SSILA 2022

Ultrasound study of coronal continuants in Akuzipik/St. Lawrence Island Yupik

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Positionality and Acknowledgements

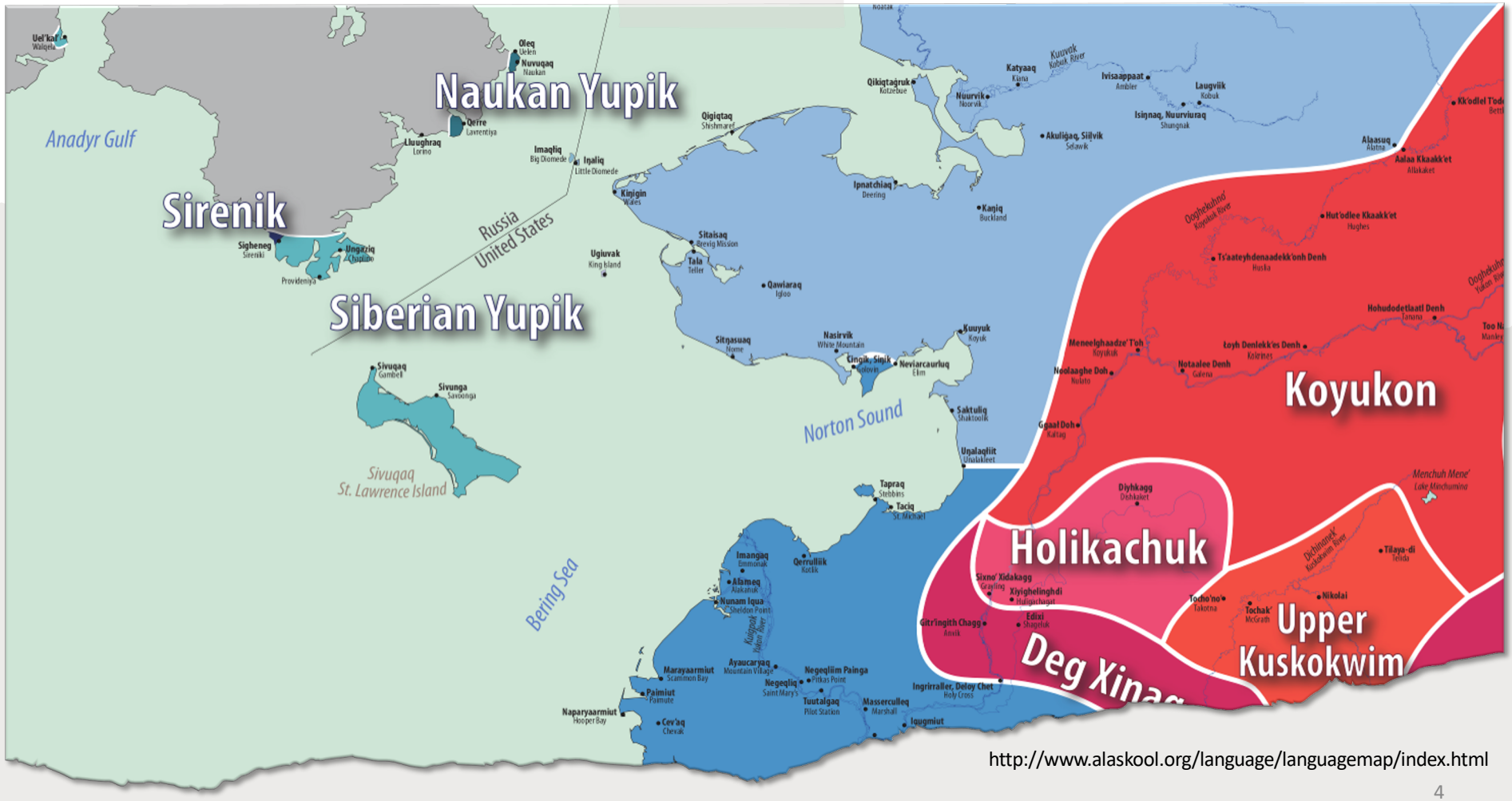
The authors are non-Indigenous individuals and are grateful to be allowed to live, work, and study on unceded land stewarded for thousands of years by tribes including the Rappahannock, Pamunkey, Upper Mattaponi, Chickahominy, Eastern Chickahominy, Nansemond, Monacan, Mattaponi, Patawomeck, Nottaway, and Piscataway.

To the Yupik community, who remain on the land inhabited by their people for generations, igamsikayugvikamsi. We are grateful to you for sharing your language, culture, and kindness.

Special thanks to Ukaall Crystal Aningayou and Miles Apatiki.

Akuzipik/ St. Lawrence Island Yupik

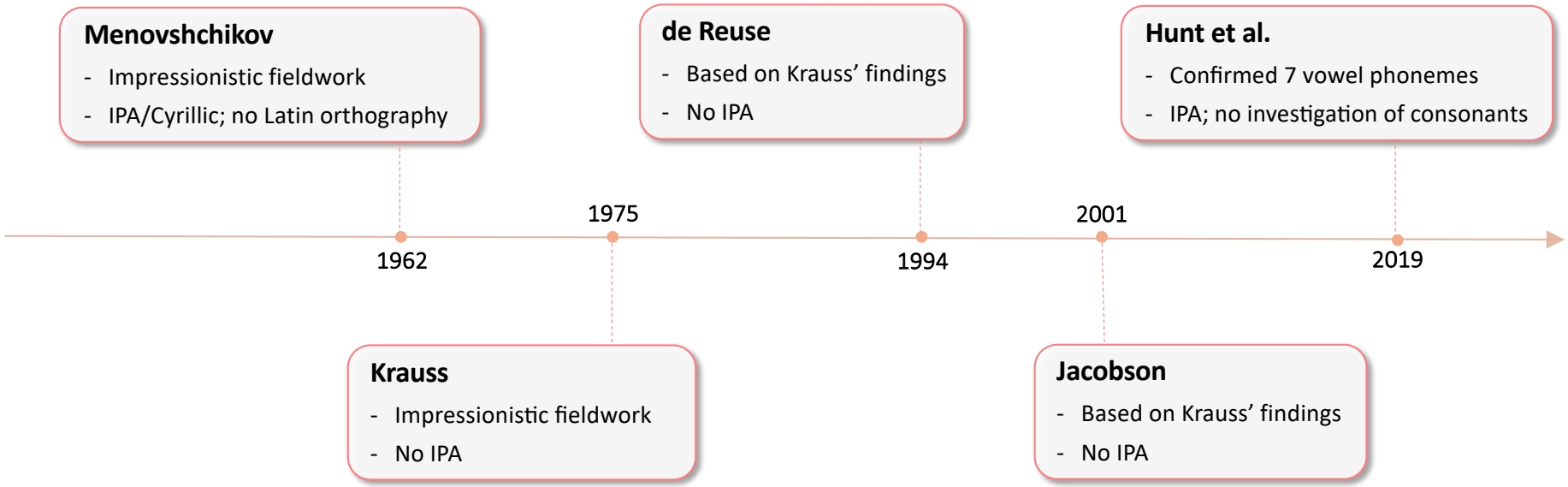
- (Central-)Siberian Yupik / *Akuzipik*: Yupik branch of Inuit-Yupik-Unangan language family
- Endangered language: fewer than 1,000 speakers; all Akuzipik-English bilinguals (Akuzipik L1 until the 1990s)
- Spoken on St. Lawrence Island (AK), Chukotka Peninsula (Russia)
- This study is part of a larger project documenting, digitizing, and creating computer tools for Akuzipik speakers and learners



http://www.alaskool.org/language/languagemap/index.html

Previous studies

Proposed inventories:
31-32 consonants
4-7 vowels



Proposed IPA inventory
(Schwartz & Chen 2017)

	Labial	Alveolar		Palatal	Retroflex	Velar	Velar (rounded)	Uvular	Uvular (rounded)	Glottal	
Unvoiced Stops	p	t				k	kw	q	qw		Latin
	p	t				k	k^w	q	q^w		IPA
	п	т				к	кў	қ	қў		Cyrillic
Voiced Continuants	v	l	z	y	r	g	w	gh	ghw		Latin
	v	l	z	j	ɻ	ɣ	$ɣ^w$	ʁ	$ʁ^w$		IPA
	в	л	з	й	р	г	(г)ў	ғ	ғў		Cyrillic
Unvoiced Continuants	f	ll		s	rr	gg	wh	ghh	ghhw	h	Latin
	f	ɬ		s	ʂ	x	x^w	χ	$χ^w$	h	IPA
	ф	ль		с	ш	х	хў	х	хў	г	Cyrillic
Voiced Nasals	m	n				ng	ngw				Latin
	m	n				ŋ	$ŋ^w$				IPA
	м	н				ң	ңў				Cyrillic
Unvoiced Nasals	mm	nn				ngng	ngngw				Latin
	m̥	n̥				ŋ̊	$ŋ̊^w$				IPA
	мь	нь				ңь	ңьў				Cyrillic

About this project

- Descriptive study of coronal continuants in Akuzipik
- In-depth acoustic analysis and ultrasound imaging investigation of the place and manner of articulation of the sounds represented by the graphemes <l>, <ll>, <r>, <rr>, <s>, <z>, <y>
- Latin orthography currently in use on St. Lawrence Island presumes a “one-to-one correspondence between phonemes and their orthographic representations” (Schreiner et al. 2020)

	Alveolar		Palatal	Retroflex
Voiced Continuants	l	z	y	r
	l	z	j	ɻ
	л	з	ӥ	р
Unvoiced Continuants	ll		s	rr
	ɬ		s	ʂ
	ль		с	ш

Summary of the proposed descriptions of the Akuzipik coronal continuants			
<l>	- sonorant alveolar lateral - voiced dental fricative - voiced alveolar continuant	**<ll>**	- voiceless alveolar fricative - voiceless dental fricative - unvoiced alveolar continuant
<r>	- sonorant trilled alveolar - voiced retroflex fricative - voiced retroflex continuant	**<rr>**	- voiceless post-alveolar fricative - voiceless retroflex fricative - unvoiced retroflex continuant
<z>	- voiced alveolar fricative (“English /z/”)	**<s>**	- voiceless alveolar fricative (“English /s/”)
<y>	- palatal approximant (“English /j/”)		

Previous descriptions

Why ultrasound?

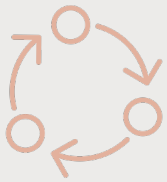
Previous studies: impressionistic

Ultrasound equipment: describe the articulatory properties of each sound

constriction location	shape of the tongue body	relative location of anterior parts of tongue

+ simultaneous audio data collection

Goals



Compare the results obtained in this study with the descriptions suggested in previous studies

Confirm or suggest new places and manners of articulation for the sounds under investigation

Contribute to the development of an updated, IPA-based phonemic inventory of Akuzipik

Method: Participants

Female in her 40s

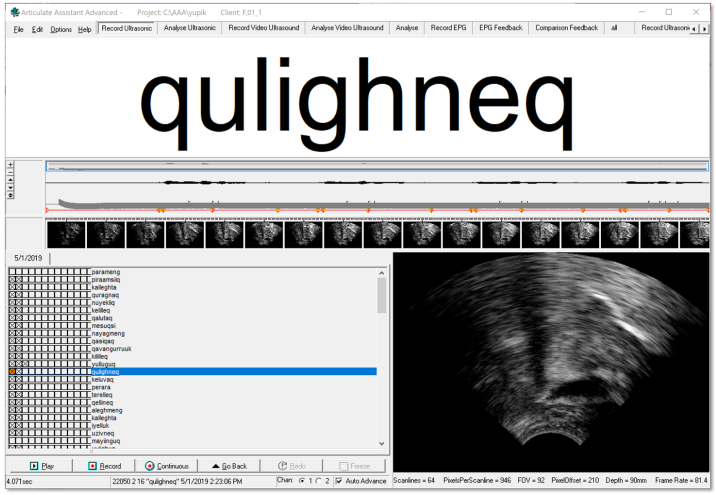
- bilingual Akuzipik-English
- L1 Akuzipik, English at school
- born on St. Lawrence Island
- lives on St. Lawrence Island

Male in his 30s

- bilingual Akuzipik-English
- L1 Akuzipik, English at school
- born on St. Lawrence Island
- lives on mainland AK

Method: Procedures

- Recording sessions: Speech Analysis Lab at GMU, April/May 2019
- Target words appeared on the screen, in Akuzipik orthography, one at a time
- 6-8 repetitions of each word per participant



Method: Stimuli

- 71 words, each containing one of the target consonants
- Target consonant: intervocalic, onset of a stressed syllable
- Inflected nouns varying in length (2~5 syllables, mostly 3)

iyelluk	paliqaq	qullikaq
kallagneq	parameng	quragnaq
kalleghta	pellugek	qusalguuq
kallugtaa	perara	qusevgeghnet
kasugun	pillugaghta	qusighneq

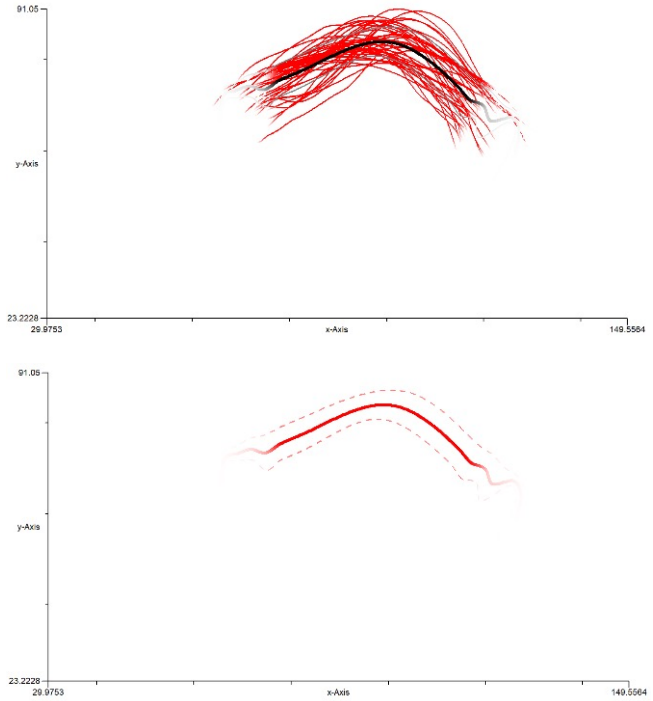
About the analysis

Acoustics

- duration of consonants (not geminates)
- voicing during constriction

Ultrasound imaging

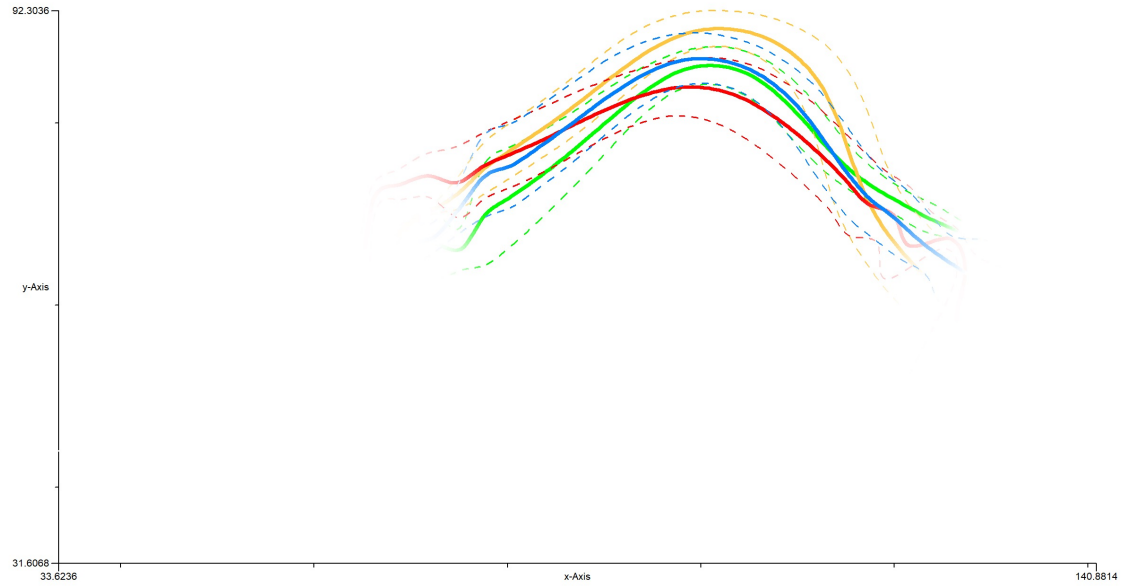
- tongue contour (coordinates)
- constriction location: one frame (at midpoint), highest position
- SSANOVA (smoothing spline ANOVA, Davidson 2006 *JASA*)



Voiced coronal continuants

Female tongue configuration:

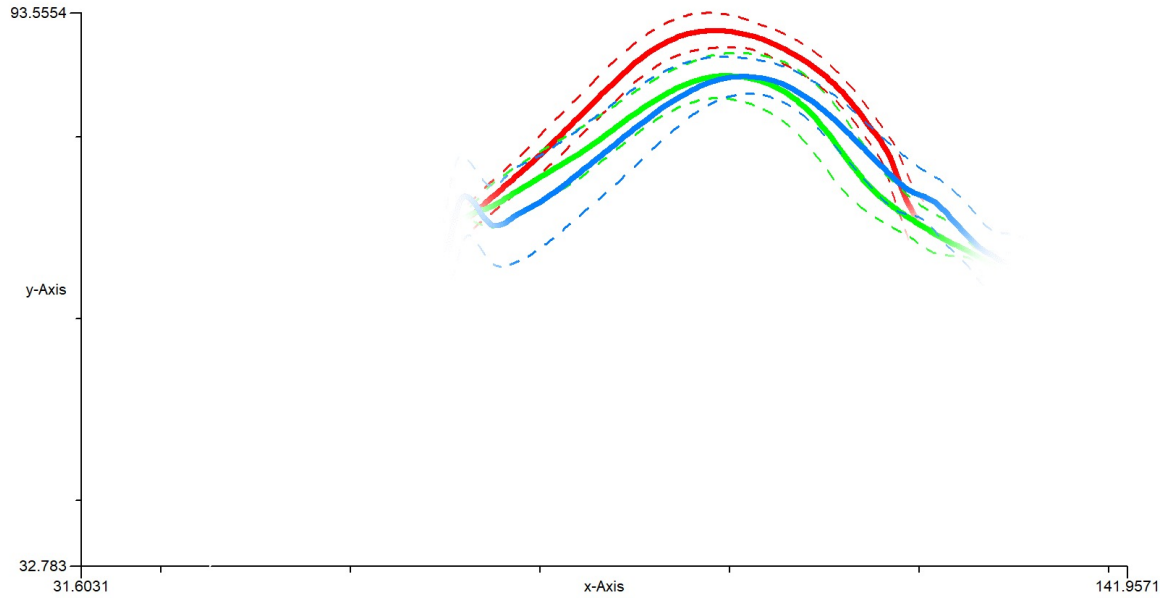
- Yellow: <y>
- Blue: <l>
- Green: <z>
- Red: <r>



Voiceless coronal continuants

Female tongue configuration:

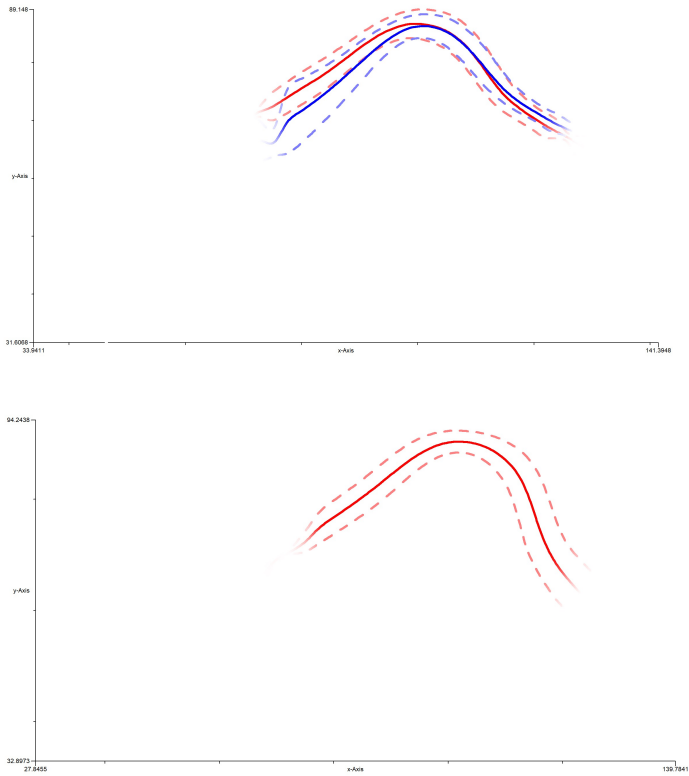
- Red: <rr>
- Blue: <ll>
- Green: <s>



<s>, <z>, and <y>

Overview

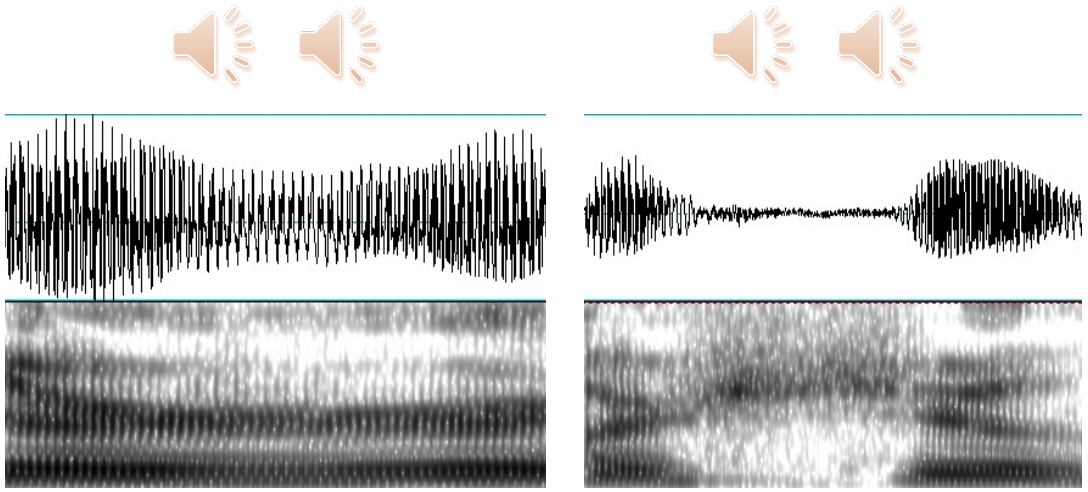
- Top: Female tongue configuration for <s> (red) and <z> (blue)
- Bottom: Female tongue configuration for <y>



<r> and <rr>

Acoustic analysis

- Voicing during constriction: <r> is voiced and <rr> is voiceless for both speakers in all investigated environments, confirming previously suggested voiced-voiceless distinction
- But also: different manners (approximant vs. fricative)

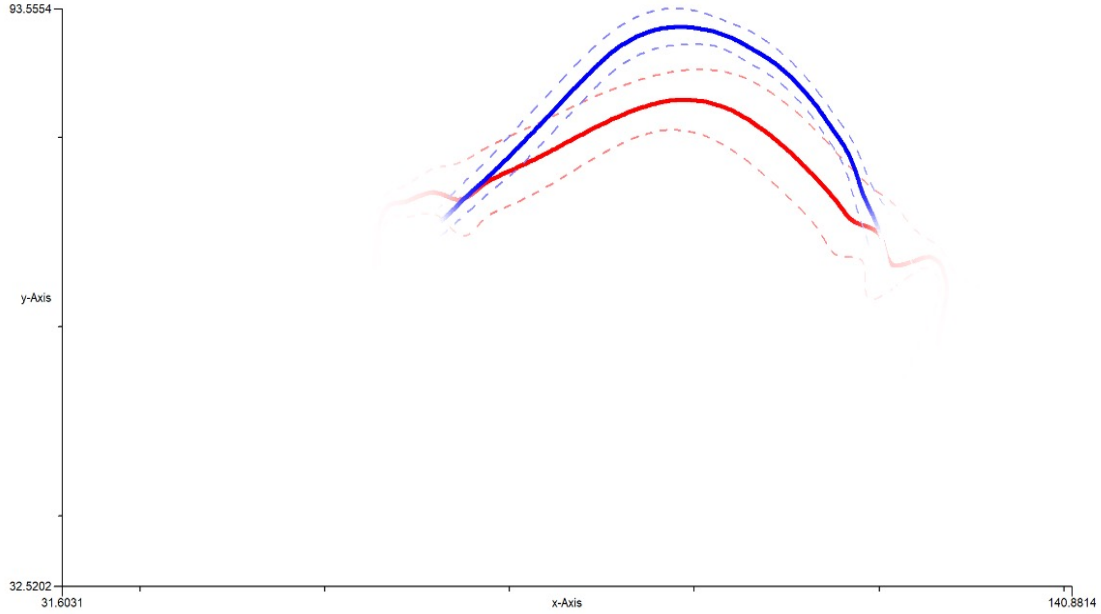


Waveform and spectrogram representations of F's production of <ere> in *terelleq* (left) and <erre> in *nayeqerregagh* (right)

<r> and <rr>

Articulatory analysis

- Different configurations: the tongue body is visibly higher in <rr> than in <r>
- <r> and <rr> are claimed to be retroflex sounds, but that was not observed here
- Hypothesis: retroflex and bunched pronunciations of “r”, like in American English

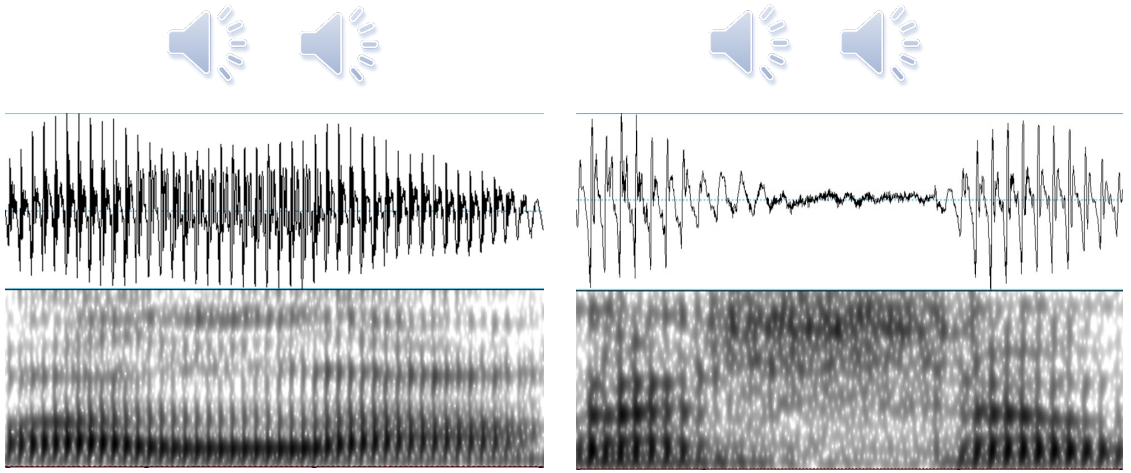


F’s mean (solid lines) and s.d. (dashed lines) tongue configurations for <r> (in red) and <rr> (in blue)

<l> and <ll>

Acoustic analysis

- Voicing during constriction: <l> is voiced and <ll> is voiceless for both speakers in all investigated environments, confirming previously suggested voiced-voiceless distinction
- But also: different manners (approximant vs. fricative)

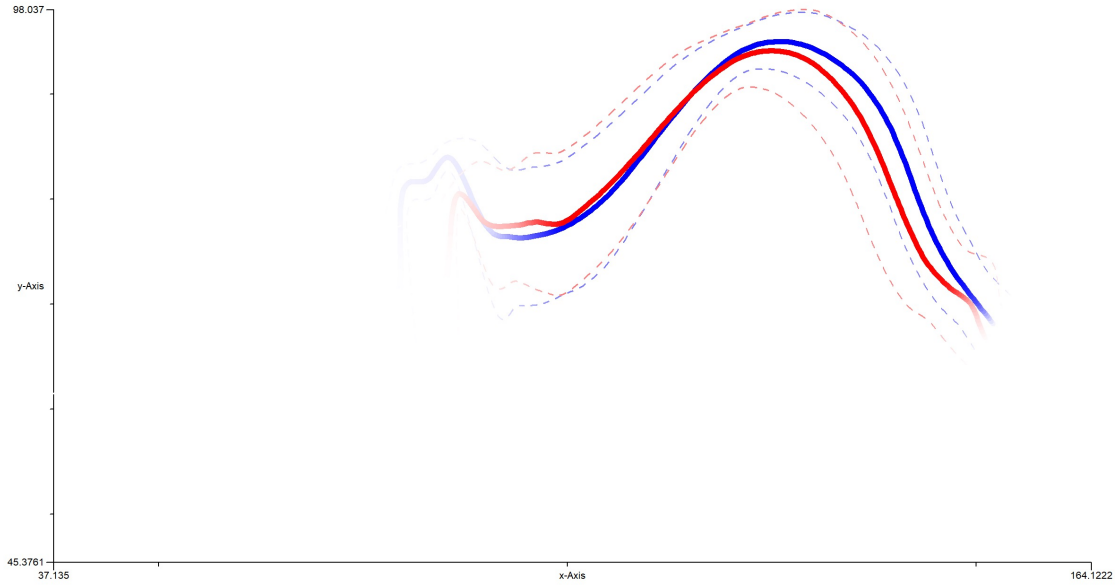


Waveform and spectrogram representations of M's production of <ala> in *palaghhaq* (left) and <alla> in *kallagneq* (right)

<l> and <ll>

Articulatory analysis

- Overlapping tongue configurations for <l> and <ll>, suggesting same (or similar) place of articulation
- But: different manners
- Future studies: transverse view rather than the midsagittal view, to confirm that these sounds are in fact lateral



M's mean (solid lines) and s.d. (dashed lines) tongue configurations for <l> (in red) and <ll> (in blue)

Conclusion

- <s>, <z>, <y>: confirmed IPA representations /s/, /z/, /j/
- <r> and <rr>: voiced and voiceless; different place and manner of articulation; suggested IPA representations: /ɹ/ and /ʃ̲/
- <l> and <ll>: voiced and voiceless; same place, different manners of articulation; suggested phonemes: /l/ and /ɬ/

- Previous descriptions were mostly confirmed; further research is still needed
- Overall project: assist in the production of Akuzipik-language educational materials

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Thank you!

Questions?

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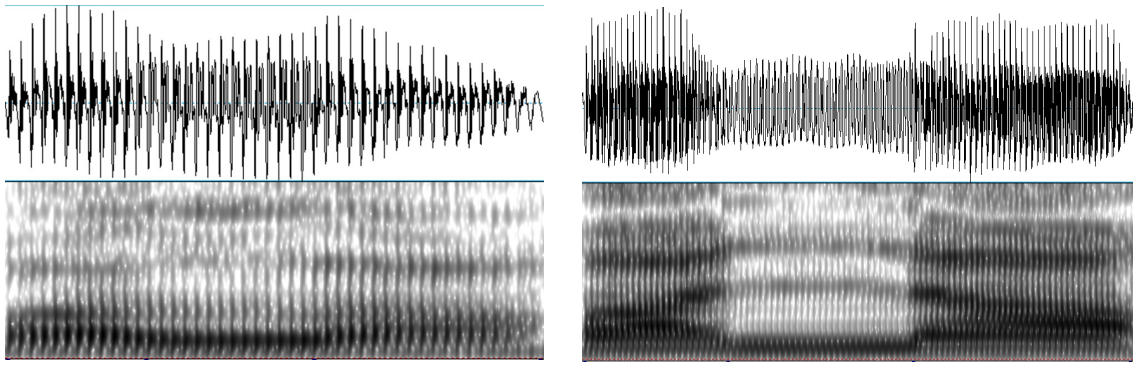
<l> and <ll>

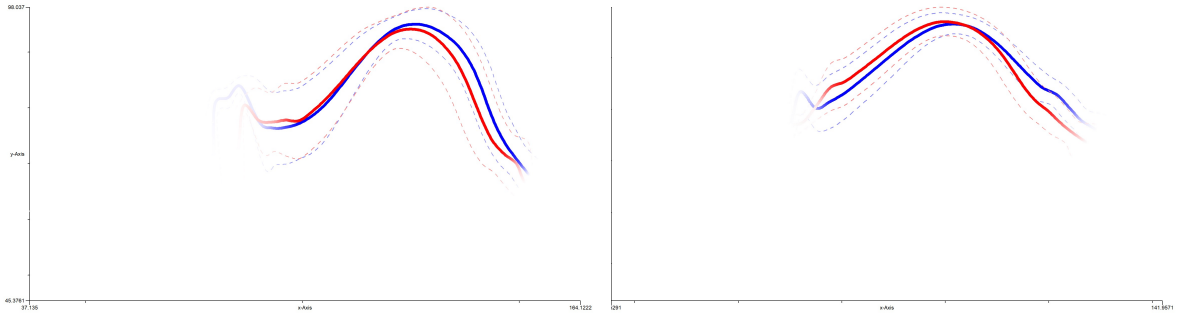
- Inter-speaker variation in the pronunciation of <l>
- Why? (future studies)
  - Age difference
  - Gender
  - Current place of residence
  - Other reasons?



Waveform and spectrogram representations of M's (left) and F's (right) productions of <ala> in *palaghhaq*

<l> and <ll>

- Inter-speaker variation: M and F show different tongue configurations (maybe due to English dominance/interference?)
- Intra-speaker consistency: same (or similar) place of articulation for <l> and <ll>



Mean (solid lines) and s.d. (dashed lines) tongue configurations for <l> (in red) and <ll> (in blue); left: M, right: F