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「通言語的観点からみた音声類型論（2）」2024 年度第 1 回研究会（通算第 1 回目）

日時：2024 年 5 月 24 日（金）13:00–16:00
場所：304，オンライン会議室
使用言語：英語
主催：AA 研基幹研究「アジア・アフリカの言語動態の記述と記録：アジア・アフリカに生きる人々の言語・文化への深い理解を目指して」(DDDLing)

報告タイトル

1. 李勝勲（AA 研共同研究員，国際基督教大学）& 倉部慶太（AA 研所員）
“Overview of the PhonTyp, phase 2”

2. Julián VILLEGAS（AA 研共同研究員，会津大学）& 李勝勲（AA 研共同研究員，国際基督教大学）
“An initial review of the acoustic and articulatory analyses of liquids”

3. 品川大輔（AA 研所員）& 李勝勲（AA 研共同研究員，国際基督教大学）
“Preliminary observations about the phonetics of lateral fricatives in Southern Bantu”

各人によるハンドアウトは別添。

PhonTyp Phase 2
May 24, 2024 @ AA-ken, Tokyo

Overview of the PhonTyp, phase 2

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PhonTyp 1 (2021.4-2024.3)

- Publication (AA-ken Supplementary Volume)
  - Expected publication date (the end of June 2024)
- Thank you all for contributing and also reviewing!

Introduction: The Phonetic Typology (PhonTyp) Project	LEE, Seunghun J. SHINAGAWA, Daisuke KURABE, Keita
The Phonetic Realization of Aspiration in Khalkha Mongolian: The Phonetic Contrast between Aspirated and Unaspirated Consonants Preceded by an Obstruent	UETA, Naoki
Cherokee S-preaspiration at the Phonetics-phonology Interface	UCHIHARA, Hiroto
Acoustic Properties of Glottalized Consonants: A Pilot Study on the Ie Dialect of the Northern Ryukyuan Languages	AOI, Hayato
Phonetics of Aspirated and Tense Fricatives in Jinghpaw and Burmese	KURABE, Keita LEE, Seunghun J.
A Typological Overview of Lateral Fricatives in Southern Bantu Languages	SHINAGAWA, Daisuke LEE, Seunghun J.
Acoustic Characteristics of Voiced and Voiceless Nasals in Mizo	SARMAH, Priyankoo LALHMINGHLUI, Wendy
Phonetic Variation of Voiceless Nasals in Drenjongke (Bhutia)	GUILLEMOT, Céleste LEE, Seunghun J.
Acoustics of Voiceless Nasals in Angami	TERHIIJA, Viyazonuo SARMAH, Priyankoo
The Interdental Approximant in Kagayanen	YAMAMOTO, Kyosuke
A Preliminary Study of the Prosody of Zanzibar Swahili tu	ABE, Yuko LEE, Seunghun J. KAMANO, Shigeto MIYAZAKI, Kumiko
Prosody of Question Elements in Two Bantu Languages: Shingazidja and Xitsonga	PATIN, Cédric LEE, Seunghun J.
A Phonetic Typology of Laryngeal Contrasts: Data from Illustrations of the IPA	LEE, Seunghun J. SUZUKI, Michinori

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PhonTyp 2 (Overview)

- 本課題は、2021 年に始動した第１期からのテーマを継承しつつ、その対象領域を拡張する形で、アジア・アフリカの諸言語を中心とした視野から音声類型論に対してさらなる実証的貢献をもたらす。
- 今回の課題では、現代音声学において未解決の問題を多く含む流音(liquid)および母音にとくに焦点をあてる。国内外に拠点を置く17人の参加研究者によって得られた一次資料をもとに、通言語的な観点から見出される新たな知見を提供する。

- Phonetic Typology
- Topics in Phase 2
  - Year 1
    - Liquids
  - Year 2 & 3
    - Vowels
      - Phonation
      - Laryngeal vowels

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Collaborative project 1

- Cross-linguistic overview of the phonetics (and phonology) of a specific group of sounds
  - Voiceless nasals (Mizoguchi, Ueta, (Guillemot))
  - Lateral fricatives (Sarmah, Shinagawa)
  - Obstruents in Korean / Burmese (Perkins) and other Tibeto-Burman lgss
  - Automatic dection of phonation types (Villegas)
  - Retroflexes (Guillemot)
  - Labial trills (Shinagawa, Lee)
- Possible venue:
  - Language and Linguistic Compass (Kawahara)

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Collaborative Project 2

- Phonetic typology of liquids
  - Liquid survey (ongoing)
    - Languages in the Americas (Uchihara)
    - Tibeto-Burman languages (Kurabe)
    - Languages of India (Sarmah)
    - Japonic and Korean languages, Uralic languages (Morimoto)
    - Altaic languages (Ueta)
    - Austronesian languages (Yamamota)
    - Bantu languages (Patin, Shinagawa)
    - Any other languages (Lee)
- 8 chapters? (maybe a book, or a collection of overview articles?)

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Overview of liquids: Laterals

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Basics of lateral approximant [l]

- Most lateral segments are produced with an occlusion in the dental/alveolar region (Maddieson 1984a).
- Comparing [l] with [t]
  - The closure around the sides of the palate in [t] is missing in [l].
  - the tongue tip touches the similar location
  - the tongue is lower in the mouth below the front palate area before the lateral
  - jaw is more open for [l] than [t].
- Laterals can have extended contact area
  - [l̪] in Tamil (Balasubramanian 1972)
  - [l̪] in Russian (Bolla 1981)

From Ladefoged & Maddieson (1996)

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Laterals

- the largest number of contrast is four in Kaititj, Pitta-Pitta (Blake 1979), Diyari (Austin 1981), Arabana (Hercuss 1973)
  - Kaititj
    - laminal dental
    - apical alveolar
    - apical post-alveolar
    - laminal post-alveolar

Table 6.1 Words illustrating contrasting laterals in Kaititj

	Laminal dental l̪		Apical alveolar l		Apical post-alveolar ɭ		Laminal post-alveolar l̠	
Initial	l̪inp	'armpit'	lubiɹ	'thigh'	ɭaɹiŋk	'hit'	l̠ukuŋk	'light (fire)'
Medial	al̪uŋ	'burrow'	aluŋk	'chase'	aɭat	'sacred board'	al̠il̠k	'smooth'
Final	al̪bal̪	'smoke'	irmal	'fire saw'	aɭdimaɭ	'west'	kural̠	'star'

From Ladefoged & Maddieson (1996)

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Cross-linguistic realization

- Albanian (Bothorel 1969-1970)
  - a ditinction between apical dental and apical alveolar laterals.
  - only utilizing different tongue body positions
- Argol Breton, Russian, Bulgarian, Serbo-Croatian
  - Choice of tongue tip and tongue blade is uncertain
  - tongue front raising favors laminal articulation
  - tongue front lowering favors apical articulation

From Ladefoged & Maddieson (1996)

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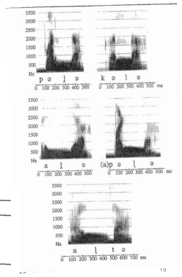
Acoustics voiced lateral approximant

Eastern Arrernte laterals

- The apical post-alveolar has a lower F1 than other laterals
- the laminal dental and palatalized retroflex has the highets F1.

Table 6.4 Formant frequencies (in Hz) of Eastern Arrernte laterals

	n	F1	F2	F3	F3–F2
Laminal dental	40	391	1811	2891	1080
Apical alveolar	75	386	1677	3162	1484
Apical post-alveolar	37	368	2132	3278	1146
Laminal post-alveolar	34	376	2324	3096	772
'Palatalized retroflex'	26	415	2282	3290	1006



From Ladefoged & Maddieson (1996)

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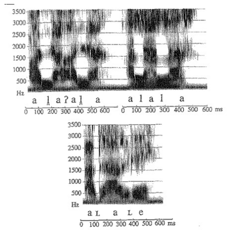
Acoustics voiced lateral approximant

Mid-Waghi

- The highest F1 is in the velar lateral.



From Ladefoged & Maddieson (1996)

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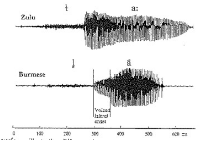
Voiceless lateral fricative vs. lateral approximant

Zulu and Burmese

- Voiceless lateral fricative (Zulu)
- Voiceless lateral approximants (Burmese)
  - a lower amplitude of noise
  - a greater tendency to anticipate the voicing of the following vowel
  - a concentration of energy lower in the spectrum

Waveforms



From Ladefoged & Maddieson (1996)

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Other laterals

Voiced laryngealized lateral

- Tiddim Chin, Nex Perce, Chemehuevi, Haida, Sedang, Klamath

Breathy voiced laterals

- Hindi
  - plain versus breathy voice laterals
  - a sequence of **lh**? (Ohala 1983)

- Montana Salish

Voiceless fricative	**ɬáqʃəlʃ**	'sit down!'
Voiced approximant	**láq'i**	'sweatbath'
Laryngealized approximant	**l̰láts**	'red raspberry'
Ejective affricate	**tɬ'áq'**	'hot'

From Ladefoged & Maddieson (1996)

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Contrast of lateral segments (L&M 1996: 212)

Table 6.14 Languages exemplifying contrasting types of lateral segments

	Voiceless affricate	Ejective affricate	Voiced fricative	Voiceless fricative	Ejective fricative	Voiced approx.	Voiceless approx.	Voiced flap
Voiced affricate	Tlingit	Tlingit		Tlingit	Tlingit			
Voiceless affricate		Tlingit	Archi	Navajo Archi	Archi	Archi		
Ejective affricate			Archi Zulu	Navajo Archi	Tlingit	Navajo		
Voiced fricative				Archi Zulu		Zulu		
Voiceless fricative					Tlingit	Navajo Zulu	****	
Ejective fricative								
Voiced approx.							Burmese	KiChaka
Voiceless approx.								

From Ladefoged & Maddieson (1996)

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Contrast in places of articulation among laterals

Table 6.15 Languages exemplifying contrasting places of articulation among lateral segments

	Dental apical 1	Dental laminal 2	Alveolar apical 3	Alveolar laminal 4	Post-alveolar apical 5	Post-alveolar laminal 6	Palatal subapical 7	Palatal laminal 8	Velar 9
Voiced approximant	Albanian	Kaititj	Albanian	Russian	Panjabi	Bulgarian	Malayalam	Italian	Mid-Waghi
Voiceless approximant			Burmese		Iaai		Toda		
Voiced flap		KiChaka			'O'odham		Tamil		
Voiceless fricative	Taishan	Kabardian	Zulu			Diegueño		Bura	Archi
Voiced fricative		Kabardian	Zulu		Ao	Pashto			Archi
Voiceless affricate			Navajo						Archi
Voiced affricate			Tlingit						
Ejective affricate		Kabardian	Navajo						Archi
Ejective fricative			Tlingit						

From Ladefoged & Maddieson (1996)

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Overview of liquids: Rhotics

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Members of the rhotic sounds

Definition	Symbol
Voiced dental or alveolar trill	r
Voiced dental or alveolar tap or flap	ɾ
Voiced dental or alveolar approximant	ɹ
Voiced post-alveolar flap	ɽ
Voiced post-alveolar approximant	ɻ
Voiced uvular trill	ʀ
Voiced uvular approximant	ʁ
Voiced dental or alveolar lateral flap	ɺ

- 75% of all languages contain a rhotic sound.
  - most of them a single /r/
  - 18% of them have 2 or 3 rhotics.
  - multiple rhotics are common in the Australian language family.

- Phonetic similarity between rhotics (Lindau 1985)
  - acoustic similarity
  - articulatorily heterogenous
    - variety of manner and place
- Phonological patterns
  - syllable structure
    - close to the nucleus in a consonant cluster
  - merger with contiguous vowels

From Ladefoged & Maddieson (1996)

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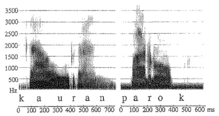
Trill



Apical trills in Finnish *kauran* 'oats (gen)' and Russian porok 'threshold'

Acoustics

- Apical trills
  - 2 to 3 periods of vibration
  - each period has a closed phase (the articulators are in contact; light area, ca. 25 ms) succeeded by an open phase (the articulators are slightly apart; dark area, ca. 25 ms)
  - Each cycle (ca. 50 ms)
    - 20 of these cycles in a ssecond
    - a frequency of vibration is 20 Hz.
  - the mean rate of vibration in Edo, Degema, Ghotuo, Kalabari, Bumo, Spanish, Swedish
    - 25 Hz (range 13-33 Hz, s.d. 4.5)

From Ladefoged & Maddieson (1996)

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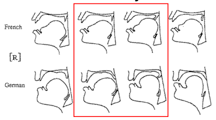
Uvular trills

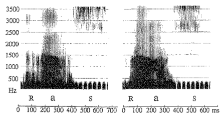
Delattre (1971)

Frames traced from x-ray films



- The second frame in each row shows retraction of the tongue.
- The third frame in each row shows backward movement of the tongue root followed by tongue body raising and fronting of the uvula.

ʀas 'bread' in Swedish



From Ladefoged & Maddieson (1996)

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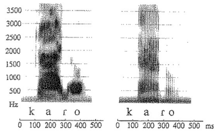
Taps and flaps

Articulation of taps and flaps

- a single short closure
- generally apical
- both are coronals

- Ladefoged (1968) proposes a distinction between the two terms.
  - a flap has a brief contact between the articulators
  - a tap is made by moving an articulator towards the roof of the mouth

Acoustics



Peninsular Spanish (female) Peru Spanish

From Ladefoged & Maddieson (1996)

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Meetings 2 & 3

Alternate start time: 12:30 pm

Meeting 2
10 am – 5 pm (Sat) Oct 5, 2024

- Presentations
  - Ai Mizoguchi
  - Priyankoo Sarmah
  - Naoki Ueta
  - Cedric Patin

- Please send me a title and a blurb (100 words) by August 15, 2024.

Meeting 3
10 am – 4 pm (Fri) Feb. 28, 2025

- Maho Morimoto
- (TBA)
- Presentations about the liquids

- Please send me a title and a blurb (100 words) by January 15, 2025.

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PhonTyp Phase 2
May 24, 2024 @ AA-ken, Tokyo

An initial review of the acoustic and articulatory analyses of liquids

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Goals

- Reviewing studies about liquids (rhotics and laterals)
  - Acoustics
  - Articulation
  - Perception
  - Statistical models
- Sources from JASA, IEEE, ACM, and Google

2

2

Target languages in liquid studies

English varieties

- American English (Alwan et al. 1997, Proctor et al. 2019, Howson & Redford 2021, Espinal et al. 2020, Narayanan et al. 1997, Harper et al. 2020)
- British English (West 1999, Nagamine 2024)
- Scottish English (Lawson et al. 2018)
- British Asian English (Kirkham & Wormald 2015)
- Australian English (Szalay et al. 2022, Szalay et al. 2021)

World languages

- Tamil (Narayanan & Byrd & Kaun 1999, Narayanan et al. 1996)
- Japanese (Nagamine 2024)
- Brazilian Portuguese (Howson et al. 2022)
- Korean (Espinal et al. 2020)
- Upper Sorbian (Howson & Kochetov 2020)
- Slovak (Beňuš 2014)
- Russian (Yang & Chen 2019)
- Mandarin Chinese (Yang & Chen 2019)
- Scottish Gaelic (Nance & Kirkham 2022)

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Articulatory studies

- Ultrasound (Kirkham & Wormald 2015, Howson et al. 2022, Lawson et al. 2018, Howson & Kochetov 2020, Nance & Kirkham 2022)
- Electropalatography (EPG) (Alwan et al. 1997, West 1999, Narayanan et al. 1997)
- Magnetic resonance imaging (MRI) (Alwan et al. 1997, Narayanan et al. 1999, Narayanan et al. 1996, Narayanan et al. 1997)
- Electromagnetic articulography (EMA) (West 1999, Szalay et al. 2022, Espinal et al. 2020)
- Palatography (Narayanan et al. 1999, Narayanan et al. 1996)
- Electromagnetic Midsagittal Articulometer (EMMA) (Narayanan et al. 1999, Narayanan et al. 1996)
- real time MRI (rtMRI) (Proctor et al. 2019, Harper et al. 2020)
- Electromagnetometer (Beňuš 2014)
- biomechanical simulations (Artisynth) (Howson et al. 2022)

- Ultrasound, EPG, MRI, EMA are commonly used to investigate the articulation of liquids.

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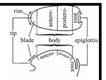
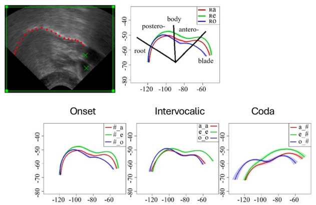
Ultrasound
(Howson & Kochetov 2020)





- Tongue retraction in the coda position

FIG. 6. (Color online) SSANOVA traces for /ʁ/ in each environment in the onset, intervocalic, and coda position for S1. The tongue tip is on the right, and the root is on the left.

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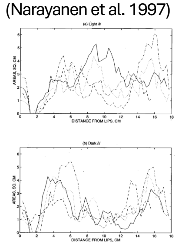
Electropalatography, EPG
(Narayanen et al. 1997)



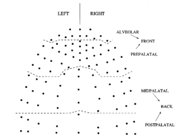


FIG. 2. Schematic of electrode placement on the pseudopalate used in electropalatography with region definitions.

- Four speakers:
  - solid AK, dashed PK, dot-dashed MI, dotted SC
- The region about
  - 1.5–2.5 cm from the lips is the alveolar region,
  - 2.5–6 cm is the palatal region,
  - 6–8.5 cm is the velar region,
  - 8.5–13 cm is the uvular and upperpharyngeal region,
  - 13–15 cm is the lower-pharyngeal region

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MRI
(Narayanen et al. 1997)

FIG. 6. A lateral (side) perspective of the 3-D vocal tract for subject MI's [l]. Small lateral channels can be seen in the region of the alveolar contact, just behind the lips. Also notice the presence of lateral channels in addition to the central airway in the oral region.

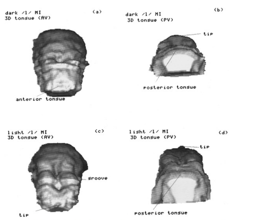

FIG. 8. The 3-D tongue shapes for the MI's dark and light lateral approximants. (a), (b) Anterior (AV) and posterior views (PV) for [ɫ]. (c), (d) Anterior and posterior views for [l].

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EMA
(lateral vocalisation, Szalay et al. 2022)

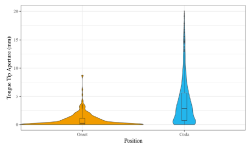

FIG. 2. (Color online) TT aperture (mm) by position. *x* axis, position. Orange, onset. Blue, coda. Greater TT aperture indicates increased degree of incomplete closure.

- Lingual articulation was tracked with TT, tongue body, tongue dorsum, and left and right lateral sensors attached to the tongue.
- Sensors were attached to the upper and lower lips to track lip aperture and lip rounding.
- One sensor was attached to the gumline elow the lower incisor to measure jaw movement.
- Reference sensors were attached to the nasion and to the left- and right mastoid to track head movement

8

Articulatory findings: Rhotics

- Tongue tip and tongue body
  - Retraction of tongue body (Alwan et al. 1997, West 1999, Beňuš 2014)
  - tongue tip raising, tongue tip constriction, no medial closure (Beňuš 2014, Narayanan et al. 1999)
  - pit-like cavity in the middle of the tongue body, more complex tongue shape (Narayanan et al. 1996)
  - Labialization (West 1999)
- Speaker variation
  - Asian speakers: an anterior constriction; Anglo speakers more posterior or retracted tongue dorsum. (Kirkham & Wormald 2015)
- Syllable position
  - onset rhotics produced with labial approximation preceding lingual gestures; no labial gesture in codas; vowels show more coarticulation; shorter intergestural lag than laterals (Proctor et al. 2019)
  - correlation between the anterior tongue gesture for the coda /r/, F3; delayed tongue gesture resulting in higher F3 (Lawson et al. 2018)
- Uvular rhotic in Sorbian
  - significant tongue root retraction and a uvular-pharyngeal tongue body constriction (Howson & Kochetov 2020)

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Articulatory findings: Laterals

- Tongue shape
  - closure and side channels in the tongue contour (Narayanan et al. 1999)
  - tongue tip raising and tong dorsum retraction (Beňuš 2014)
  - [l] in Tamil is apical (Narayanan et al. 1996)
- Speaker variation
  - Asian British English speakers: an anterior constriction; Anglo British English speakers more posterior or retracted tongue dorsum. (Kirkham & Wormald 2015)
- Syllable positions
  - onsets are initiated by tongue tip closure, followed by tongue body constriction; coda laterals are produced reversed (Proctor et al. 2019)
  - onset lateral in Brazilian Portuguese (BP) shows tongue tip constriction in the alveolar, and tongue body constriction in the back of the mouth // coda lateral in BP: lack of tongue tip gesture, retraction and raising of tongue body (Howson et al. 2022)

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Acoustic Studies

- Praat (Lawson et al. 2018, Harper et al. 2020, among others)
- Time frequency analysis software based on linear predictive coding (LPC) analysis (Espinal & Thompson & Kim 2020)
- Random forest classification (Szalay et al. 2021)
- Hierarchical cluster analysis (Szalay et al. 2021)

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Acoustic parameters: Rhotics and laterals

- Formants
  - lowered F3 (West 1999)
  - F1, F2, F3, F4 (Lawson et al. 2018)
  - higher F2 and F3 (Kirkham & Wormald 2015)
  - first three formants *(Spajić et al. 1996)*, F2 – F1 *(Iskarous & Kavitskaya 2010, Howson 2018)*, whole spectrum *analysis (Iskarous & Kavitskaya 2018)*, and SSANOVAs fitted to the first three formants *(Howson 2018)*. (Nance & Kirkham 2022)
- Nance & Kirkham 2022
  - F2 – F1 and F3 – F2 at 80% duration of the word-initial rhotics
  - F2– F1 and F3 – F2 in the vowel following word-initial rhotics at 20% duration of the vowel, and in the vowel preceding word-final rhotics at 80% duration of the vowel
- Nagamine 2024
  - (1) the distance between second (F2) and first (F1) formants (F2–F1) and (2) the third formant (F3) F2–F1 is used as a measure to evaluate acoustic liquid quality;
    - lower F2–F1 values can be related to darker realisations of liquids, resulting from a greater degree of tongue retraction. F3 is a primary acoustic dimension that distinguishes English /l/ and /r/

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Acoustic results

Rhotic

- anticipatory and perseverative coarticulation (West 1999)
- /r/ and /l/ distinction was less marked higher F3 for rhotics, higher F2 for laterals (Espinal et al. 2020)

Lateral

- anticipatory and perseverative coarticulation (West 1999); /r/ and /l/ distinction was less marked higher F3 for rhotics, higher F2 for laterals (Espinal et al. 2020)
- **lower F1 and higher F2** in British Asian speaker than Anglo speaker (Kirkham & Wormald 2015)
- **lateral vs. rhotics in F3**, only adults distinguish /l/ from rhotic with a lower F2 (Howson & Redford 2021)
- Korean L2 speakers have **longer duration, but the durational contrast between the liquids was similar** to L1 English (Espinal & Thompson & Kim 2020)
- in pre-lateral environment, **spectral properties of AusE vowels change (lowering and backing)** (Szalay et al. 2021)
- **increased F1 and decreased F2 in Vs** before /l/ codas (Szalay et al. 2021)

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Factors of variability

Rhotics

- Articulatory variable
  - oral constriction [middle part of the tongue body, or tongue tip/blade] (Alwan et al. 1997)
  - articulatory variability in Am Eng; also F3 variability (Harper et al. 2020)
  - uvular rhotic in Sorbian (Howson & Kochetov 2020)
- Sociolinguistic variable
  - ethnic groups (Kirkham & Wormald 2015)
  - social class (Lawson et al. 2018)

Laterals

- Perception
  - Individual variation in the /l/ perception (Szalay et al. 2022)
- Articulation
  - Variability in midsagittal tongue contours (Narayanan et al. 1997)

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Perception studies

- Perception tasks
  - forward-gated audiovisual speech prediction task (Howson & Redford 2021)
  - forced choice listening task (Lawson et al. 2018)
  - perceptual assimilation task (PAT) identification+ similarity rating (Yang & Chen 2019)
  - perceptual discrimination task (PDT) AX paradigm, same or different (Yang & Chen 2019)
- Results
  - variation in perceiving lateral vocalization (Szalay et al. 2022)

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Statistical methods

- Linear Mixed Effect Models
- Generalized Additive Model (GAMM) for ultrasound data (Nance & Kirkham 2022)
- Principle Component Analysis (PCA) for ultrasound data (Nance & Kirkham 2022)
- Vocal Tract Normalization (Howson & Redford 2021)
- Static formant values were normalized for vocalic tract length, using **a modified bark difference metric** (Syrdal & Gopal, 1986).
- Formants were f**irst converted to the perceptual bark scale** using the Kendall and Thomas (2018) vowels package in R (R Core Team, 2019).
- Normalized F1 and F2 values were then calculated by **subtracting the bark-transformed F1 (= Z1) and F2 (= Z2) values from the bark-transformed F3 (= Z3) values.**
- Interpretation
  - low normalized F1 values for open vocal tract configurations
  - high normalized F1 values for more closed con- figurations.
  - low normalized F2 values indicate a more anterior constriction than higher normalized F2 values.
  - Normalized F2–F1 values were also calculated by subtracting (Z3–Z2) from (Z3–Z1) because it correlates with retraction of the tongue dorsum/root (Sproat & Fujimura, 1993).

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Conclusion

- Reviewed the cross-linguistic realization of liquids (Ladefoged & Maddieson 1996)
- Articulatory results show variabilities in syllable-internal positions as well as language-specific variation.
- Acoustic results mainly report the change in formant values preceding or following liquids (laterals and rhotics).
- Other work will be reviewed in coming months.
  - JIPA, JPhon, Phonetica, ICPhS etc.

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PhonTyp Phase 2
15:00-16:00, May 24, 2024 @ AA-ken, Tokyo

Preliminary observations about the phonetics of lateral fricatives in Southern Bantu

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1

Goals

- Contextualizing the typology of lateral fricatives in Southern Bantu languages
- Providing phonetic details of the lateral fricatives of seven Southern Bantu languages collected through our field research
- Exploring their cross-linguistic (and intra-linguistic) variation from phonetic typological points of view

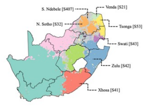
2

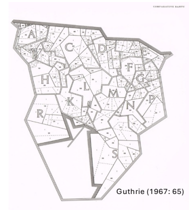
2

Typological overview of Lateral Fricatives in Southern Bantu

Target languages of this study

- Niger-Congo
  - Atlantic-Congo
    - …
      - Benue-Congo
        - Bantu
          - Eastern Bantu
            - Zone S
              - N. Sotho [S32]
              - S. Sotho/ Sesotho [S33]
              - S. Ndsebele [S407]
              - Xhosa [S41]
              - Zulu [S42]
              - Swati [S43]
              - Tsonga [S53]





Guthrie (1967: 65)

3

Typological overview of Lateral Fricatives in Southern Bantu

Phylogenegtic features of Zone S languages (cf. Grollemund et al. 2015)

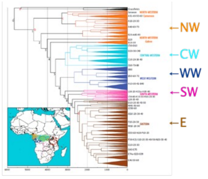


Fig 1. Consensus time tree of n=424 Bantu languages

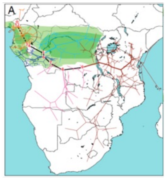


Fig 2. Ancestral migration route reconstructed on the consensus time tree (Fig 1)

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Typological overview of Lateral Fricatives in Southern Bantu

Fricatives in Bantu (Shinagawa and Lee 2022)

		GFB	A43	A44	A53	A83	B30	C101	D25	D32	E60	JE17	JE25	P13	P21	P23	P31	R11	R22	R41	K43	K34b	K33	K31	K14	R31	S61	S41		
labial	bilabial						β			ɸ												β	β	β					6	25
	labioden	f, (v)		f	f, v	f, v	f		(f, v)		f, (v)	f, v	f		(f)		v	f, v	f, v	f, v	f, v	f, v	f, v	f	f, v	v	f	f, v	24	
oronal	dental																		θ, ð		θ, ð					θ, ð			3	26
	alveolar	s, (z)	s	s	s, z	s, z	s	s	s, z	s	s, (z)	s, z	s	(s)	s	s	s	s	s, z	s, z			s	s, z	s, z		s, sw̄, r̥	s, z	24	
	palatoalv	(ʃ, ʒ)				ʃ, ʒ			(ʃ)		ʃ		(ʃ)			(ʃ)	ʃ	ʃ	ʃ, (ʒ)	ʃ, ʒ	ʃ	ʃ	ʃ	ʃ	ʃ, ʒ		(ʃ)	ʃ	17	
	lateral																										(ɬ)	ɬ, ɮ	2	
orsal	velar	(ɣ)		x			ɣ												x, ɣ		ɣ	ɣ						x, ɣ	7	7
lottal	glottal		h	h		h		h			h					h	h		h	h	h	h	h		h		ɦ	h, ɦ	15	15

SW (Zones K&R) — SE (Zone S)

- Many of the Bantu languages (esp. NW, CW, CE) have a rather simple system of fricatives, typically **labial and coronal fricatives** with or without voice contrast
- From a geographical viewpoint, **Southern languages tend to develop a rich system** of fricatives

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5

Typological overview of Lateral Fricatives in Southern Bantu

Tentative typological generalisation (Shinagawa and Lee 2023)

1. A language that has a voiced lateral fricatives in its phonemic inventory, it must also have a voiceless lateral fricatives and not vice versa.
2. In all languages that allow both lateral fricatives, a voiceless lateral fricatives occurs more frequently than a voiced counterpart.
3. In some languages, there is a positional restriction that a voiceless lateral fricatives does not occur in a post-nasal position.
4. In all languages that allow both lateral fricatives, voiced lateral fricatives show preference to occur in post-nasal positions.

Distribution of the voice and voiceless lateral fricatives in different phonological environments

	[ɬ]			[ɮ]		
	#R[	V_V	N_	#R[	V_V	N_
Venda [S21]	0.00	0.00	0.00	0.00	0.00	0.00
N. Sotho [S32]	0.53	0.47	0.00	0.00	0.00	0.00
S. Ndebele [S407]	0.46	0.18	0.00	0.04	0.14	0.18
Xhosa [S41]	0.20	0.40	0.00	0.07	0.07	0.27
Zulu [S42]	0.22	0.33	0.11	0.11	0.06	0.17
Swati [S43]	0.28	0.17	0.17	0.11	0.06	0.22
Tsonga [S53]	0.42	0.26	0.16	0.05	N/A	0.11

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Typological overview of Lateral Fricatives in Southern Bantu

Tentative typological generalisation (Shinagawa and Lee 2023)

If a language has a phonemic voiced lateral fricative, it also has a voiceless counterpart.

no LF	> /ɬ/	> /ɬ, ɮ/
Venda [S21] (Tswana [S31])	N.Sotho [S32] (Copi [S61])	S. Ndebele [S407], Xhosa [S41], Zulu [S42], Swati [S43], Tsonga [S53]

	[ɬ]			[ɮ]		
	#R[	V_V	N_	#R[	V_V	N_
Venda [S21]	0.00	0.00	0.00	0.00	0.00	0.00
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Typological overview of Lateral Fricatives in Southern Bantu

Tentative typological generalisation (Shinagawa and Lee 2023)

In a language where both voiceless and voiced lateral fricatives are present, voiceless lateral fricatives tend to appear more frequently than the voiced counterpart.

In all languages with both lateral fricatives, more than 60% of occurrences in our sample tokens are voiceless, i.e., S. Ndebele 64%, Xhosa 60%, Tsonga 84%, Swati 61%, Zulu 67%.

Distribution of the voice and voiceless lateral fricatives in different phonological environments

	[ɬ]			[ɮ]		
	#R[	V_V	N_	#R[	V_V	N_
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Typological overview of Lateral Fricatives in Southern Bantu

Tentative typological generalisation (Shinagawa and Lee 2023)

If a language allows a voiceless lateral fricative to occur in post-nasal positions, it also occurs in stem-initial and inter-vocalic positions.

/N-ɬ/ disallowed
N.Sotho [S32]
S. Ndebele [S407]
Xhosa [S41]
/N-ɬ/ allowed
Zulu [S42]
Swati [S43]
Tsonga [S53]

	[ɬ]			[ɮ]		
	#R[	V_V	N_	#R[	V_V	N_
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N. Sotho [S32]	0.53	0.47	0.00	0.00	0.00	0.00
S. Ndebele [S407]	0.46	0.18	0.00	0.04	0.14	0.18
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Typological overview of Lateral Fricatives in Southern Bantu

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13

Typological overview of Lateral Fricatives in Southern Bantu

Tentative typological generalisation (Shinagawa and Lee 2023)

The number of occurrence of voiced lateral fricatives in the post-nasal position exceeds that in all other phonotactic environments.

What may be directly suggested by this tendency is that lateral fricatives may also be the target of voicing effect triggered by the preceding homorganic nasal, i.e., post-nasal voicing as a typical segmental process of Bantu phonology.

	[ɬ]			[ɮ]		
	#R[	V_V	N_	#R[	V_V	N_
Venda [S21]	0.00	0.00	0.00	0.00	0.00	0.00
N. Sotho [S32]	0.53	0.47	0.00	0.00	0.00	0.00
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Phonetics of the voiceless lateral fricative

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Exploring phonetics of the voiceless lateral fricative

- After identifying voiceless lateral fricatives [ɬ] in target words, examine the phonetic characteristics.
- How is the [ɬ] in seven Southern Bantu languages phonetically realized? Are they similar or different?

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voiceless alveolar lateral fricative in Welsh

(Ball and Müller 1992)

- after an initial voiceless stop
- initial and medial [ɬ] is twice as long as [l], and it has no naticipatory voicing
- [ɬ] has a higher F2, and noise concentration in the range of 5000 – 7000 Hz

Table 6.10 Words illustrating laterals in Welsh (from Thomas 1992)

Voiceless fricative		Voiced approximant		Voiceless approximant	
ɬond	'full'	lo:n	'road'	tl̥u:s	'pretty'
miɬdir	'mile'	xwɨldro	'revolution'	kl̥ɨ:st	'ear'

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Lateral consonants in Zulu (L&M 1996: 204-206)

- Five lateral sounds
  - [ɬ, tɬ, ɮ, l, kʟ]
- Voiceless lateral fricative
  - less energy in the region below 2000 Hz than fricative portion of [kʟ]
- The voiced [ɮ]
  - has a similar noise spectrum to [tɬ],
  - but lower amplitude in voicing than [l], and
  - lacks strong low frequency.

Table 6.11 Words illustrating lateral consonant types in Zulu

	Voiceless		Voiced	
Alveolar approximant			lálà	'lie down'
Alveolar fricative	ɬàɬá	'cut off'	ɮálà	'play'
Alveolar affricate	íntɬàntɬà	'good fortune'		
Velar ejective affricate	kʟ'ájà	'push in between'		
Alveolar click	k‖ók‖a	'narrate'	g‖álà	'stride'

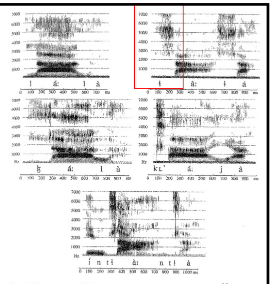

Figure 6.14 Spectrograms of Zulu lateral approximants, fricatives and affricates.

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Data collection

- 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] from the Swadesh list recordings of seven languages (n = 2620)

Language	Nr of speakers	Nr. of items	Nr. of tokens	Avg token per item
Northern Sotho	8	14	438	31.3
Sesotho	9	10	358	35.8
Xitsonga	10	14	303	21.6
Southern Ndebele	12	19	886	46.6
Siswati	8	16	540	33.8
isiXhosa	1	10	40	4.0
isiZulu	1	15	55	3.7

SSW = Siswati, NBL = S. Ndebele, NSO = N. Sotho, SOT = Sesotho, TSO = Xitsonga, XHO = Xhosa, ZUL = Zulu

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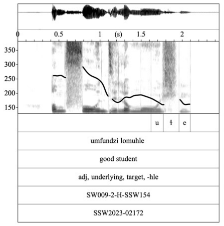
Annotation

- Preceding vowel
- Target consonant [ɬ]
- Following vowel
- Data was annotated using a Praat script that automatically saved any changes upon advancing (or retracting) to the another recording.



We would like to thank Haseru Ida, Takaki Yanagida, Izumi Cook for annotating the date at a short notice.

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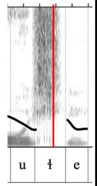
Data processing

- Using a Praat script (DiCanio 2021), extracting the first four spectral moments from fricative spectra.
- The discrete Fourier transforms (DFTs) are averaged using time-averaging (Shadle 2012).
  - Within time-averaging, a number of DFTs are taken from across the duration of the fricative. These DFTs are averaged for each token and then the moments are calculated.
  - The analyzed duration of the fricative is always equivalent to the center 80% of the total duration, cutting off the transitions.



DiCanio, Christian (2021) Time_averaging_for_fricatives_4.0.praat

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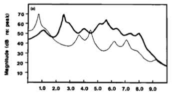
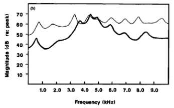
Acoustics of fricatives

- duration
- intensity
- Four Spectral Moments (Forrest et al. 1988)
  - centre of gravity (cog)
  - standard deviation (sdev)
  - skewness (skew)
  - kurtosis (kurt)



thin line: mean 1 kHz, positive skewness 4.0
thick line: mean 4.5kHz, negative skewness -1.2



similar means and skewness, but
thin line: kurtosis -0.7 (diffused peaks)
thick line: kurtosis 6.7

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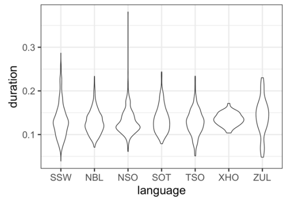
Results: duration

- Descriptive Statistics
  - min = 39 ms
  - max = 380 ms
  - median = 126 ms
  - mean = 130 ms
- A linear mixed effect model
  - No significant difference in the duration when compared to the baseline language (SSW).



SSW = Siswati, NBL = S. Ndebele, NSO = N. Sotho, SOT = Sesotho, TSO = Xitsonga, XHO = Xhosa, ZUL = Zulu

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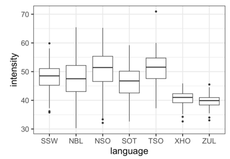
Results: intensity

- Descriptive stats
  - min = 30.28 dB
  - max = 70.95 dB (outlier in TSO)
  - median = 48.41 dB
  - mean = 48.12 dB
- A linear mixed effect model
  - XHO and ZUL have (marginally) significant difference from SSW
    - Caveat: only 1 female speaker in each language



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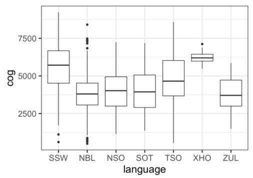
Results: centre of gravity

- Descriptive stats
  - min = 499 Hz
  - max = 9227 Hz
  - median = 4283 Hz
  - mean = 4403 Hz
- A linear mixed effect model
  - **Cog is significantly lower** in NBL, NSO, SOT, TSO ($p < 0.01$) than SSW.



SSW = Siswati, NBL = S. Ndebele, NSO = N. Sotho, SOT = Sesotho, TSO = Xitsonga, XHO = Xhosa, ZUL = Zulu

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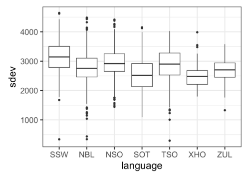
Results: standard deviation

- Descriptive stats
  - min = 293.2
  - max = 4640.2
  - median = 2844.7
  - mean = 2856.7
- A linear mixed effect model
  - **Standard deviation is significantly lower** in NBL, SOT TSO ($p < 0.01$) than SSW.



SSW = Siswati, NBL = S. Ndebele, NSO = N. Sotho, SOT = Sesotho, TSO = Xitsonga, XHO = Xhosa, ZUL = Zulu

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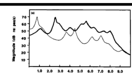
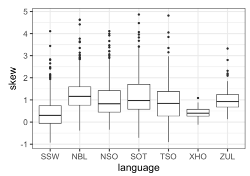
Results: skewness

(outliers (n = 10) removed)



thin line:
mean 1 kHz,
positive skewness 4.0
thick line:
mean 4.5kHz,
negative skewness -1.2

- Descriptive stats
  - min = -0.93
  - max = 4.86
  - median = 0.85
  - mean = 0.95
- A linear mixed effect model
  - **Skewness is significantly higher (positively skewed)** in NBL, NSO, SOT, TSO ($p < 0.01$) than SSW.

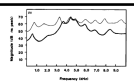


SSW = Siswati, NBL = S. Ndebele, NSO = N. Sotho, SOT = Sesotho, TSO = Xitsonga, XHO = Xhosa, ZUL = Zulu

27

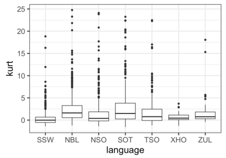
Results: kurtosis

(13 outliers with kurtosis over 30 were excluded)



similar means and skewness, but
thin line: kurtosis -0.7 (diffused peaks)
thick line: kurtosis 6.7

- Descriptive stats
  - min = -1.58
  - max = 24.76
  - median = 0.82
  - mean = 1.76
- A linear mixed effect model
  - **Kurtosis is significantly higher (less diffused peaks)** in NBL, SOT, TSO (p < 0.01) than SSW.



SSW = Siswati, NBL = S. Ndebele, NSO = N. Sotho, SOT = Sesotho, TSO = Xitsonga, XHO = Xhosa, ZUL = Zulu

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Results Summary

- Compared to other languages, the [ɬ] in SSW has lower cog and standard deviation, and higher skewness and kurtosis.
- The [ɬ] in NBL, SOT, TSO, NSO does not show much difference in the spectral moments of fricatives.

- **Cog is significantly lower** in NBL, NSO, SOT, TSO (p < 0.01) than SSW.
- **Standard deviation is significantly lower** in NBL, SOT TSO (p < 0.01) than SSW.
- **Skewness is significantly higher (positively skewed)** in NBL, NSO, SOT, TSO (p < 0.01) than SSW.
- **Kurtosis is significantly higher (less diffused peaks)** in NBL, SOT, TSO (p < 0.01) than SSW.

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SiSwati (SSW) and Southern Ndebele (NBL)

SSW and NBL

- Both languages are Nguni languages.
- Both languages are spoken in the Mpumalanga Province in South Africa.

Follow-up questions

- How different is the acoustic cues of [ɬ] in these two languages?

SSW = Siswati, NBL = S. Ndebele, NSO = N. Sotho, SOT = Sesotho, TSO = Xitsonga, XHO = Xhosa, ZUL = Zulu

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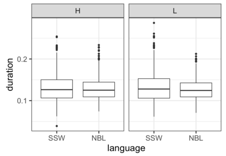
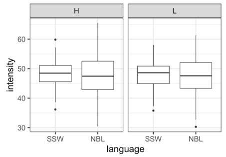
Siswati (n=540) and S. Ndebele (n=886)

duration

t(847.61) = 2.38 p<0.05 BUT only 5 ms which is linguistically not meaningful



intensity



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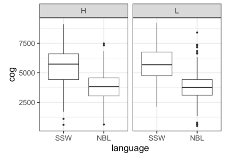
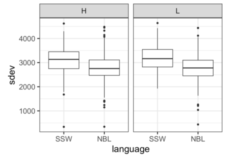
Siswati (n=540) and S. Ndebele (n=886)

centre of gravity

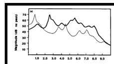


standard deviation



32

Siswati (n=540) and S. Ndebele (n=886)



thin line: mean 1 kHz, positive skewness 4.0
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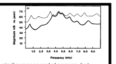
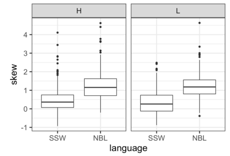


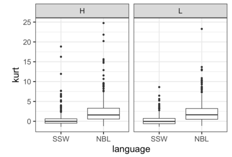
similar means and skewness, but
thin line: kurtosis -0.7 (diffused peaks)
thick line: kurtosis 6.7

skewness



S. Ndebele shows positive skewness.
(= lower frequencies have larger amplitude)

kurtosis



S. Ndebele has larger kurtosis (less diffused)

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Discussion

Articulation

- Higher centre of gravity (cog) in Siswati suggests that [ɬ] may be articulated closer to the alveolar region
  - in other languages, [ɬ] may be produced further back in the alveo-palatal region.
- Ultrasound studies may be used to reveal the differences.

Fricative inventory

- The fricative inventory between SSW and NLB are similar.
  - Siswati
    - f, s, ɬ, ʃ, h
    - v, z, ɮ, ʒ, ɦ
  - S. Ndebele
    - f, s, ɬ, x
    - v, z, ɮ, ɦ

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Thank you!

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