Welsh laterals (from Thomas 1992)

Voiceless fricative		Voiced approximant		Voiceless approximant	
ɬond	'full'	loːn	'road'	t̥luːs	'pretty'
miɬdir	'mile'	xwiɬdro	'revolution'	k̥l̥iːst	'ear'

In detailed study on Northern Welsh (Bell *et al.* 2023), lateral fricatives freely occur in various positions in a word. Bell *et al.* (2023: 495) present that spectral energy is lower in the lateral fricative than in sibilants /s/ or /ʃ/. An earlier study by Jones and Nolan (2007: 874–875) reports that lateral fricatives are shorter in duration than other fricatives, contra Thomas (1992), and the lateral fricatives have high center of gravity. The LPC spectra comparing the three fricatives are shown in Figure 3, taken from Bell *et al.* (2023).

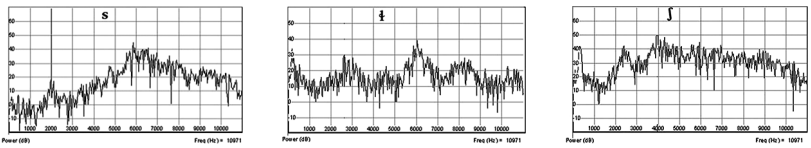


a. alveolar fricative [s] b. lateral fricative [ɬ] c. palatal fricative [ʃ]

Figure 3 LPC spectra of three fricatives in Northern Welsh: (a) alveolar fricative [s], (b) lateral fricative [ɬ], and (c) palatal fricative [ʃ] (Bell *et al.* 2023)

In Mecapalapa Tepehua (Zendejas 2023: 289, 294), lateral fricatives can appear in both onset and coda positions: [ɬi] 'in the morning' and [ʃiɬ] 'mucus'. The FFT spectra of the three fricatives in Mecapalapa Tepehua display that [ɬ] has a more diffused spectra with double peak around 2800 Hz and 6000 Hz as in Figure 4, and it has lower center of gravity (cog) than [ʃ] and [s].

Phonetic studies of lateral fricatives in Bantu languages seem to have been limited to Zulu. Maddieson and Emmorey (1984) include lateral fricatives produced by three Zulu speakers. Zulu has five lateral consonants [ɬ, tɬ, ɮ, l, k̥l̥] (Ladefoged and Maddieson 1996: 204–206) as shown in Table 2.



a. alveolar fricative [s]
mean cog (n= 20)
female 6150 Hz
male 5959 Hz

b. lateral fricative [ɬ]
mean cog (n= 20)
female 5359 Hz
male 5052 Hz

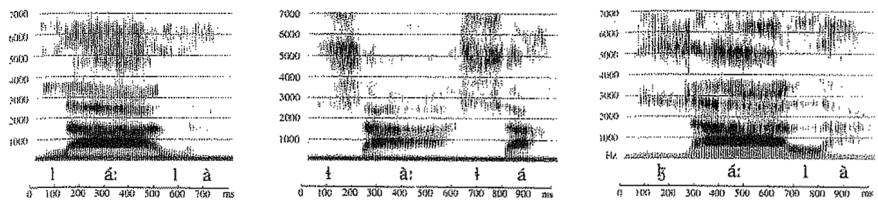
c. palatal fricative []
mean cog (n=20)
female 5588 Hz
male 5506 Hz

Figure 4 FFT spectra of three fricatives in Mecapala Tepehua (Zendejas 2023)

Table 2 Lateral consonant types in Zulu (Ladefoged and Maddieson 1996: 204–206)

	Voiceless		Voiced	
Alveolar proximant			lálà	'lie down'
Alveolar fricative	ɬàɬá	'cut off'	ɮálà	'play'
Alveolar affricate	íntl͡ànt͡ɬà	'good fortune'		
Velar ejective affricate	kǐ̯'ájà	'push in between'		
Alveolar click	k‖ók‖a	'narrate'	g‖álá	'stride'

The three laterals have less energy in the region below 2000 Hz as shown in Figure 5. The voiced [ɮ] in (c) has a lower amplitude in voicing than [l] in (a), and lacks strong low frequency, typical in voicing. The lateral fricative [ɬ] in (b) is voicelesss but it has energy distribution in the 4000–5000 Hz frequencies, which is absent in the two voiced laterals.



(a) alveolar approximant [l] (b) voiceless alveolar fricative [ɬ] (c) voiced alveolar fricative [ɮ]

Figure 5 Spectrograms of three Zulu laterals (Ladefoged and Maddieson 1996)

A detailed study of fricatives in Francoprovençal (Nendaz) (Chong and Kasstan 2023) includes an acoustic study of lateral fricatives [ɬ] along with other three fricatives [f], [s], and [ʃ]. The lateral fricatives are produced with double articulation [ɬ͡ɬ] and the center of gravity is between [s] and [ʃ]. The skewness values are lower in the lateral fricative than in [ʃ], suggesting that more energy in the higher frequencies. The kurtosis value is also lower in the lateral fricative, indicating a more diffused distribution of spectral energy (p. 907). The total duration of the lateral fricative is longer than other fricatives in Francoprovençal (p. 908). Gordon *et al.* (2002: 143) suggest that center of gravity, spectra and formant transition may

distinguish voiceless fricatives, but hints that duration may not be a good predictor of distinguishing them, but Francoprovençal demonstrates that duration could also be an indicator of lateral fricatives.

3. Lateral fricatives in Southern Bantu languages

3.1. Data

Data in this paper comes from fieldwork between December 2022 to March 2024 in various parts of South Africa (JSAntu grant: https://sites.google.com/view/jsantuproject/home). Words with [ɬ] 'hl' are taken from the Swadesh list recordings of five languages (n = 2525). All languages have recordings from at least eight speakers. A summary of number of speakers, items and tokens is shown in Table 3.

Table 3 Voiceless lateral consonant in five Southern Bantu languages

Language	speakers	items	tokens	Avg token per item
Northern Sotho [S32]	8	14	438	31.3
Sesotho [S33]	9	10	358	35.8
Xitsonga [S53]	10	14	303	21.6
Southehrn Ndebele [S407]	12	19	886	46.6
Siswati [S43]	8	16	540	33.8
Total	47		2525	

As shown in the Appendix, in the referential system based on Guthrie (1967–71) and later updated by Maho (2009) and Hammarström (2019), Northern Sotho (Sepedi) [S32; nso] and Sesotho [S33; sot] are classified into the Sotho-Tswana language group. Both Siswati [S43; ssw] and Southern Ndebele [S407; nde] are Nguni languages, and Xitsonga [S53; tso] is part of the Tswa-Rhonga group. Except for Sesotho, the other four languages are mainly spoken in the provinces of Limpopo and Mpumalanga. Sesotho is spoken in the Free State, and also in the kingdom of Lesotho. Siswati is spoken in Mpumalanga and in eSwatini. All of these languages have an established orthography, and participants were comfortable with producing stimuli written in their own orthography.

3.2. Annotation and Analysis

3.2.1. Annotation

The target consonant [ɬ] and its surrounding vowels were manually annotated using a Praat script that automatically saved any changes upon advancing (or retracting) to the next recording. An example of the annotation is shown in Figure 6.

3.2.2. Data processing

Using a Praat script (DiCanio 2021), the first four spectral moments from fricative spectra were extracted. The script calculated the discrete Fourier transforms (DFTs) and averaged them using a time-averaging method (Shadle 2012). This method takes a number of DFTs across the duration of the fricative, which are

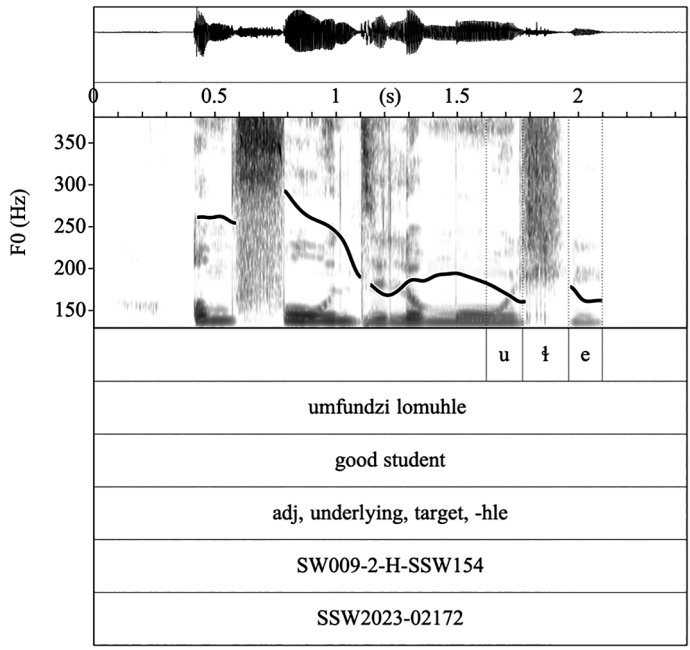


Figure 6 A Siswati example of annotated voiceless lateral fricative

then averaged for each token from which the spectral moments are calculated. The script cuts off the transition between the fricative and the surrounding vowels, resulting in obtaining the measures from the center 80% of the total duration of the fricative.

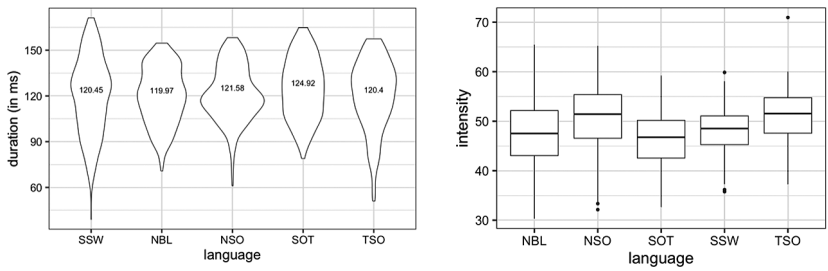
In addition to duration and intensity measure, the four spectral moments are used to identify properties of fricatives (Forrest *et al.* 1988). The center of gravity (cog) is a mean value of the energy of the spectra, and standard deviation (sdev) is the value around the cog. Skewness (skew) indicates the distribution of energy over frequencies. If skewness is positive, the energy is larger in lower frequencies. A negative value of skewness indicates that the energy is largely distributed in higher frequencies. Spectra with similar center of gravity and skewness can still differ in kurtosis, which indicates how diffused peaks are. Higher kurtosis value displays a prominent peak, whereas lower kurtosis value indicates spectra being diffused with no discernable peaks. These measures are frequently used in studies introduced in section 2 for identifying similarities and differences between the fricatives.

The frication noise of lateral fricatives is analyzed with these four spectral moments. No acoustic difference is found between the lateral fricative of word-initial and word-medial positions; thus, this paper does not consider the positional effects. The rest of this section reports results of acoustic analyses of lateral fricatives in five Southern Bantu languages.

3.3. Results comparing five languages

3.3.1. Duration and intensity

The results of duration and intensity of the frication noise are shown in Figure 7. After excluding outliers (n = 372) that exceed the value of the standard deviation plus mean in each language, 2153 tokens were included in the final analysis: Southern Ndebele (n = 752), Northern Sotho (n = 380), Sesotho (n = 299), Siswati (n = 463), and Xitsonga (n = 259). The average of duration in all languages is about 121 ms; the duration of lateral fricatives in the five languages does not differ from one another. A linear mixed effect model with languages as a fixed effect with the Siswati as the baseline language does not show significant difference.



a. Duration (in sec) b. Intensity (in dB)

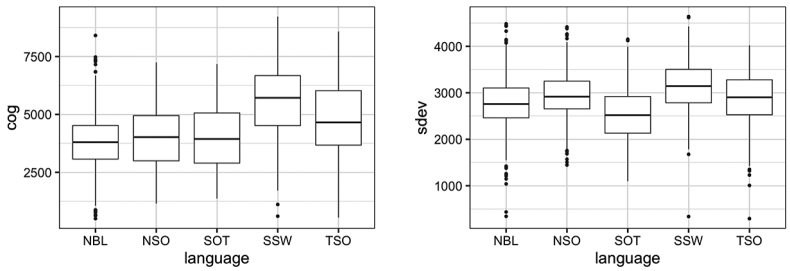
Figure 7 Duration and Intensity of the lateral fricatives. The number in (a) displays the mean duration of lateral fricatives in each language

The intensity of all the fricatives in Figure 7b show the median as 48.41 dB and mean as 48.12 dB. Even though the recording conditions were not identical across languages, the head-worn microphone (Shure WH-30XLR) used in the recording sessions in South Africa enabled the creation of a recording condition where the intensity is recorded with consistency. A linear mixed effect model with languages as a fixed effect showed no difference in the intensity.

3.3.2. Spectral moments

This section reports the results of the four spectral moments of the lateral fricatives in the five languages. The center of gravity (cog, M1) indicates the concentration of the energy band within the spectra of the fricative noise. See Figure 8a that compares the cog in the five languages. Relatively higher cog indicates that a fricative is produced in the front part of the oral cavity, whereas fricatives produced in the back of the oral cavity have relatively lower cog; the alveolar fricative [s] has higher cog than the palatal fricative [ʃ]. The median value across all the lateral fricatives is 4283 Hz and mean is 4403 Hz. A liner mixed model with languages as a fixed effect showed that compared to Siswati the cog value is significantly lower in Southern Ndebele, Northern Sotho, Sesotho and Tsonga. Standard deviation (M2) results in Figure 8b present the median 2844.7, and the mean 2856.7. A linear mixed effect model indicates that standard deviation is significantly higher in

Siswati compared to Southern Ndebele, Sesotho and Tsonga ($p < 0.01$).



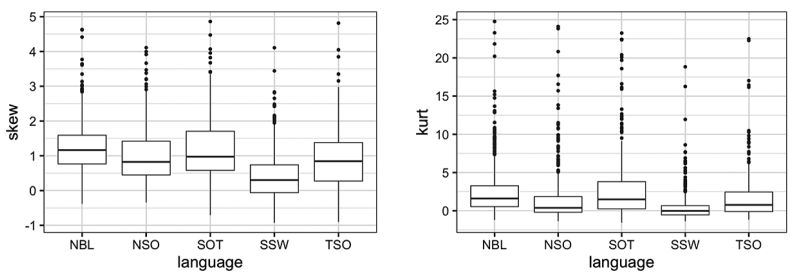
a. Center of Gravity (cog, in Hz) b. Standard deviation

Figure 8 (a) Centre of gravity (M1) and (b) standard deviation (M2) of the lateral fricatives

Skewness (M3) is a measure that indicates whether spectra have energy concentration in the higher frequencies or in the lower frequencies. Small number of outliers (n = 10) are removed. The median is 0.85 and the mean is 0.95. A fitted linear mixed effect model shows that skewness is significantly lower in Siswati than in S. Ndebele, N. Sotho, Sesotho and Tsonga ($p < 0.01$) as demonstrated in Figure 9(a). This means that spectra of lateral fricatives tend to be negatively skewed in Siswati with more energy distributed across lower frequencies.

The kurtosis (M4) measurements had 13 outliers that had kurtosis value of more than 30. After excluding these tokens, the median is 0.82 and the mean of all tokens is 1.76. Higher kurtosis values indicate a peak in the spectra, but lower kurtosis demonstrates that spectra show diffusion.

The trend in higher kurtosis results indicates the energy distribution in a spectrum has a spectral peak, indicating that spectra have non-prominence across the frequencies. A linear mixed effect model shows that Southern Ndebele, Sesotho and Xitsonga have a significantly higher kurtosis value as indicated in Figure 9(b). This suggests that they have less diffused peak ($p < 0.01$) compared to the spectra in Siswati, which have a more diffused peak.



a. Skewness b. Kurtosis

Figure 9 (a) Skewness (M3) and (b) kurtosis (M4) of the lateral fricatives

3.3.3. Interim Summary

Compared to other languages, the lateral fricative [ɬ] in Siswati has lower cog and standard deviation, and higher skewness and kurtosis. The [ɬ] in the other four languages (S. Ndebele, Sesotho, Xitsonga and N. Sotho) does not show much difference amongst themselves. Compared to Siswati, center of gravity and standard deviation are significantly lower in the other languages, and skewness and kurtosis are significantly higher in the languages. This finding is intriguing because differences in the acoustics of lateral fricatives are not directly expected.

3.4. Two Nguni languages: Siswati and S. Ndebele

In this section, we focus on the lateral fricative in the two Nguni languages: SiSwati [S43; SSW] and Southern Ndebele [S407; NBL]. Both languages are spoken in and around the Mpumalanga Province in South Africa. The reason why the lateral fricatives in these two languages have different acoustic features is intriguing. When only the tokens in Siswati (n = 540) and S. Ndebele (n = 886) are compared, the duration difference of 5 ms is not linguistically meaningful (statistically significant, however, $t(847.61) = 2.38$ $p < 0.05$), see Figure 10a. The intensity of the lateral fricatives is not different in the two languages (Figure 10b).

The four spectral moments behave in opposite directions in the two languages (Figure 10c–f). S. Ndebele shows positive skewness, meaning that lower frequencies have larger amplitude. S. Ndebele also has larger kurtosis, suggesting the spectra is less diffused. Siswati, on the other hand, has higher cog and standard deviation, but shows less positive skewness, less kurtosis (with more diffusion of the spectra).

The higher center of gravity (cog) in Siswati suggests that the lateral fricative [ɬ] may be articulated closer to the alveolar region, whereas [ɬ] is produced toward the palatal in S. Ndebele and the other three languages. Future ultrasound studies may reveal the differences in the tongue placement. In the absence of articulatory data for lateral fricatives, we examined the fricatives in the two languages.

The fricative inventories of Siswati and S. Ndebele are similar as shown in Table 4, but the lateral fricative in Siswati is placed between the alveolar [s] and the palatal fricative [ʃ], whereas the lateral fricative of S. Ndebele is articulated between the alveolar [s] and the velar [x]. S. Ndebele has more room for variation or to be pronounced distinctively because the palatal region is not as crowded as in Siswati.

Table 4 Fricative inventory with sounds under discussion highlighted

Language	labio-dental		alveolar		lateral		palatal		velar		glottal	
Siswati	f	v	s	z	ɬ	-	ʃ	ʒ	-	-	h	ɦ
S. Ndebele	f	v	s	z	ɬ	ɮ	-	-	x	-	-	ɦ

To test the hypothesis put forward in the previous section, this section analyzes frication noise of [s], [ʃ], and [x] in Siswati and S. Ndebele. A sample of two items from each sound were selected for this comparison. Siswati items were ***s**andla* and *ngiya**s**aba* for [s], and *ngiya**sh**a* and *nigya**sh**ayana* for [ʃ]. The items in S. Ndebele

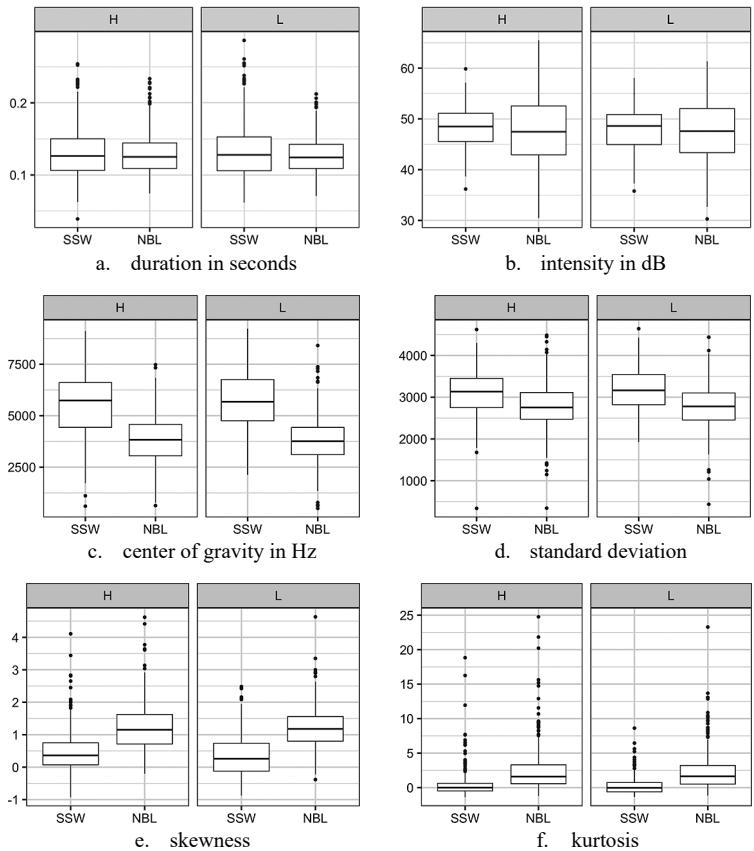


Figure 10 Comparing Siswati and S. Ndebele in various acoustic measures by tonal contexts (H and L): (a) duration of the frication noise, (b) intensity, (c) center of gravity (M1), (d) standard deviation (M2), (e) skewness (M3), and (f) kurtosis (M4)

were *ngiya**s**aba* and *e**s**arulana* for [s] and *i**rh**waba* and *ngiya**rh**uhla* for [x]. Table 5 shows the number of tokens analyzed for this section. The fricatives were manually annotated using Praat, and the spectral moments were extracted using DiCanio (2021).

Table 5 Voiceless fricatives in S. Ndebele and Siswati analyzed

Language	speakers	Tokens		
		[s]	[ʃ]	[x]
Soutehrn Ndebele	12	96	-	96
Siswati	8	64	64	-

The results in Figure 11a demonstrate that alveolar fricative [s] in both Siswati and S. Ndebele have higher center of gravity and lower skewness than the other

two fricatives. The palatal fricative [ʃ] in Siswati shows higher center of gravity than [x] in S. Ndebele. The skewness values in Figure 11b are lower in [s] than in [ʃ] and [x]. In all plots, lateral fricatives show values that are placed between the alveolar fricative and the palatal or velar fricatives.

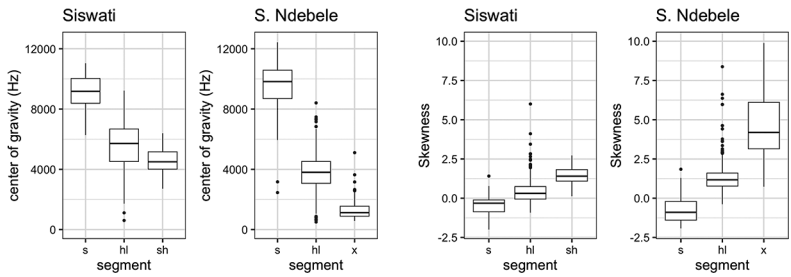


Figure 11 (a) Center of gravity (M1) and (b) skewness (M3) of voiceless fricatives in Siswati and Southern Ndebele

In Figure 11a, it is observed that the center of gravity in lateral fricatives is produced closer to the following fricatives rather than being placed symmetrically between [s] and the other fricatives. This tendency of being produced closer to the sibilants that are produced in the back of the oral cavity is unexpected but it also raises interesting questions. Exploring whether the reasons for this tendency is due to the perceptibility of these sounds or due to the articulatory easiness is beyond the scope of this paper, but it opens an interesting question regarding the acoustic parameters concerning voiceless fricative series in a given language.

4. Discussion: Lateral fricatives

4.1. Phonetics of lateral fricatives

Lateral fricatives are produced with a frication noise, but this study has shown that acoustics of lateral fricatives are not always identical even in languages that are neighboring one another. What has been described commonly as lateral fricatives may need to be distinguished between voiceless lateral fricatives and voiceless lateral approximants (Maddieson and Emmorey 1984); Zulu and Navajo have voiceless lateral fricatives, whereas Taishan Chinese, Burmese and Tibetan have voiceless lateral approximants. Lateral fricatives may be realized with a short or long lateral release with anticipatory voicing. Phonotacticallly, lateral fricatives have positional restrictions in some languages, but no restriction in other language (Mecapalapa Tepehua, Zendejas 2023). Lateral fricatives can also be further aspirated as in Hmu in Liu *et al.* (2020).

A comparison of the phonetics of lateral fricatives in five Southern Bantu languages demonstrates that there is a common acoustic target for lateral fricatives in four languages, to the exclusion of Siswati. As shown in previous studies, lateral fricatives have lower center of gravity with spectra energy diffused across multiple

frequencies. Siswati was an exception to that (see section 3.3), suggesting that some languages produce lateral fricatives with a different target, which we further analyzed by comparing lateral fricatives in Siwati and those in S. Ndebele; the distribution of fricatives in the fricative inventory may be responsible for producing a different acoustic target.

4.2. Diachrony of lateral fricatives

As mentioned earlier, recent studies propose a hypothesis about the developmental process of the lateral fricatives and its chronology mapping onto the phylogeny of the Zone S languages. Based on the extensive survey on the distribution of lateral obstruents, Gunnink and van der Vlugt (2024) provide a hypothetical chronology of emergence and development of lateral obstruents in Southern Bantu, mapping onto the the latest phylogenic tree proposed by Gunnink *et al.* (2023). Figure 12 is a simplified diagram based on the hypothesis.

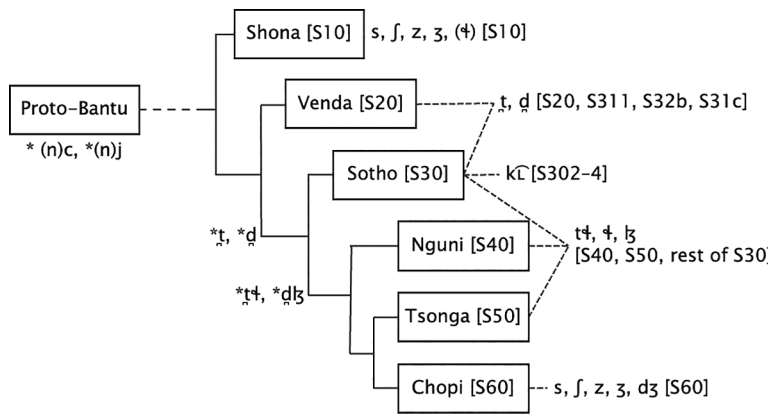


Figure 12 A diachrony of the development of lateral fricatives in Southern Bantu mapping onto a hypothetical chronology of phylogenetic branching based on Gunnink *et al.* (2023) and Gunnink and van der Vlugt (2024)

Of a special interest here is the wide distribution of the alveolar lateral obstruents /tɬ/, /ɬ/, and /ɮ/ spreading over Nguni [S40], Tsonga (= Tswa-Rhonga) [S50], and Sotho-Tswana [S30] to the exclusion of the outliers of the last group, such as East Sotho [S302–304] where velar lateral /kʟ/ is a regular reflex of *c and *j, as well as a few other Sotho languages including Kgalagadi [S311], Lobedu [S32b], and Tawana (North Tswana) [S31c], all of which make use of dental stops /t̪/, /d̪/ as reflexes of Proto-Bantu *c and *j as in the case of Venda [S20] (Gunnink *et al.* 2023: 93). Given this phonologically heterogenous situation in Sotho-Tswana languages, it may be worth pointing out that variation of the phonetic realizations of the lateral obstruents between Northern Sotho and Sesotho in our sample is not so salient than the variation we find between the two Sotho languages and those from other groups. In contrast, at least the phonetic measurement presented in this

study, especially the value of cog that is supposedly associated with the place of articulation feature, shows more salient contrast between S. Ndebele and Siswati, both of which are classified into the same phylogenetic branch where lateral obstruents stably occur as the regular reflexes of Proto-Bantu *c, and *j.

On the other hand, it is also important to further investigate the group-internal variation in Sotho especially between the languages with both alveolar and velar laterals, i.e., East Sotho varieties [S302–304] and the rest of the languages that do not have /kʟ/ in their phonemic inventory. Detailed examinations about acoustic contrasts of the lateral obstruents in these languages may provide an empirical basis for substantial investigations into the diversification process within the group. On the other hand, group-external comparison of phonetic details of the lateral obstruents observed in each phylogenetic group will provide us with substantial evidence about articulatory, acoustic, and perceptual factors that might have motivated the emergence and development of this uncommon segments in Bantu phonology.

5. Conclusion

This paper has analyzed lateral fricatives in five Southern Bantu languages. Although the lateral fricatives are impressionistically perceived as identical sounds (with identical orthography *hl*), acoustic measurements comparing the fricatives showed that the lateral fricative in Siswati is not acoustically identical to the lateral fricatives in other four languages; Siswati has a higher center of gravity and lower skewness than the other languages. This difference was somewhat unexpected. We compared acoustic characteristics of voiceless fricatives in Siswati with one of the closest languages, Southern Ndebele. Lateral fricatives in Siswati are surrounded by [s] and [ʃ], while the lateral fricative in Southern Ndebele is placed between [s] and [x], which provides a wider acoustic space for the lateral fricative. An analysis suggests that the difference in the fricative inventory may be the source of the difference in the phonetic realization of lateral fricatives in Siswati.

Future studies need to investigate why the lateral fricative in Xitsonga and Northern Sotho does not pattern together with Siswati, since both languages also have the palatal fricative [ʃ]. It could be that the acoustic space of Xitsonga and Northern Sotho is wider than Siswati, which suggests that the acoustic similarities between Xitsonga, Northern Sotho, and Southern Ndebele are an artifact of the size of the acoustic space used for fricatives. We will leave this part to another paper.

References

Beer, Samuel J., Andrew Harvey, Maarten Mous, Christian J. Rapold, Terrill Schrock, and Ahmed Sosal (forthcoming) Lateral obstruents in East Africa from an areal and historical perspective: A case for contact-induced non-change. In: Jeroen Darquennes, Joseph C. Salmons, and Wim Vandenbussche (eds.) *Language Contact: An International Handbook*, 9–26. Berlin, Boston: De Gruyter Mouton.

Bell, Elise, Diana B. Archangeli, Skye J. Anderson, Michael Hammond, Peredur Webb-Davies, and Heddwen Brooks (2023) Northern Welsh. *Journal of the International Phonetic Association* 53(2): 487–510. doi.org/10.1017/S0025100321000165

Bostoen, Koen (2008) Bantu Spirantization: Morphologization, lexicalization and historical classification. *Diachronica* 25(3): 299–356. doi 10.1075/dia.25.2.02b

Carlson, Barry F. John H. Esling, and Katie Fraser (2001) Nuuchahnulth. *Journal of the International Phonetic Association* 31(2): 275–279. doi.org/10.1017/S0025100301002092

Cho, Taehong, Sun-Ah Jun, Peter Ladefoged (2002) Acoustic and aerodynamic correlates of Korean stops and fricatives. *Journal of Phonetics* 30(2): 193–228. doi.org/10.1006/jpho.2001.0153

Chong, Adam J., Jonathan R. Kasstan (2023) Acoustic characteristics of fricatives in Francoprovençal (Nendaz). *Journal of the International Phonetic Association* 53(3): 888–921. doi.org/10.1017/S0025100322000147

Clements, G. N. and Annie Rialland (2008) Africa as a phonological area. In: Bernd Heine and Derek Nurse (eds.) *A linguistic geography of Africa*, 36–85. New York: Cambridge University Press.

Demuth, Katherine (1992) Acquisition of Sesotho. In: Dan I. Slobin (ed.) *The Cross-Linguistic Study of Language Acquisition*, 557–638. Lawrence Erlbaum Associates.

DiCanio, Christian (2021) Time_averaging_for_fricatives_4.0.praat

Doke, Clement M. (1926) *The Phonetics of the Zulu Language*. Johannesburg: Witwatersrand University Press.

Doke, Clement M. (1931) *A Comparative Study in Shona Phonetics*. Johannesburg: Witwatersrand University Press.

Doke, Clement M. (1961) *Textbook of Zulu Grammar*. Cape Town: Longmans. (6th edition (1st edition 1927)).

Fortune, George (1955) *An Analytical Grammar of Shona*. London: Longmans, Green & Co.

Forrest, K., G. Weismer, P. Milenkovic, and R.N. Dougall (1988) Statistical analysis of word-initial voiceless obstruents: preliminary data. *The Journal of the Acoustical Society of America*, 84(1): 115–123.

Gordon, Matthew, Paul Barthmaier, and Kathy Sands (2002) A cross-linguistic acoustic study of voiceless fricatives. *Journal of the International Phonetic Association* 32(2): 141–174. doi.org/10.1017/S0025100302001020

Gowlett, Derek (2003) Zone S. In: Derek Nurse and Gérard Philippson (eds.) *The Bantu Languages*, 609–638. London and New York: Routledge.

Gunnink, Hilde and Nina van der Vlugt (2024) The development of lateral obstruents in Southern Bantu languages: A comparative diachronic study. Paper presented at the 10th International Conference of Bantu languages held at Dar es Salaam University College of Education on August 12–14, 2024.

Gunnink, Hilde, Natalia Chousou-Polydouri, and Koen Bostoen (2023) Divergence and contact in Southern Bantu language and population history: A new phylogeny in cross-disciplinary perspective. *Language dynamics and change* 13: 74–131. doi:10.1163/22105832-bja10022

Gutiérrez, Analía (2019) Nivaĉle (*shichaam lhavos* variety). *Journal of the International Phonetic Association* 49(3): 401–417. doi.org/10.1017/S0025100316000335

Hammarström, Harald (2019) An inventory of Bantu languages. In: Mark van de Velde, Koen Bostoen, Derek Nurse, and Gérard Philippson (eds.) *The Bantu Languages, 2nd edition*, 17–78. London and New York: Routledge.

Holton, Gary (2001) Fortis and Lenis Fricatives in Tanacross Athapaskan. *International*

Journal of American Linguistics 67(4): 396–414. doi.org/10.1086/466469
Jones, Mark J. and Francis J. Nolan (2007) An acoustic study of North Welsh Voiceless Fricatives. In: *Proceedings of ICPhS XVI*, 873–876. Saarbrücken. Retrieved from http://www.icphs2007.de/conference/Papers/1145/1145.pdf
Kraft, Charles H. (1971) A note on lateral fricatives in Chadic. *Studies in African Linguistics* 2(3): 271–281.
Kurabe, Keita and Seunghun J. Lee (2024) Phonetics of Aspirated and Tense Fricatives in Jinghpaw and Burmese. In: Lee, Seunghun J., Daisuke Shinagawa, and Keita Kurabe (eds.) *Crossroads for phonetic typology*: *Journal of Asian and African Studies, Supplement* 4, 53–67. Tokyo: Research Institute for Languages and Cultures of Asia and Africa.
Liu, Wen, You-Jing Lin, Zhenghui Yang, and Jiangping Kong (2020) Hmu (Xinzhai variety). *Journal of the International Phonetic Association* 50(2): 240–257. doi.org/10.1017/S0025100318000336
Maddieson, Ian and Karen Emmorey (1984) Is There a Valid Distinction between Voiceless Lateral Approximants and Fricatives? *Phonetica* 41(4): 181–190. doi.org/10.1159/000261725
Maddieson, Ian and Bonnie Sands (2019) The sounds of the Bantu languages. In: Mark van de Velde, Koen Bostoen, Derek Nurse, and Gérard Philippson (eds.) *The Bantu Languages, 2nd edition*, 79–127. London and New York: Routledge.
Maddieson, Ian (1980) A survey of liquids. *UCLA Working Papers in Phonetics* 50: 93–112.
Maddieson, Ian (1984) *Patterns of sounds*. Cambridge University Press.
Maho, Jouni F. (2009) NUGL Online: The online version of the New Updated Guthrie List, a referential classification of the Bantu languages. Available online at https://brill.com/fileasset/downloads_ products/35125_Bantu-New-updated-Guthrie-List.pdf
Moran, Steven, Daniel McCloy (eds.) (2019) PHOIBLE 2.0. Jena: Max Planck Institute for the Science of Human History. Available online at http://phoible.org, Accessed on 2024-09-09.
Naumann Chrisfried and Hans-Jörg Bibiko (2015) Southern Africa as a phonological area. Paper presented at the "Speaking (of) Khoisan" A symposium reviewing African prehistory at Max Planck Institute for Evolutionary Anthropology/Linguistics on May 16, 2015.
Newman, Paul (1977) Lateral fricatives ('Hlaterals') in Chadic. In: Paul Newman and Roxana Ma Newman (eds.), *Papers in Chadic linguistics*, 107–119. Leiden: Africa-Studiecentrum.
Rycroft, David K. and A. B. Ngcobo (1979) *Say It in Zulu*. London: School of Oriental and African Studies.
Schötz, Susanne, Francis Nolan, Eva Liina Asu (2014) An acoustic study of the Estonian Swedish lateral [ɬ]. In: M. Heldner (ed.), *Proceedings from Fonetik 2014*, 23–28.
Schadeberg, Thilo C. (1994–1995) Spirantization and the 7-to-5 vowel merger in Bantu. In: Mark Dominicy and Didier Demolin (eds.) *Sound Change*, 73–84. Amsterdam: John Benjamins.
Shinagawa, Daisuke and Seunghun J. Lee (2024) A Typological Overview of Lateral Fricatives in Southern Bantu Languages. In: Lee, Seunghun J., Daisuke Shinagawa, and Keita Kurabe (eds.) *Crossroads for phonetic typology*: *Journal of Asian and African Studies, Supplement* 4, 69–89. Tokyo: Research Institute for Languages and Cultures of Asia and Africa.
Tuttle, Siri G. and Merton Sandoval (2002) Jicarilla Apache. *Journal of the International Phonetic Association* 32(1): 105–112. doi.org/10.1017/S0025100302000191

van der Vlugt, Nina and Hilde Gunnink (2024) Inheritance and contact in the development of lateral obstruents in Nguni languages. ms.
Zendejas, Esther Herrera (2023) Mecapalapa Tepehua. *Journal of the International Phonetic Association* 53(1): 287–303. doi.org/10.1017/S0025100321000098

Authors' contact information
International Christian University
Seunghun J. Lee
seunghun@icu.ac.jp

[Received September 23 2024;
Accepted January 31 2025]

【要　旨】

南部バントゥ諸語5言語における無声側面摩擦音の音声学

李　　勝　勲
国際基督教大学・ヴェンダ大学

品　川　大　輔
東京外国語大学
アジア・アフリカ言語文化研究所

無声側面摩擦音 [ɬ] は，通言語的には比較的希少な言語音とされているが，南部バントゥ諸語には広く観察される。本論文は，5つの南部バントゥ諸語に見られる側面摩擦音の音響特徴について報告する。音声的な長さや強さについては言語間に実質的な差がない一方，4種類のスペクトルモーメント分析の結果，スワティ語は他の4言語に比べ加重平均は有意に高く，歪度は低いという結果が得られた。そのうえで，系統的にも地理的にも近縁なスワティ語と南ンデベレ語に焦点を当ててさらに詳細な分析を行ったところ，両言語の調音様式の違いはそれぞれの言語の音韻体系における摩擦音の位置付けの差異によるものであることが示唆された。すなわち，硬口蓋摩擦音を欠く南ンデベレ語においては側面摩擦音の調音の際により広い調音空間が許容されるのに対し，スワティ語の場合は硬口蓋摩擦音の存在が側面摩擦音の調音のための空間を制限していると見られる。

Appendix

List of the selected Zone S languages (cf. Guthrie 1967–71, Maho 2009, Hammarström 2019)

Group		Language		
code	name	code	name	ISO (639-3)
S10	Shona	S11–15≈S10	Shona	
		S11	Korekore	twl
		S12	Zezuru	sna
		S13	Manyika	mxc
		S14	Karanga	sna
		S15	Ndau	ndc
		S16	Kalanga	kck
S20	Venda	S21	Venda	ven
S30	Sotho-Tswana	S31	Tswana	tsn
		S32	Northen Sotho	nso
		S33	Southern Sotho (Sesotho)	sot
S40	Nguni	S41	Xhosa	xho
		S42	Zulu	zul
		S43	Swati	ssw
		S44	Ndebele of Zimbabwe (Sindebele)	nde
		S407	South Ndebele	nbl
S50	Tswa-Rhonga	S51	Tswa	tsc
		S53	Tsonga	tso
		S54	Rhonga	rng
S60	Chopi	S61	Chopi	cce
		S62	Tonga	toh