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Anton Buzanov, Ilya Egorov, Vasily Molchanov

Diphthongs and Kildin Saami vowel system

Anton Buzanov, Institute of Linguistics RAS, National Research University
"Higher School of Economics" (Moscow); anton.buzanov.00@gmail.com
Ilya Egorov, School for Advanced Studies in the Humanities RANEPA (Moscow); i.m.jegorow@gmail.com
Vasily Molchanov, National Research University
"Higher School of Economics" (Moscow); vasilymoltchanoff@gmail.com

The aim of this paper is to present a revision of the phonological system of Kildin Saami. This revision is based on the results of a computational analysis of the Kildin vowel inventory. Specifically, a number of segments that have been variously described by different scholars as either diphthongs or monophthongs have been examined using two automatic methods: trajectory length and changepoint detection. These methods were tested on the material of Estonian and Lithuanian before the examination of the Kildin data. The data analyzed in this research was collected during fieldwork in the city of Murmansk, the rural locality of Lujaavv'r (Lovozero), and the urban locality of Verkhnetulomsky in the Murmansk Oblast of Russia in 2021 and 2022. Computational analysis revealed that the segments analyzed by some scholars as diphthongs /ie/ and /ea/ are monophthongs /eː/ and /aː/ occurring after palatal and palatalized consonants. The low back vowels analyzed sometimes as diphthongs /oa/ and /oaː/ are monophthongs /ɒ/ and /ɒː/. The first component of /ua/ is acoustically closer to /o(ː)/ than to /u(ː)/. The phonetic quality of /ue/ remains to be defined. It is proposed to analyze this phoneme as having three allophones in free variation, diphthong [ʊə] (or even [ɔə]) and monophthongs [ɵː] and [əː]. /i/ and /ɨ/ were shown to be in contrastive distribution only word-initially if Russian loanwords are taken into consideration, so /i/ should be considered a marginal phoneme. /i/-final diphthongs and triphthongs are proposed not to be postulated and analyzed instead as combinations of vowels with /j/ or /jː/. The vowel inventory thus comprises two diphthongs and thirteen monophthongs.

Keywords: phonology, instrumental phonetics, vowels, diphthongs, Kildin Saami

ДИФТОНГИ И СИСТЕМА ГЛАСНЫХ В КИЛЬДИНСКОМ СААМСКОМ

Бузанов Антон Олегович, Институт языкознания РАН, Национальный исследовательский университет
«Высшая школа экономики» (Москва); anton.buzanov.00@gmail.com
Егоров Илья Михайлович, Школа актуальных гуманитарных исследований РАНХиГС (Москва); i.m.jegorow@gmail.com
Молчанов Василий Владимирович, Национальный исследовательский университет
«Высшая школа экономики» (Москва); vasilymoltchanoff@gmail.com

Цель настоящей статьи — предложить пересмотр фонологической системы кильдинского саамского языка на основе результатов компьютерного анализа гласных. Инструментальному анализу подверглись сегменты, которые разными исследователями описывались то как дифтонги, то как монофтонги. Акустические данные обрабатывались с применением двух компьютерных методов: trajectory length и changepoint detection. Перед применением этих методов к материалу кильдинского саамского они были протестированы на литовских и эстонских данных. Материалы были собраны в экспедициях в городе Мурманске, селе Ловозере и поселке Верхнетуломском в Мурманской области в 2021 и 2022 гг. Проведенный анализ показал, что сегменты, иногда рассматриваемые ранее как дифтонги /ie/ и /ea/, являются на самом деле монофтонгами /eː/ и /aː/ перед палатализованными согласными. Гласные среднего ряда нижнего подъема, которые в некоторых опсаниях считались дифтонгами /oa/ и /oaː/, в действительности являются монофтонгами /ɒ/ и /ɒː/. Первый компонент дифтонга /ua/ акустически ближе к /o(ː)/, чем к /u(ː)/. Фонетический коррелят /ue/ не был однозначно установлен. Эта фонема имеет три свободно варьирующихся аллофона: дифтонг [ʊə] (или даже [ɔə]) и монофтонги [ɵː] и [əː]. Анализ распределения /i/ и /ɨ/ показывает дополнительную дистрибуцию только при учете русских заимствований. Фонему /i/ следует считать маргинальной. /i/-конечные дифтонги и трифтонги предлагается не постулировать и рассматривать как сочетание гласного с /j/ или /jː/. Таким образом, вокалический инвентарь кильдинского саамского включает два дифтонга и 13 монофтонгов.

Ключевые слова: фонология, инструментальная фонетика, гласные, дифтонги, кильдинский саамский

1. Introduction

Kildin Saami is described as a language with a large number of phonemes. It occupies the fourth top position by the number of items in inventory in the current version of the PHOIBLE database [Moran, McCloy 2019]. Despite such a big phoneme inventory, this language currently remains beyond the attention of phoneticians, phonologists, and typologists. Previously the Kildin Saami phonology was an object of consideration in [Kert, Matusevich 1962; Itkonen 1971; Bjarnson 1976; Kostina 2006]. Among these works, only Donald Bjarnson's [1976] master thesis is consistently based on the modern understanding of phonology. A single recent paper specifically dedicated to phonological issues is [Kuzmenkov, Rießler 2012]. It deals with one peculiar feature of the Kildn Saami consonants. The results of this paper lead to the reduction of the inventory, namely, a transformation of a trinary opposition between "soft" vs "semi-soft" vs "hard" dental stops to a binary opposition between palatalized vs non-palatalized ones. Further revision of the Kildin Saami phonological inventory is undertaken in [Rießler 2022].

The present study deals with several issues in the Kildin Saami vocalism related to the interpretation of diphthongs. The Saami languages are known for a big number of diphthongs. Since the Great Saami Vowel Shift [Aikio 2012: 70], when a range of Pre-Proto-Saami vowels yielded diphthongs, most Saami languages demonstrate phonemes of this type in vowel inventories. The Proto-Saami system included four diphthongs (*ie, *ea, *uo, *oa) and five monophthongs (*i, *ę, *ā, *u, *o). Most of the modern Saami languages have rebuilt that system by enlarging (South Saami, North Saami, Inari Saami, Skolt Saami, Akkala Saami) or reducing (Pite Saami) the number of diphthongs. The number of diphthongs varies from one in Pite Saami [Wilbur 2014] to thirty in the Veahčat subdialect of Eastern Inland North Saami [Aikio, Ylikoski 2022: 149]. One of the ways of increasing the number of diphthongs was the introduction of quantitative opposition for example in Inari and North Saami. Many qualitative changes occurred in different Saami languages as well, but they maintain a peculiar feature of the Proto-Saami system: almost all diphthongs attested in the Saami languages are opening. Diphthongs are often a subject of variation for example in South Saami [Ylikoski 2022: 116; Kowalik 2023: 78] or between the North Saami dialects. The number of diphthongs also strongly depends on phonological solutions as shown in [Koponen et al. 2022] for Skolt Saami, cf. also [Korhonen et al. 1973: 13—16; Feist 2010: 74—80].

In the present paper, we will explore several issues in the Kildin Saami vocalism considering diphthongs. In the next section, an overview of previous descriptions will be provided and the number of questions will be formulated. Some of these problems, namely, the quantity opposition in diphthongs (Section 2.1), the existence of *i*-final diphthongs (Section 2.2), and the opposition between /i/ and /ɨ/ (Section 2.3), will be solved immediately in the process of discussion. The question about the opposition of /i/ and /ɨ/ does not regard diphthongs, however, we will address it to make the revision of the vowel system complete. The above-named problems only require reinterpretation from the standpoint of classical phonology. Some other questions will be only briefly formulated in Sections 2.4—2.7. These questions are as follows: the monophthongal or diphthongal nature of palatalizing /ʲaː/ and /ʲeː/ a.k.a. front opening diphthongs (Section 2.4) and the low back vowels /ɒ/ and /ɒː/ a.k.a. diphthongs /oa/ and /oaː/ (Section 2.5), the monophthongization of /ue/ (Section 2.6), the exact phonetic quality of /ua/ (Section 2.7). They all require detailed investigation using the methods of instrumental phonetics and the application of special statistical algorithms for data processing that we discuss in Section 3. The main part of the paper (Sections 4—7) provides the results of the investigation into these three issues. In the final section, we summarize the results of the revision of the Kildin Saami vowel system undertaken here.

2. Previous research and problem statement

Previous studies posited from three to eight diphthongs, some also included triphthongs. The vowel inventories proposed in the earlier descriptions are summarized in Table 1. Below we will discuss the most obvious minor problems that can be solved without a special phonetic study and require only consistent application of the principles of phonology. The main part of the present paper will be dedicated to more complicated issues requiring a more detailed acoustic investigation.

The most non-trivial correspondences between these seven transcription systems will become clear in the next subsections (2.1—2.7). Table 2 provides correspondences between transcription/orthography of major Kildin Saami dictionaries.

Table 1. The Kildin Saami vowel inventory according to the major phonological description of this language and grammar sketches

[Itkonen 1971: 87]					
i ī	į		u ū	ĭĕ ie	ŭĕ ue
	ę ę̄		o ō		
	ą		å [å̄]	ĕă eå	ŏă oa
		a ā	ɑ ɑ̄		
[Kert 1971: 64—70]					
i ī	į į̄	u ū	uɛ ua	įi	uɛi
ɛ		o		ɛi oi	
	a ā	å å̄		ai åi	
[Bjarnson 1976: 14]					
i ī	į	u ū	ie	ue	
ę ę̄		o ō	eå	ua	
	a ā	å å̄			
[Kuruch et al. 1985: 531]					
и й	ы ы̄	y ȳ		уэ	
э э̄		o ō		ya	
	a ā			oa	
[Kostina 2006: 47]					
i i:	ɨ ɨ:	u u:	ue ua	ɨi	uei
e e:		o o:		ei oi	
	a a:			ai åi	
[Wilbur 2007: 15]					
i i:	ɨ ɨ:	u u:		u̯e u̯e:	
e e:		o o:		u̯a u̯a:	
	a a:	ɑ ɑ:		o̯a o̯a:	
[Rießler 2022: 221]					
i i:	ɨ	u u:	ie	ue	
ɛ ɛ:		o o:	ea	ua	
ɑ ɑ:		ɒ ɒ:			

Table 2. Major correspondences between the signs for vowels in the first syllables in the main dictionaries

[Genetz 1891]	[Itkonen 1958]	[Kuruch et al. 1985; Kert 1986; Sammallahti, Khvorostukhina 1991; Antonova 2014]
a	ą̇	a
ā	à ā ą̀ ą̄	ā
ea	ėå ĕå	я̄
ɵ	ę	э
ɵ	ę̀ ę ę̀	э̄
ie	ie ʲie	ē
ī	ī jì ì iė	ӣ
i̊	į į̂	ы
o	o ò	o
ō	ō ò	ō
u	u	y
ū	ū ų̄	ȳ
o	o ò ᵒ	oa
ą	ɑ ɑ̄ ą̄	oā[1]
uɵ	uə u̯ə ᵛuə ᵛŭə	уэ
oa	ŭa ᵛu̯a ᵛŭa	ya

[1] Kuruch et al. [1985] use this symbol only in the case of homographs to distinguish the lexemes with the short and long counterparts.

2.1. Quantitative opposition

Erkki Itkonen [1971: 87] postulates 14 monophthongs and 8 diphthongs combined in pairs with opposition in quantity. The quantitative opposition for diphthongs does not seem to be phonological. Although Itkonen [ibid.: 96] cites some minimal pairs, they could be easily reinterpreted in terms of consonant gradation:

(1) *kĭĕ´llaj* 'clock.GEN.PL' vs *viellaj* 'fix.PASS.PST.3SG'
(2) *tĕăŋga* 'money.DIM.NOM.PL' vs *teəŋga* 'money.DAT.SG'
(3) *čŏărva* 'horn.DIM.NOM.PL' vs *čoarva* 'horn.DAT.SG'

All the forms with short diphthongs represent a weak grade whereas forms with long diphthongs represent a strong grade (see [Bakró-Nagy 2022] on the phenomenon of consonant gradation in the Uralic languages). Exactly the same picture can be observed in Joshua Wilbur's [2007: 45, 48] data:

(4) *vu͡ejv* 'head.GEN.SG' vs *vu͡e:jjv* 'head.NOM.SG'

Wilbur's transcription reflects the difference in the length of consonants as well. He provides measurements that reveal that in the weak grade, both the vowel and the immediately following consonant are shorter than in the strong grade: *ue* (weak) — 94 ms; *ue* (strong) — 147 ms; *j* (weak) — 99 ms; *j* (strong) — 192 ms; *v* (weak) — 102 ms; *v* (strong) — 92 ms [ibid.]. Earlier works marked both lengths of diphthongs and the following consonants using an extremely detailed narrow phonetic transcription, e.g. [Itkonen 1916; Itkonen, Europaeus 1931; Itkonen 1958]. Since the length of diphthongs is convinced by the grade and the grade in turn determined mostly by the length of consonants, it seems unnecessary to introduce quantitative opposition into the system of diphthongs on the phonological level.

2.2. *i*-final diphthongs

Georgiy Kert [1971: 69—70] postulated a range of *i*-final diphthongs and one *i*-final triphthong. Earlier this approach was applied by László Szabó [1967: 16]. It is a clear misinterpretation of the palatal glide which should be treated as a consonant being a subject of gradation. Kert himself noted it but still applied a somewhat inconsistent solution. He claims that these diphthongs occur only before a consonant in the first syllable of the non-inflecting part of speech. According to Kert, *j* changes to *i* and becomes a part of a diphthong in this position. Kert combines morphophonological and phonetic factors. The palatal approximant indeed can be realized as a non-syllabic vowel [i̯], which is hardly distinguishable from what is expected in the second part of an *i*-final diphthong. However, this segment is considered a consonant when it should be a subject of consonant gradation and as a part of another vocalic phoneme otherwise.

There are some further inconsistencies in Kert's analysis. His approach should lead to postulating a triphthong *uai* alongside *uɛi*, however, he does not do so. Moreover, it remains unclear why he does not treat *v* (realized as [u̯] before consonants) in the same way.

Another strong argument against such treatment of *j* is that it can be a subject of morphological alternations in laryngeal features (voiced/voiceless). A causative suffix added to the verb *ujjte* 'to go away' cannot be seen in the surface representation *per se* but realized in the devoicing of *j*:

(5) *ujjte* 'to go away' vs *u̯o̯o̯jte* 'to take away' < *ujjt-t-e* 'go_away-CAUS-INF'

In all the later works on Kildin Saami except [Kostina 2006], Kert's *i*-final diphthongs were rejected without any discussion. However, Kert was followed by some other Russian researchers in their descriptions of East Saami languages, namely, Sergei Tereshkin [2002] and Pekka Zaikov [1987]. Zaikov postulates also the range of *u*-final diphthongs being more consequent than Kert. All the arguments against the *i*-final diphthongs in Kildin Saami remain true for Akkala and Ter Saami as well.

2.3. Note on high mid vowels

All previous descriptions of Kildin Saami phonology include at least one high mid phoneme /ɨ/, some of them postulate a quantitative opposition as well. Kert was the first one who proposed the quantitative opposition for high mid vowels, and the inclusion of this phoneme into phoneme inventory in the later studies [Kuruch et al. 1985; Kostina 2006; Wilbur 2007] is based on the uncritical treatment of his description. The opposition introduced in Kert's work is supported by a single ghost example:

(6) *pɨ̯ss* 'gun.NOM.SG' vs *pɨ̯̄ss* 'gun.NOM.PL'

Neither our field data nor the data from dictionaries [Itkonen 1958: 358; Kuruch et al. 1985: 278; Antonova 2014: 240] confirm this example. This word belongs to the groups of stems with the earlier geminate *ss in the consonant center. Such stems do not show consonant gradation and forms of NOM.SG and NOM.PL (together with GEN.SG and ACC.SG) are homonymic in the substantive paradigm (7).

(7) *piss* 'gun.NOM.SG' & *piss* 'gun.NOM.PL'

Since there is no other evidence for the distinction between /ɨ/ and /ɨ:/, we believe that this opposition is not descriptively adequate. However, there is another even more serious problem with the tentative phonemes /ɨ/ and /i/. Evidence in favor of this opposition is scanty. These segments are mostly in complementary distribution in the word-internal position. [i] occurs after the palatal consonants /j/, /ɲ/, and /č/ whereas [ɨ] elsewhere. [i] is impossible after palatalized consonants as well as the short [i]. A contrast can be observed in the word-initial position due to *i* occurring in the Russian loans and *ɨ* in inherited items. Such a distribution is observed in the dictionaries [Kuruch et al. 1985; Antonova 2014] We have failed to elicit a single inherited word or an old borrowing with the initial [i], so our field studies confirm the data from the dictionaries. Given these facts, we will keep /i/ in the vowel inventory but mark its marginal status. Possibly, there are (or were) idiolects that could give solid evidence in favor of opposition /i/ vs /ɨ/ in word-onset, otherwise [i] should be regarded as an allophone of /ɨ/.

2.4. Diphthongs *ie* and *ea*

One can speak about two descriptive traditions regarding the front opening diphthongs. One goes back to the first descriptions made by Halász [1881] and Genetz [1891], where these diphthongs were posited. Toivo Itkonen [1958] as well as Erki Itkonen [1971] and then Bjarnson [1976] and Rießler [2022] followed this approach. Another descriptive tradition starts with Kert [1971] followed by other Russian researchers [Kuruch et al. 1985; Kostina 2006], Szabó [1967; 1968], and Wilbur [2007], who treat these segments as long monophthongs /e:/ and /a:/ after palatalized consonants. It is difficult to say whether we are dealing here just with different research traditions or with dialectal, chronological, or idiolectal variants. The descriptions showing diphthongs *ie* and *ea* focus primarily on the western Kildin Saami varieties spoken in Killt sijt and Shongui. However, Bjarnson and Rießler worked with speakers from the central Kildin Saami varieties (Lujaavv'r and Koardõgk sijjt), whose speech could indeed demonstrate that diphthongs underwent monophthongization in less archaic dialects.

A significant coarticulation effect is expected for the vowels after palatalized consonants. It can be perceptually similar to diphthongs, especially for speakers of languages with phonological diphthongs and without phonological palatalization. We will apply several statistical methods to our acoustic data on these segments to make a firm conclusion about their diphthongal or monophthongal nature.

2.5. Low back vowels and diphthongs

As can be seen from Tables 1 and 2, the existing sources differ in their interpretation of the low back vowels. The only researcher who does not mention these phonemes in the vowel inventory is Kostina [2006]. She makes an explicit claim that *å* is an allophone of *a* (positions are not specified), but then she uses it in slash marks as if it were a separate phoneme.

Other researchers mostly treat the segments in question as monophthongs and posit the opposition in quantity /ɒ/ vs /ɒ:/. In Cyrillic orthography, the digraph <oa> is used to denote the low back vowel. Since there is no suitable sign in the Cyrillic alphabet, the decision to use a digraph seems good. However, the question arises whether it is only a graphical convention or such spelling indeed reflects a diphthongal nature. We will explore this issue in Section 5 using the same tool as for the exploration into the front diphthongs a.k.a. palatalizing /ʲa:/ and /ʲe:/.

Kuruch [1985: 531] does not include <oā> in the table showing the vowel inventory in her grammar sketch. However, she sporadically uses the sign <oā> to distinguish lexemes homographic otherwise:

(8) *лоагк* 'count' vs *лоāгк* 'ceiling'

So, the quantity opposition is not reflected in the Kuruch's orthography in most cases. On the other hand, the orthography used in Antonova's dictionary [2014] consistently distinguishes the quantity of the back low phonemes with signs <oa> vs <oā>.

Older sources demonstrate the picture deviating from the newer ones. T. Itkonen [1958] and Genetz's [1891] dictionaries reflect a special low back phoneme in place of Antonova's <oā>. Similarly, E. Itkonen [1971] notes

a low back vowel here. In place of Antonova's short vowel, T. Itkonen and Genetz have the medium back vowel /o/. However, E. Itkonen [1971: 87] posits a medium-low vowel /å/ here, distinct from both medium-high /o/ and low /ɑ/. Both /å/ and /ɑ/ have long counterparts, according to E. Itkonen, however, he doubts the phonological nature of /ɑː/. It's difficult to say whether we are dealing here with dialectal variation, or just with different transcriptions. Similarly, Wilbur [2007: 15] posits four segments in place of two segments in other descriptions. He has diphthongs /o͡a/ and /o͡aː/ alongside monophthongs /ɑ/ and /ɑː/. However, they do not correspond regularly to either long or short segments of the other sources.

2.6. *ua* or *oa*

In the sources based on earlier recordings [Genetz 1891; Itkonen, Europaeus 1931; Itkonen 1958; Itkonen 1971], the diphthong *oa* is posited in place of *ua* of later sources [Szabó 1967; 1968; Kert 1971; Kuruch et al. 1985; Antonova 2014; Rießler 2022]. It remains not entirely clear whether we are dealing here with dialectal differences, diachronic change, or just with the different notation. The components of diphthongs often deviate from the vowels they are labeled in a phonological transcription. We attempt to shed some light on the exact quality of the first component of this diphthong using acoustic analysis.

2.7. Monophthongization of *ue*

The last problem requiring an acoustic analysis is the monophthongization of the diphthong *ue* > *e(:)*. Surprisingly, the previous phonological descriptions do not mention that the diphthong *ue* undergoes monophthongization in some positions. In the transcriptions of previously published texts, this phenomenon is observed only in the comitative plural marker *-guejm*, inchoative marker *-škuedd-* and in some postpositions. It can be explained by the fact that diphthongs are normally limited to the first syllables. All the items where the monophthongization was previously observed represent the results of recent grammaticalization (see [Kuokkala 2019] on the inchoative markers).

Our observations on the recently collected field material show that the monophthongization takes place in the first syllables as well. In the scope of the present paper, we aim to set the positions of monophthongization. Our hypothesis is that the monophthongization is triggered by a velar or a labial consonant immediately preceding the diphthong. It is important to note that we consider here only the monophthong involving delabialization of the first component of the diphthong. The shift *ue* > *uu* occurring in some forms of the inchoative marker *-škuedd-* is an outcome of a regular morphophonological alternation.

3. Data and methods

The data for the present paper were collected during several field trips to Lujaavv'r (or Lovozero; Lovozersky District, Murmansk Oblast, Russian Federation) and to Murmansk 2020—2023. Lujaavv'r currently remains the single settlement where a community of Kildin Saami speakers is still preserved; these speakers represent four dialects which are mixed to some extent. The diphthongs are a matter of dialectal differentiation. The relevant dialectal features will be discussed below. It seems impossible to eliminate dialectal variation from the data since it would cause a significant reduction of material.

3.1. Questionnaires and data collection

The use of diachronically oriented questionnaires seems to be a proper way to bring in order somewhat chaotic data of the dictionary sources often suffering from inaccurate transcription. The use of such questionnaires implies that we explore the phonetic quality of the reflexes of the particular Proto-Saami phonemes. It allows us to avoid the selection of one dictionary source (and, hence, a dialect) as the most reliable or representative one. The diachronic approach also seems more justifiable than analyzing deviations from a standard variant when exploring dialectal variation. The existence of a consensus reconstruction ([Korhonen 1981], see for some later minor revision [Sammallahti 1998; Aikio 2012; Koponen 2022; Zhivlov 2023]) together with the standard etymological dictionary [Lehtiranta 1989] and Álgu etymological database fully allows the use of this approach to the Kildin Saami material.

When composing the questionnaires, we also take into account the phonological context. That is especially crucial for the exploration into monophthongization of *ue* since we believe it depends on the specific context. The list of stimuli can be found in Appendix A.

The phonetic material was recorded in conditions as close to the studio as it was possible during the field-work. Both Russian stimuli and stimuli written in standard Kildin Saami were used to elicit the data. Speakers were asked to respite each word three times with pauses without any context. Our recordings reflect careful but not overarticulated speech.

3.2. Annotation of acoustic data

The collected data were annotated and analyzed using Praat software [Boersma, Weenink 2021]. The annotation and analysis were performed as follows:

1) First, the data were imported into the program;
2) Second, a three-layer text grid was created using the 'Annotate' function, the layers being: 1) sound symbol; 2) word in the official orthography of the language (with romanization when needed); 3) English translation (with glosses when needed);
3) Third, the pronunciation of each relevant word, as well as every vowel sound that was of interest, was appropriately demarcated;
4) Fourth, the formant values were exported using the FastTrack Praat plugin [Barreda 2021].

For /ue/, we made an additional layer in the text grid. Upon listening to the realizations, we noticed perceptual differences, so we decided to mark how we perceived this phoneme in each sample. We classified the perception of /ue/ into different categories, such as /ue/, /e/, /o/, or using other labels when appropriate.

3.3. Statistical processing of the acoustic data

For our task of detecting diphthongs in Kildin Saami, we propose using a metric that has been tested in previous research, namely formant trajectory length [Jacewicz et al. 2011; Asu et al. 2012] and a new algorithm which, to our knowledge, has never been applied to a problem like ours: changepoint detection.

Trajectory length is the distance between the starting point of a sound and its ending point, assuming that F1 and F2 are axes. [Asu et al. 2012] proposed a formula that to some extent moderates the effect of coarticulation. They suggested cutting off the first and last fifths of the sound to eliminate the distortion that can appear at the edges of the sound due to the influence of neighboring segments. We made use of this formula (9) as well.

(9) $$\sqrt{(F1_{0.2} - F1_{0.8})^2 + (F2_{0.2} - F2_{0.8})^2}$$

While trajectory length has been shown to be useful for identifying differences between groups of sounds, it cannot be used as a classifier directly. The numbers obtained through this method cannot tell whether a particular sound is a diphthong or a monophthong because a threshold must be set by a researcher, i.e. there is an additional task of deciding which trajectory length is large enough for one's purposes.

We propose that a reliable threshold for trajectory length can be obtained by using balanced data. In balanced data, each tentative diphthong should be matched with a corresponding monophthong, and the overall number of diphthongs and monophthongs should be similar (though not necessarily exactly equal). Using this kind of a dataset, one can compute the trajectory length for all segments and then calculate the mean values. The threshold value for classification can be set as the mean of these means. If the number of diphthongs is equal to the number of monophthongs, it is possible to use the median value.

Another method used for the automatic recognition of diphthongs is changepoint detection. Changepoint detection is the process of identifying points in a time series where the underlying statistical properties of the data change abruptly. Unlike with trajectory length, a researcher does not need to come up with a threshold when working with changepoint detection.

In this study, we used the ruptures package for Python [Truong et al. 2020] to detect changepoints in our data. We chose to use the Pelt algorithm, a popular method for offline changepoint detection. To analyze diphthongs, we used the RBF (radial basis function) model that clusters data by searching for representative centroids. The RBF model is well-suited for identifying the two distinct targets of a diphthong. If two or more centroids were found, we considered the sound to resemble a diphthong.

To determine the accuracy of these metrics, we decided to test them in languages that undoubtedly have monophthong versus diphthong opposition. We chose Standard Estonian (we recorded samples from one male and one female speaker) and Standard Lithuanian (two female speakers). Here are the results in summary.

The performance of trajectory length was impressive. The balanced accuracy of this metric in identifying sounds as monophthongs or diphthongs for Estonian (male) was 0.91; 0.89 for Estonian (female); 0.87 for Lithuanian. The changepoint classifier demonstrated a successful ability to identify most real diphthongs as

diphthongs, as well as most real monophthongs as monophthongs too, and its balanced accuracy is as follows: 0.76 for Estonian (male); 0.81 for Estonian (female); 0.68 for Lithuanian. We thus conclude that these metrics are suitable for applying to our problem.

4. Palatalization or opening diphthongs

4.1. Origin of /ie/ and /ea/ a.k.a. /ʲe:/ and /ʲa:/

The phonemes in question originate from the Proto-Saami diphthongs **ie* and **eä* in the first syllable before **ō* and **ā* of the second syllable, from **ie* before **u*, and from **eä* before **ē*, **ę*, and **i*.

(10) PSaa. **pierkō* > KSaa. *pʲe:r:k ~ pier:k* 'food'[2]
(11) PSaa. **pierkō-sęn* > KSaa. *pier:ku* > *pʲe:r:ke ~ pier:ke* 'food.DAT.SG'
(12) PSaa. **kiemnē-sęn* > **kiem:nu* > KSaa. *kʲe:m:na ~ kiem:na* 'pot.DAT.SG'
(13) PSaa. **seäjpē* > KSaa. *sʲe:j:p ~ siej:p* 'tail'
(14) PSaa. **meärę* > KSaa. *mʲe:r: ~ mier:* 'sea'
(15) PSaa. **meärę-sęn* >**meäri* > KSaa. *mʲe:rʲ:e ~ mierʲ:e* 'sea.DAT.SG'

(16) PSaa. **peältō* > KSaa. *pʲa:l:t ~ peal:t* 'lawn'
(17) PSaa. **seäjpē-sęn* > **seäj:pā* > KSaa. *sʲa:j:pa ~ seaj:pa 'tail.*DAT.SG*'*

There was no opposition between **ie* and **jie* in the onset according to Lehtiranta's dictionary, whereas the roots with **eä* and **jeä* in the onset were opposed in Proto-Saami. However, modern Kildin Saami lost this distinction due to the appearance of a prosthetic *j*.

(18) PSaa. **eärttē* > KSaa. *je:ɾʲ:t* 'side', ISaa. *ertti* 'side'
(19) PSaa. **jeäkē-* > KSaa. *je:gʲ:e* 'to endure', ISaa. *jeehiđ* 'to be hermetic'

T. Itkonen's dictionary [1958] still reflects this opposition. A superscript *ʲ* is used there for the prosthetic phoneme *ʲieɾ̄ˈt̨ᴱ* 'side' and a regular *j* for the reflexes of the Proto-Saami **j jieçķeᵟ* 'to endure'. It is not clear whether this opposition in T. Itkonen's transcription reflects some phonetic reality or just etymology.

4.2. Results of acoustic analysis

To answer whether the phonemes in question are diphthongs or monophthongs, we compared them to undoubted corresponding monophthongs /a:/ and /e:/. We masked tentative diphthongs as real diphthongs and evaluated changepoint and trajectory length classifiers' performance. If the performance was satisfactory, we concluded that the distinction between diphthongs and monophthongs holds. Otherwise, we concluded that there were no phonetic reasons to posit diphthongs.

For /i/- and /e/-initial diphthongs, we identified changepoints only for the first formant since we expect a greater change in closeness than in frontedness. Overall, the number of tentative diphthongs we examined is 120, and the number of monophthongs is 149. The results are presented in Table 3 and Figures 1 and 2[3].

Both classifiers attempt to classify all Kildin Saami vowels primarily as monophthongs regardless of whether they are marked as diphthongs or as monophthongs.

The results are also visualized with violin charts (Figure 2). The x-axis of these plots represents different segment types, while the y-axis represents the value of the statistics used (in this case, the number of changepoints or formant trajectory length). The width of the area within each plot provides information about the distribution of statistical values within the sample. As a general rule, a wider area around a specific value indicates a higher frequency of cases associated with that particular value. Neither tentative /ea/ nor /ie/ show a dramatic difference compared to the monophthongs. They are indeed skewed towards the upper parts of the violins, however, this is not enough to declare them diphthongs since this behavior follows from the fact that these sounds appear after palatalized consonants. In most cases, the number of changepoints and formant trajectory length overlap with the ones found in monophthongs.

[2] Here and in the further examples, we list two variants of phonological interpretations (or variants of pronunciations) divided by tilda.

[3] The temperature scale on the right side of confusion matrices represents the proportion of values by column. In essence, each value in the matrix is color-coded based on its relative proportion within its respective column. For instance, a value 105 appears nearly white, indicating that it comprises approximately 70% of the total count within its column (105 out of the sum of 105 and 44). This way is the best visualization for a balanced accuracy score.

Table 3. Balanced accuracy for Kildin Saami /ʲe:/ and /ʲa:/

Method	Balanced accuracy
changepoint	0.54
trajectory length	0.57

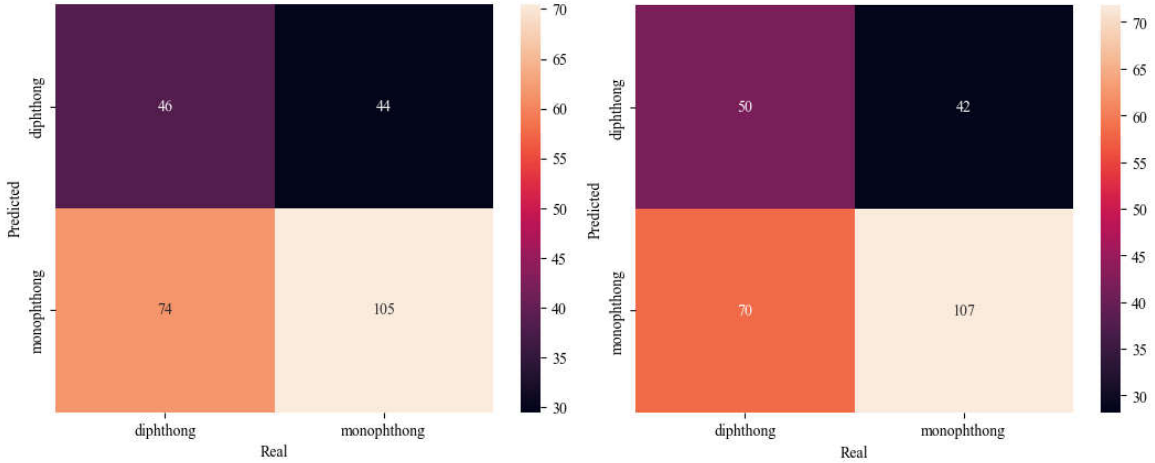

Figure 1. Confusion matrices for Kildin Saami /ʲe:/ and /ʲa:/: changepoint (left) and trajectory length (right)

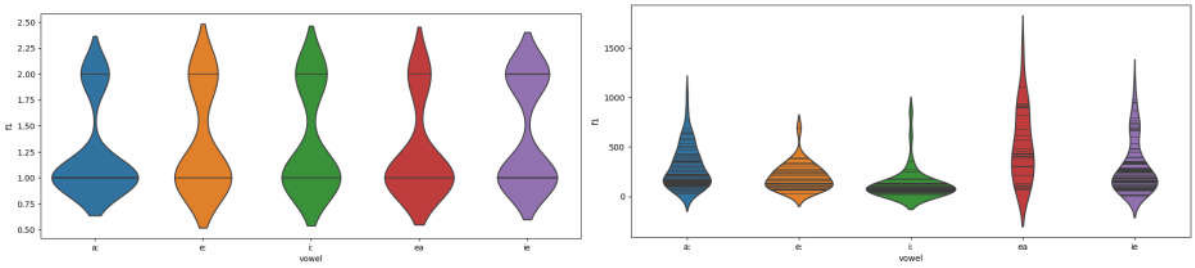

Figure 2. Violin charts for Kildin Saami /ʲe:/ and /ʲa:/: changepoint (left) and trajectory length (right)

To gather further evidence, we extended our analysis to include the data from the Muotka dialect of Skolt Saami. Despite previous descriptions of Skolt Saami as a language with diphthongs and the absence of the alternative interpretation treating them as monophthongs after palatalized consonants, we hypothesized that the Muotka dialect would exhibit similarities with Kildin Saami in this regard.

Therefore, we applied our methods to the Muotka dialect with the expectation of obtaining comparable results to Kildin Saami, supporting the notion of monophthongs after palatalized consonants rather than distinct diphthongs. We investigated the following diphthongs: /iõ/, /eä/, /ie/ that correspond to IPA /iə/, /eæ/, and /ie/. The roadmap was the same. We masked these segments as diphthongs and compared them to the corresponding monophthongs: /õ(:)/, /â(:)/, /e(:)/. The number of diphthongs was equal to 47, and the number of monophthongs was equal to 82. The results are presented in Table 4 and Figure 3.

Contrary to our expectations, the variety of Skolt Saami we researched proved to have /i/- and /e/-initial diphthongs. The confusion matrices for Skolt Saami data show that both classifiers were able to identify most of the diphthongs and monophthongs correctly, indicating that there are acoustic differences that allow for the distinction between these two types of sounds in the language.

Table 4. Balanced accuracy for Skolt Saami

Method	Balanced accuracy
changepoint	0.78
trajectory length	0.75

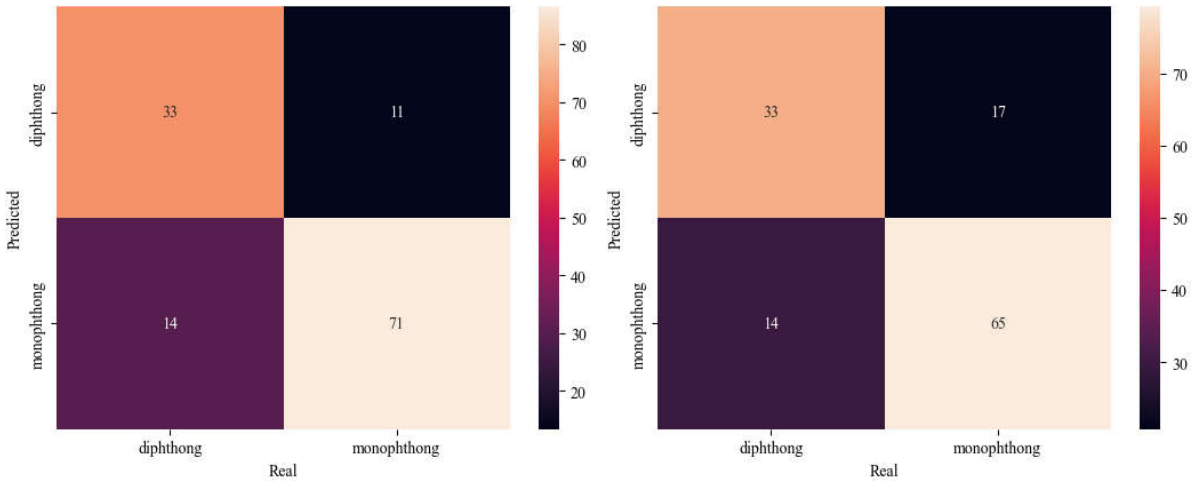

Figure 3. Confusion matrices for Skolt Saami: changepoint (left) and trajectory length (right)

5. Low back vowel or diphthong

5.1. Origin of the low back vowels

The low back vowels originate from two Proto-Saami vowels of the first syllable. Proto-Saami **ā* yields a long low back vowel when before **ę* or contracted vowels **i* and **u* in the second syllable. Proto-Saami **o* yields a short low back vowel before **ō*, **ē*, and contracted **u* and **ā*.

(20) PSaa. **ńārkę* > KSaa. *ɲɒ:r:k ~ ɲoa:r:k* ‘cape’
(21) PSaa. **ńārkę-sęn* > *ńār:ki* > KSaa. *ɲɒ:rʲ:kʲe ~ ɲoa:rʲ:kʲe* ‘cape.DAT.SG’
(22) PSaa. **tālō-sęn* > **tāl:u* > KSaa. *tɒ:l:e ~ toa:l:e* ‘bear.DAT.SG’

(23) PSaa. **olkō* > KSaa. *ɒl:k ~ oal:k* ‘outside’
(24) PSaa. **kopē* > KSaa. *kɒbʲ: ~ koabʲ* ‘pit’
(25) PSaa. **olkō-sęn* > **ol:ku* > KSaa. *ɒl:ke ~ oal:ke* ‘outside.DAT.SG’
(26) PSaa. **kopē-sęn* > **kop:ā* > KSaa. *kɒb:a ~ koab:a* ‘pit.DAT.SG’

Both reflexes of Proto-Saami **ā* and **o* are subject to dialectal variation in these positions. As already noted by Sammalahti [1998: 34], the alternation of the reflexes of **ā* triggered by the contracted vowels is absent in the Aarsjogk dialect. The data on the Aarsjogk dialect are scanty and do not allow us to verify this claim. T. Itkonen’s [1958] materials based first of all on the Killt sõjjt dialect do not show the low back vowel in the place of the Proto-Saami **o*. Most examples demonstrate *o*, i.e. the same reflex as in the position before **ę* (in the weak grade) and **i* of the second syllable. Itkonen uses the symbol ɑ only in rare examples. This variation can be caused either by the dialectal heterogeneity of his material or by the inaccuracy of transcription. The difference in the reflexes of **o* and **ā* is not purely quantitative but qualitative in the Shongui dialect, according to E. Itkonen’s [1971] phonological description.

5.2. Results of acoustic analysis

Two questions arise regarding the acoustic nature of /ɒ/~/oa/. The first question revolves around the presence of a length distinction, investigating whether two distinct segments, short and long, can be identified as /ɒ/~/oa/ and /ɒ:/~/oa:/ respectively. The second question explores the possibility of either of these segments being classified as a diphthong, aiming to determine whether /ɒ/~/oa/ or /ɒ:/~/oa:/ exhibits acoustic characteristics typical of diphthongs.

To address the first question, we conducted a comparison of the lengths of /ɒ/ and /oa/. To carry out this analysis, we performed a two-sample one-sided t-test, assuming that /ɒ/ would have a lesser length than /oa/. We are aware of the problems associated with comparing absolute lengths; however, since both segments were recorded from the same speakers, using non-normalized lengths could potentially yield relevant results. Nevertheless, we consider the conclusions drawn from this analysis to be preliminary.

Sample sizes are 112 and 86 for /ɒ/~/oa/ and /ɒ:/~/oa:/ respectively. The t-test results indicated a significant difference in the average values between the two samples, namely /ɒ/~/oa/ and /ɒ:/~/oa:/ (p-value is less than 0.05), suggesting the existence of a short-long distinction within these segments.

The subsequent question employs a similar methodology to the analysis of /i/- and /e/-initial diphthongs. Given that changepoint has been demonstrated as a valid metric, we rely on its results for examination. For /ɒ/~/oa/, we explored both first and second formants, and the findings are presented in Table 5, with /ua/ serving as a baseline for a diphthong and with /a:/ serving as a baseline for a monophthong.

Table 5. Proportions of cases when the number of changepoints is > 1 for /ɒ/~/oa/, /ɒ:/~/oa:/, /a:/, and /ua/ for two speakers

Segment	Speaker	F1	F2
/ɒ/~/oa/	1	0.277	0.532
	2	0.140	0.360
/ɒ:/~/oa:/	1	0.364	0.364
	2	0.058	0.286
a:	1	0.286	0.333
	2	0.188	0.313
ua	1	0.429	0.667
	2	0.222	0.361

It is evident that two speakers differ in the way they articulate vowels. The first speaker clearly articulates diphthongs such as /ua/, while the second speaker mostly does not articulate even /ua/ as a proper diphthong. However, based on the results of the changepoint analysis, we suggest interpreting both segments, /ɒ/~/oa/ and /ɒ:/~/oa:/, as monophthongs. Nevertheless, it should be considered that /ɒ/~/oa/ has more diphthong-like realizations than /ɒ:/~/oa:/.

Table 6. Average trajectory lengths for /ɒ/~/oa/, /ɒ:/~/oa:/, /a:/ and /ua/

Segment	Speaker	Trajectory length
/ɒ/~/oa/	1	396.5
oa	2	335.9
/ɒ:/~/oa:/	1	371.3
ua	2	281.5
a:	1	273.2
	2	373.8
ua	1	714.9
	2	404.1

The results of the trajectory length analysis are displayed in Table 6, following a similar organizational structure to Table 5. These findings further support the interpretation that the segments under investigation, /ɒ/~/oa/ and /ɒ:/~/oa:/, are much more akin to monophthongs than diphthongs, as well as the idea that the second speaker does not articulate diphthongs as proper diphthongs at all.

To ensure a more robust validation of our observations, we conducted further analysis using the same classifiers as before. However, this time, we ran the classifiers twice: once with /ɒ/~/oa/ and /ɒ:/~/oa:/ included in the list of monophthongs, and once with them excluded from it. We focused on investigating the second formant, as evident from Table 6, where any potential changes appear to be present in this formant. We used the data from the first speaker exclusively. The results of these experiments are illustrated in Figures 4 and 5, respectively.

The results from the classifiers indicate that including /ɒ/~/oa/ and /ɒ:/~/oa:/ in the list of monophthongs leads to higher accuracy of classification even than we look at the second formant which is often under the influence of coarticulation. Considering the efficiency of these methods in identifying diphthongs, we draw the conclusion that both short /ɒ/~/oa/ and long /ɒ:/~/oa:/ should be interpreted as monophthongs. The evidence gathered from these experiments strongly supports the notion that neither of these segments demonstrates characteristics indicative of diphthongs, reinforcing their classification as monophthongs.

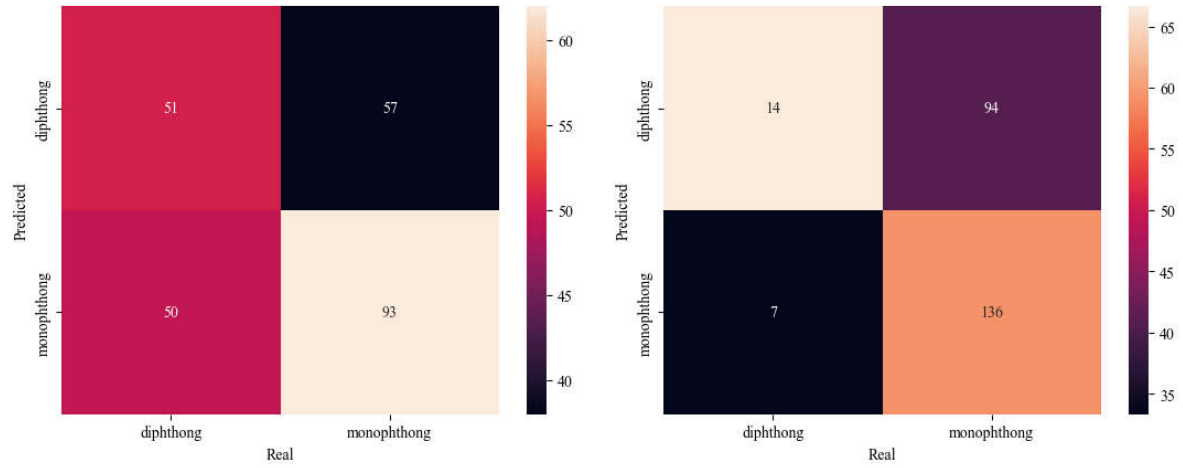

Figure 4. Changepoint analysis: /ɒ/~/oa/ and /ɒː/~/oaː/ as diphthongs (balanced accuracy = 0.56) vs /ɒ/~/oa/ and /ɒː/~/oaː/ as monophthongs (balanced accuracy = 0.63)

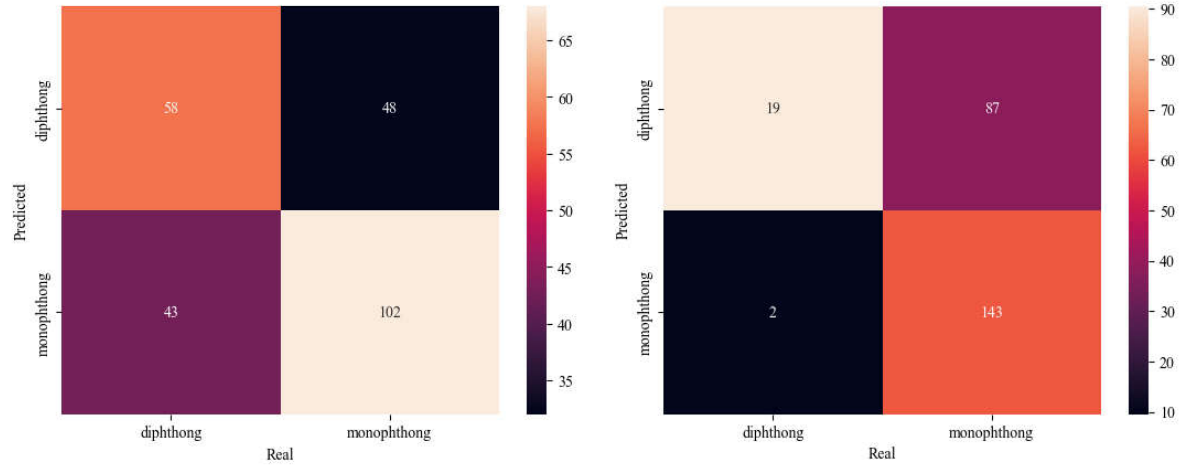

Figure 5. Trajectory length analysis: /ɒ/~/oa/ and /ɒː/~/oaː/ as diphthongs (balanced accuracy = 0.63) vs /ɒ/~/oa/ and /ɒː/~/oaː/ as monophthongs (balanced accuracy = 0.76)

6. Quality of /ua/ a.k.a. /oa/

6.1. Origin of /ua/ a.k.a. /oa/

The diphthong /ua/ (or /oa/ as it is reflected in the sources based on the earlier recordings) originates only from two sources, namely, Proto-Saami **oa* of the first syllable before **ō* and a contracted **ā* in the second syllable.

(27) PSaa. **poalō* > KSaa. *pual:* 'button'
(28) PSaa. **voaǵčē-sẹn* > **voaǵčā* > KSaa. *vuaŋ:ča* 'meat.DAT.SG'

The distribution *ua* is broader in the Aarsjogk dialect since it corresponds also to *ue* of the other dialects there, see Section 7.1 on the origin of *ue*.

6.2. Results of acoustic analysis

The question under investigation is as follows: In the diphthong /ua/, is the first segment (represented here by /u/) acoustically more similar to the corresponding realizations of /o/ or to those of /u/? To answer this question, we conducted a comparison of the realizations of these segments for two native speakers. We aimed to determine the acoustic similarity between the first segment of /ua/ and the corresponding realizations of /o/ and /u/[4].

[4] In this section, we treat long and short vowels as vowels of the same quality, i.e. we do not distinguish here between long and short vowels, since distinguishing between them would not change the overall results.

To minimize artifacts arising from coarticulation, we implemented a preprocessing step by excluding the first and last fifths of all segments. For the /ua/ segment, we specifically extracted only the first third of the sound. This decision was made based on the observation that the formant changes in /ua/ begin very early, and the first third of the segment is considered the most appropriate section, taking into account both its length and acoustic quality.

We extracted N specific anchor points from each realization, where N represents the number of values present in the shortest sound across the sample. For instance, if the shortest sound had 10 identified values, we extracted every tenth value from a sound with 100 identified values. This approach allowed us to standardize the sample sizes and remove extreme values resulting from imperfect formant value identification mechanisms.

Subsequently, we calculated the averages of all anchor points. The results are summarized in Figure 6, where the lines connect the mean values, and the filling represents the standard deviation. For the second formants, we omitted the filling in the figures since our primary interest lies in the first formants, and the standard deviation for second formant values is extensive, making the visualization difficult to perceive.

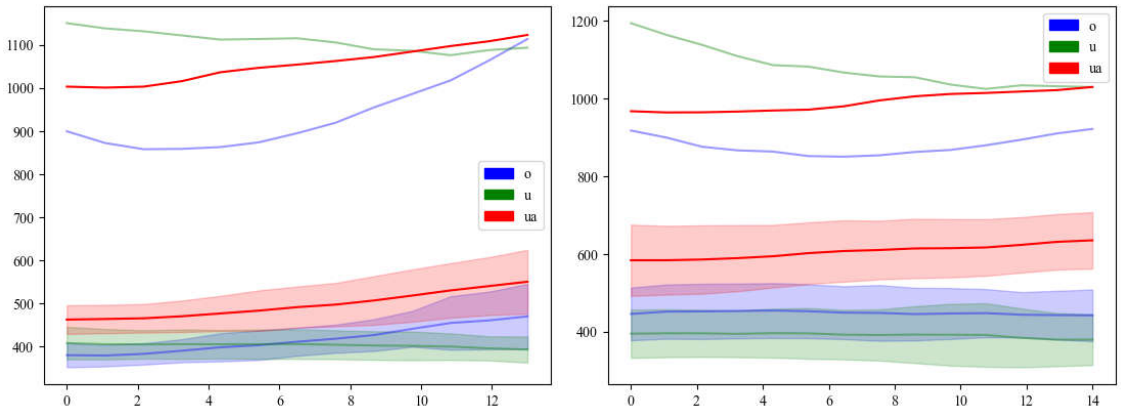

Figure 6. Mean formant values of /o/, /u/, and the first part of /ua/ by two speakers

The results presented in Figure 6 indicate a substantial distinction in the first formant between the first part of /ua/ and both /o/ and /u/. Specifically, the first formant of the initial part of /ua/ is higher, suggesting that the vowel itself is more open compared to both /o/ and /u/. Consequently, this implies that the first part of /ua/ exhibits more similarity to /o/ than to /u/ in terms of the first formant.

7. Monophthongization of /ue/

7.1. Origin of /ue/

The diphthong *ue* originates from Proto-Saami **uo* before **ō* of the second syllable and before the contracted vowels **u* and **ā* and from **oa* before the **ē* of the second syllable.

(29) PSaa. **vuorō* > KSaa. *vuer:* ~ *ve:r:* '(one) time'
(30) PSaa. **vuorō-sẹn* > **vuor:u* > KSaa. *vuer:e* ~ *ve:r:e* '(one) time.DAT.SG'
(31) PSaa. **kuolē-sẹn* > **kuol:ā* > KSaa. *kuel:a* 'fish.DAT.SG'
(32) PSaa. **voaǩčē* > KSaa. *vueɲ:č* ~ *ve:ɲ:č* 'meat'

In the Aarsjogk dialect, the diphthong *ua* corresponds to *ue* of the other Kildin Saami dialects. The results provided below are relevant for the Lujaavv'r, Koardõg sijjt, and Chuudz'jaavv'r dialects.

7.2. Results of acoustic analysis

For the segment /ue/, we conducted an independent annotation process using an additional tier called "perception". In this tier, we marked what sound each realization of /ue/ perceptually resembled. Our hypothesis was that /ue/ undergoes monophthongization in specific positions, and our objective was to identify these positions using acoustic analysis.

When comparing automatic diphthong identification with manual annotation, we found some variation in the results. The changepoint algorithm identified 257 diphthongs and 104 monophthongs in the sample, while manual annotation yielded a total of 191 /ue/ realizations and 170 monophthongs. While the results are compa-

rable, they are not identical, indicating some discrepancies between the automatic and manual identification of diphthongs and monophthongs. These differences may be due to different unaccounted factors involved in the identification process.

The results of both manual and automatic annotation demonstrate a strong correlation. Out of 191 segments that were defined as perceived /ue/ based on manual annotations, 156 were also identified as having more than one changepoint in either formant through automatic analysis. Likewise, out of 257 segments that were automatically identified as having more than one changepoint in either formant, 156 of them were also perceived as /ue/ during the manual annotation process.

We consider the results of manual annotation to be more reliable than those of automatic annotation. The results of manual annotation are summarized in Tables 7 and 8, which include data from one of our speakers specifically examined for this question. This speaker was selected since the monophthongal realization of /ue/ prevails in their speech. The data consist of mean formant values and their corresponding standard deviations for each mean.

We divided the monophthongized realizations of /ue/ into two groups based on their perceptual quality: those similar to [ɘː] and those similar to [ɵː]. Additionally, we provided data separately for the realizations of /ue/ as well as for /uː/~/u/, /oː/~/o/, and /eː/~/e/.

Table 7. Means F2 and F1 for /ue/, /uː/~/u/, /oː/~/o/, and /eː/~/e/ after non-palatalized consonants

	/ue/ > [ɘː]	/ue/ > [ɵː]	/uː/, /u/	/oː/, /o/	/eː/ > [əː], /e/ > [ə]
F2 mean	1872,85	1067,611	861,09	879,92	1832,73
F1 mean	406,72	408,92	421,47	452,66	449,02

Table 8. Means for /ue/, /uː/~/u/, /oː/~/o/, and /eː/~/e/ after palatal(ized) consonants

	/ʲue/ > [ɘː]	/ʲue/ > [ɵː]	/ʲuː/, /ʲu/	/ʲoː/, /ʲo/	/ʲeː/ > [əː], /ʲe/ > [ə]
F2 mean	2283,93	1279,68	1313,35	980,21	2236,87
F1 mean	376,60	362,11	362,18	426,62	403,79

One can see that the unrounded monophthongal realization of /ue/ almost fully coincides with the realization of /eː/~/e/ both after plain and palatalized consonants although it is somewhat closer. The rounded variant deviates both from /uː/~/u/ and /oː/~/o/ being fronted after plain consonants. The variant occurring after palatalized consonants is identical with realizations of /ʲuː/~/ʲu/. These results should be treated as preliminary. The monophthongization of /ue/ requires further investigation involving more data from more speakers.

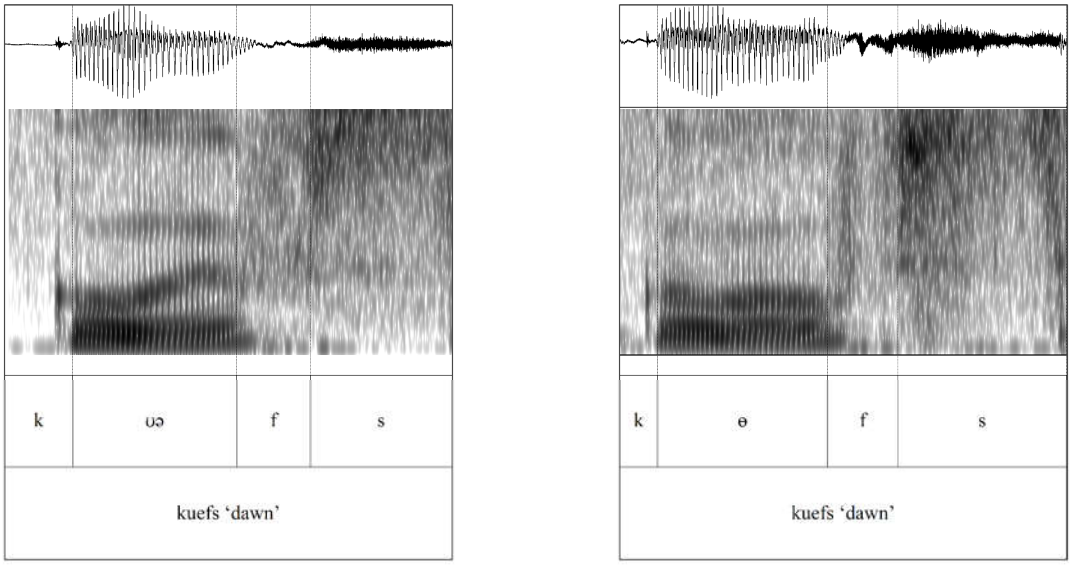

Figure 7. Waveform and spectrogram of two pronunciations of the word *kuefs* 'dawn' produced by one speaker

From our analysis of the patterns of monophthongization, we did not discover any consistent rule or tendency. A crucial observation is that /ue/ can be realized as either a diphthong or a monophthong in the same word produced by the same speaker (Figure 7). The initial hypothesis we made is not supported by the findings. However, the factors responsible for monophthongization remain uncertain, and we acknowledge that further research is required to explore this phenomenon more in depth. As such, we leave this aspect for future investigations.

8. Discussion and conclusions

Some of the problems with the Kildin Saami vowel system can be solved by consistent application of the basic principles of phonological analysis. The simple analysis of the distribution of the long and short diphthongs (Section 2.1) indicates that they are distributed complementary, and, hence, there is no reason to postulate a phonological opposition in quantity, contrary to [Itkonen 1971] and [Wilbur 2007]. Similarly, the analysis of the distribution of i and ɨ (Section 2.3) points to the lack of phonological opposition in the inherited vocabulary. This opposition is forming now due to the newer loans from Russian that show the initial /i/ in contrast to inherited words with the initial /ɨ/. It still has a marginal status that was not emphasized in the previous works. The tentative quantitative opposition of /ɨ/ and /ɨː/ finds no support in the data, so we agree with the conclusions recently reached by Rießler [2022]. Some additional morphophonological considerations help to prove the lack of i-final diphthongs as well as triphthongs. From the phonological point of view, palatal consonants /j/ and /jː/ is a more proper analysis for the segment in question (Section 2.2), contrary [Szabó 1967; Kert 1971; Kostina 2006].

Other problems required more detailed acoustic analysis. To address these challenges, we utilized an established metric, trajectory length, and also incorporated another effective method, changepoint detection, which has demonstrated success in identifying diphthongs. However, it is important to acknowledge that these tools might not provide a conclusive answer to all questions, and additional manual analysis is often necessary. Despite this, they can offer valuable insights into the overall trends.

Application of trajectory length and changepoint detection methods strongly support a non-diphthongal nature of /eː/ and /aː/ after palatal and palatalized consonants (Section 4). One can speak about two allophones of the phonemes /eː/ and /e/. They are represented by the mid front vowels [eː] and [e] after palatal and palatalized (only [eː]) phonemes and by mid central vowels [əː] and [ə] after non-palatalized phonemes. The results of our investigation confirm Kert's [1971] view of these segments.

The same computational procedures reveal that the phonemes corresponding to the orthographic <oa> and <oā> are monophthongs, i.e. low back vowels /ɒː/ and /ɒ/ (Section 5). Thus, our study confirms the findings of the earlier phonetic investigations. The notation <oa> and <oā> should be seen as a purely orthographic convention.

Acoustic analysis of /ua/ reveals that the first part of the diphthong is more open than both /u(ː)/ and /o(ː)/ (Section 6). This result supports E. Itkonen's [1971] interpretation of this diphthong as *oa* and contradicts other authors who prefer to transcribe it as *ua*. A real phonetic realization of the two components of a diphthong almost never fully coincides with cardinal vowels. Thus, our results are not unexpected. The choice of notation in the broad phonological transcription is just a matter of convention: /oa/ stays somewhat closer to phonetic reality but /ua/ is supported by a long research tradition and orthography.

The heterogeneous phonetic realization of /ue/ is revealed in both manual and automatic analysis (Section 7). It shows diphthongal pronunciations [ʊə] (or even [ɔə]) alongside monophthongs [ɵ] and [ə]. There is a considerable inter- and intra-speaker variation in our data. We failed to establish any complementary distribution. Thus, we have to postulate a free variation here. Possibly, we are dealing with an ongoing process of monophthongization which fits into the major trend to reduce the number of diphthongs in Kildin Saami. We hypothesize that the process began relatively recently since there is almost no evidence for monophthongization of /ue/ in the previous descriptions.

Table 9. Vowel system of Kildin Saami according to the present study

Monophthongs			Diphthongs
/iː/ (/i/)	/ɨ/	/u/ /uː/	/ue/
/eː/ /e/		/o/ /oː/	/oa/
	/a/ /aː/	/ɒ/ /ɒː/	

Our view of the Kildin Saami vowel inventory is summarized in Table 9. It includes 15 segments: two diphthongs and 13 monophthongs, one of which has a marginal status. The interpretation of the subsystem of monophthongs as a rectangular space with only front and back rows is theoretically possible if one rejects the opposition /i/ vs /ɨ/. However, phonetically /a/ and /aː/ are clearly low central vowels, cf [Rießler 2022: 221].

It is important to note that our conclusions are based on the material limited to speech of contemporary speakers originating from Lujaavv'r, Koardõgk sijjt, and Chuudz'jaavv'r (only a little data from Aarsjogk are available). At least some discrepancies with the results of earlier studies can be explained by the fact that they reflect features of another dialect [Itkonen, Europaeus 1931; Itkonen 1958; Itkonen 1971; Lehtiranta 1985], or diachronic stratum [Szabó 1967; 1968; Kert 1971; Bjarnson 1976; Wilbur 2007; Rießler 2022]. The lack of diphthongs in the place of *ie* and *ea* as well as the monophthongization of *ue* can be either an older dialectal feature or a very recent innovation. Any verification of T. Itkonen and E. Itkonen's transcriptions (also those published by Lehtiranta [1985]) is impossible since they represent currently extinct dialects of Killt sijjt, Teriberka, and Shongui.

In this paper, the vocalism of Kildin Saami has been thoroughly investigated through the application of two methods of acoustic analysis that demonstrated accuracy in interpreting phonetic data. By employing various techniques, ranging from Praat and automatic formant extraction to changepoint detection, we were able to verify some of the claims made in previous studies on the phonology and phonetics of Kildin Saami. Importantly, these methods can be applied to data from other languages.

As a result of our research, we have achieved a comprehensive understanding of the vowel system, supported by robust evidence, opening the way for future research and offering possibilities for further exploration. Our findings contribute valuable insights to the field of Saami linguistics and offer opportunities for wider application in linguistic studies.

Abbreviations

Languages

ISaa. — Inari Saami
KSaa. — Kildin Saami
PSaa. — Proto-Saami

Glosses

3 — 3rd person
CAUS — causative
COM — comitative
DAT — dative
DIM — diminutive
GEN — genitive
INF — infinitive
LOC — locative
NOM — nominative
NPST — non-past
PASS — passive
PST — past
PL — plural
SG — singular

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References

Aikio 2012 — *A. Aikio.* An essay on Saami ethnolinguistic prehistory. In: A Linguistic Map of Prehistoric Northern Europe (Suomalais-Ugrilaisen Seuran Toimituksia 266). Helsinki: Suomalais-Ugrilainen Seura, 2012. P. 63—117.

Aikio, Ylikoski 2022 — *A. Aikio*, *J. Ylikoski*. North Saami. In: M. Bakró-Nagy, J. Laakso, E. Skribnik (eds.). The Oxford Guide to the Uralic Languages. Oxford: Oxford University Press, 2022. P. 147—177.

Antonova 2014 — *S. Antonova*. Sām'-rūšš sānn'nehk'. Murmansk: Lema, 2014. {S. Antonova. Saami-Russian dictionary. Murmansk: Lema, 2014.}

Asu et al. 2012 — *E .L. Asu, P. Lippus, E. Niit, H. Türk*. The acoustic characteristics of monophthongs and diphthongs in the Kihnu variety of Estonian. In: Linguistica Uralica. 2012, 48 (3). P. 161—170.

Bakró-Nagy 2022 — *M. Bakró-Nagy.* Consonant gradation. In: M. Bakró-Nagy, J. Laakso, E. Skribnik (eds.). The Oxford guide to the Uralic languages. Oxford: Oxford University Press, 2022. P. 859—867.

Barreda 2021 — *S. Barreda*. Fast Track: fast (nearly) automatic formant-tracking using Praat. In: Linguistics Vanguard. 2021, 7 (1). 20200051.

Bjarnson 1976 — *D. E. Bjarnson*. A phonemic transcription of Lovozero (Kildin) Lappish. Bloomington: Indiana University MA thesis. 1976.

Boersma, Weenink 2021 — *P. Boersma, D. Weenink*. Praat: doing phonetics by computer [Computer program]. http://www.praat.org/. 2021.

Feist 2010 — *T. Feist*. A grammar of Skolt Saami. University of Manchester PhD thesis. 2010.

Genetz 1891 — *A. Genetz*. Kuollan lapin murteiden sanakirja ynnä kielennäytteitä (Bidrag till Kännedom Af Finlands Natur Ock Folk 50). Helsinki: Finska Litteratur-Sällskapets tryckeri, 1891.

Halász 1881 — *I. Halász*. Orosz-lapp nyelvtani vázlat. Nyelvtudományi közlemények. 1881, (17). P. 1—45.

Itkonen 1971 — *E. Itkonen*. Ehdotus kildininlapin Šongujn murteen fonemaattiseksi transkriptioksi. In: Lapin murteiden fonologiaa (Castrenianumin Toimitteita 1). Helsinki: Suomalais-Ugrilainen Seura, 1971. P. 87—110.

Itkonen 1916 — *T. I. Itkonen*. Venäjänlapin konsonanttien astevaihtelu koltan, kildin ja turjan murteiden mukaan (Suomalais-Ugrilaisen Seuran Toimituksia XXXIX). Helsinki: Societe finno-ougrienne, 1916.

Itkonen 1958 — *T. I. Itkonen*. Koltan- ja kuolanlapin sanakirja (Lexica Societatis Fenno-Ugricae XV). 2 vols. 2nd ed. Helsinki: Suomalais-Ugrilainen Seura, 1958.

Itkonen, Europaeus 1931 — *T. I. Itkonen, D. E. D. Europaeus*. Koltan- ja kuolanlappalaisia satuja (Suomalais-Ugrilaisen Seuran Toimituksia LX). Helsinki: Suomalais-Ugrilainen Seura, 1931.

Jacewicz et al. 2011 — *E. Jacewicz, R. A. Fox, J. Salmons*. Vowel change across three age groups of speakers in three regional varieties of American English. In: Journal of Phonetics. 2011, 39 (4). P. 683—693.

Kert 1971 — *G. M. Kert*. Saamskij jazyk (kil'dinskij dialekt): fonetika, morfologija, sintaksis. Leningrad: Nauka, 1971. {G. M. Kert. Saami language (Kildin dialect): phonetics, morphology, syntax. Leningrad: Nauka, 1971.}

Kert 1986 — *G. M. Kert*. Saamsko-russkij, russko saamskij slovar'. Leningrad: Prosveshchenie, 1986. {G. M. Kert. Saami-Russian, Russian-Saami dictionary. Leningrad: Prosveshchenie, 1986.}

Kert, Matusevich 1962 — *G. M. Kert, M. I. Matusevich*. K voprosu o sostave soglasnyh fonem v voroninskom govore kil'dinskogo dialekta saamskogo jazyka. In: Finno-ugorskaja filologija. (Uchenye Zapiski Leningradskogo Gosudarstvennogo Universiteta Imeni A. A. Zhdanova; № 314, vyp. 63). Leningrad: Leningradskij Gosudarstvennyj Universitet imeni A. A. Zhdanova, 1962. P. 19—37. {G. M. Kert, M. I. Matusevich. On the issue of the inventory of consonant phonemes in the Voronie dialect of the Kildin macrodialect of the Saami language. In: Finno-Ugric philology (Scientific Notes of the Leningrad Order of Lenin State University Named after A. A. Zhdanov. No. 314, issue 63). Leningrad: Leningradskij Gosudarstvennyj Universitet imeni A. A. Zhdanova, 1962. P. 19—37.}

Koponen 2022 — *E. Koponen*. Saami: general introduction. In: M. Bakró-Nagy, J. Laakso, E. Skribnik (eds.). The Oxford Guide to the Uralic Languages. Oxford: Oxford University Press, 2022. P. 103—112.

Koponen et al. 2022 — *E. Koponen, M. Miestamo, M. Juutinen*. Skolt Saami. In: M. Bakró-Nagy, J. Laakso, E. Skribnik (eds.). The Oxford Guide to the Uralic Languages. Oxford University Press, 2022. P. 196—218.

Korhonen 1981 — *M. Korhonen*. Johdatus lapin kielen historiaan. Helsinki: Suomalaisen Kirjallisuuden Seura, 1981. {M. Korhonen. Introduction to the history of the Saami languages. Helsinki: Suomalaisen Kirjallisuuden Seura, 1981.}

Korhonen et al. 1973 — *M. Korhonen, J. Mosnikoff, P. Sammallahti*. Koltansaamen opas (Castrenianumin Toimitteita 4). Helsinki, 1973.

Kostina 2006 — *G. V. Kostina*. Vokalicheskaja sistema kildinskogo dialekta saamskogo jazyka v svete russko-saamskoj interferencii. Sankt-Peterburg: Sankt-Peterburgskii Gosudarstvennyi Universitet, dissertacija na soiskanie uchenoj stepeni kandidata filologicheskikh nauk 2006. {G. V. Kostina. Vowel system of Kildin Saami in the light of Russian-Saami interference. Saint Petersburg: Saint Petersburg State University PhD thesis. 2006.}

Kowalik 2023 — *R. Kowalik*. Towards a grammar of spoken South Saami. Stockholm: Stockholm University PhD thesis. 2023.

Kuokkala 2019 — *J. Kuokkala*. Saami -(š)goahti inchoatives: their variation, history, and suggested cognates in Veps and Mordvin. In: Suomalais-Ugrilaisen Seuran Aikakauskirja. 2019, 97. P. 153—181.

Kuruch et al. 1985 — *R. D. Kuruch, N. E. Afanasieva, E. I. Mechkina, A. A. Antonova, B. A. Glukhov, L. D. Yakovlev*. Saamsko-russkij slovar'. Moskva: Russkij jazyk, 1985. {R. D. Kuruch, N. E. Afanasieva, E. I. Mechkina, A. A. Antonova, B. A. Glukhov, L. D. Yakovlev. Saami-Russian dictionary. Moscow: Russkij jazyk, 1985.}

Kuzmenko, Rießler 2012 — *Y. K. Kuzmenko, M. Rießler*. K voprosu o tverdyh, mjagkih i polumjagkih soglasnyh v kol'skom saamskom. In: Acta Linguistica Petropolitana. 2012, 8 (1). P. 21—42. {Y. K. Kuzmenko, M. Rießler. On "hard", "soft" and "half-soft" consonants in Kola Saami. In: Acta Linguistica Petropolitana. 2012, 8 (1). P. 21—42.}

Lehtiranta 1985 — *J. Lehtiranta* (ed.). Kildinlappische Sprachproben (Suomalais-Ugrilaisen Seuran Toimituksia 191). Helsinki: Suomalais-Ugrilainen Seura, 1985.

Lehtiranta 1989 — *J. Lehtiranta*. Yhteissaamelainen sanasto (Suomalais-Ugrilaisen Seuran Toimituksia 200). Helsinki: Suomalais-Ugrilainen Seura, 1989.

Moran, McCloy 2019 — *S. Moran, D. McCloy* (eds.). PHOIBLE 2.0. Jena: Max Planck Institute for the Science of Human History, http://phoible.org 2019.

Rießler 2022 — *M. Rießler*. Kildin Saami. In: M. Bakró-Nagy, J. Laakso, E. Skribnik (eds.). The Oxford Guide to the Uralic Languages. Oxford University Press, 2022. P. 219–239.

Sammallahti 1998 — *P. Sammallahti*. The Saami Languages: An Introduction. Kárášjohka: Davvi Girji, 1998.

Sammallahti, Khvorostukhina 1991 — *P. Sammallahti, A. Khvorostukhina*. Unna sámi-sām' sām'-sámi sátnegirjjáš. Ohcejohka: Girjegiisá Oy, 1991. {P. Sammallahti, A. Khvorostukhina. Small (North) Saami — (Kildin) Saami dictionary. Ohcejohka: Girjegiisá Oy, 1991.}

Szabó 1967 — *L. Szabó*. Kolalappische Volksdichtung (Texte aus der Dialekten in Kildin und Ter) (Abhandlungen Der Akademie Der Wissenschaften in Göttingen. Philologisch-Historische Klasse 68). Vol. 3. Göttingen: Vandenhoeck & Ruprecht, 1967.

Szabó 1968 — *L. Szabó*. Kolalappische Volksdichtung (Texte aus der Dialekten in Kildin und Ter). Zweiter Teil nebst grammatischen Aufzeichnungen (Abhandlungen Der Akademie Der Wissenschaften in Göttingen. Philologisch-Historische Klasse 72). Göttingen: Vandenhoeck & Ruprecht, 1968.

Tereshkin 2002 — *S. N. Tereshkin*. Jokan'gskij dialekt saamskogo jazyka. Sankt-Peterburg: Rossiiskii Gosudarstvennyi Pedagogicheskii Universitet imeni A. I. Gerzena, dissertacija na soiskanie uchenoi stepeni kandidata filologicheskikh nauk, 2002. {S. N. Tereshkin. Yokanga dialect of the Saami language. Saint Petersburg: Herzen State Pedagogical University of Russia PhD thesis, 2002.}

Truong et al. 2020 — *C. Truong, L. Oudre, N. Vayatis*. Selective review of offline change point detection methods. In: Signal Processing. 2020, 167. 107299.

Wilbur 2007 — *J. Wilbur*. Syllable Structures and Stress Patterns in Kildin Saami. Leipzig: Leipzig University MA thesis. 2007.

Wilbur 2014 — *J. Wilbur*. A grammar of Pite Saami (Studies in Diversity Linguistics 5). Berlin: Language science press, 2014.

Ylikoski 2022 — *J. Ylikoski*. South Saami. In: M. Bakró-Nagy, J. Laakso, E. Skribnik (eds.). The Oxford guide to the Uralic languages. Oxford: Oxford University Press, 2022. P. 113—129.

Zaikov 1987 — *P. M. Zaikov*. Babinskij dialekt saamskogo jazyka. Petrozavodsk: Karelija, 1987. {P. M. Zaikov. Akkala dialect of the Saami language. Petrozavodsk: Karelija, 1987.}

Zhivlov 2023 — *M. A. Zhivlov*. Reconstruction of Proto-Uralic. In: D. M. Abondolo, R.-L. Valijärvi (eds.). The Uralic languages (Routledge Language Family). 2nd ed. Abingdon; Oxon; New York, NY: Routledge, 2023. P. 117—175.

Appendix A: list of stimuli

ʲe:

cʲeːl̥ʲːkʲe	‘to say’	*lʲeːk*	‘chair back.NOM.PL’	*tʲeːmʲe*	‘even’
jeːkxelːe	‘to disturb’	*lʲeːfː*	‘barn’	*tʲeːdː*	‘know.NPST.3SG’
jeːlːe	‘to live’	*lʲeːn̥ʲkʲesʲtʲ*	‘strap.LOC.SG’	*vʲeːkʲ*	‘assistant.NOM.PL’
jeːnːe	‘many’	*lʲeːn̥ʲːkʲ*	‘strap’	*vʲeːr̥ːc*	‘bag’
jeːr̥ʲːtʲ	‘side’	*ɲeːlʲːkʲ*	‘hunger’	*vʲeːʰkʲ*	‘assistant’
jeːʰk	‘stranger’	*pʲeːlʲːkʲ*	‘thumb’	*vʲeːlʲːkʲ*	‘debt’
lʲeːjːp	‘bread’	*sʲeːl̥ːke*	‘to butt’	*vʲeːrːe*	‘to hew’

e: **e**

eːlʲːesʲ	‘high’	*meːnːe*	‘to go’	*seːrːv*	‘moose’
elʲkʲetʲ	‘begin.PST.2PL’	*leːsːt*	‘leaf’	*sʲeːjːp*	‘(long) tail’
eːxːt	‘one’	*neːdː*	‘handle’	*sʲeːsːan*	‘(my) paternal aunt’
eːlʲːesʲ	‘tall’	*peːks*	‘lip’	*šeːr̥ː*	‘noise’
jenta	‘tomorrow’	*peːlːe*	‘to fear’	*terʲvenʲ*	‘pitch.COM.SG’
keːʒe	‘to ask’	*peːr̥ːt*	‘house’	*veːrː*	‘blood’
kepše	‘to be ill’	*peːvːl*	‘cloud’	*veːʒ*	‘snow’

i:

iːnː	‘voice’	*lʲiːfːte*	‘to go out’	*pʲiːŋːk*	‘wind’
kʲiːbː	‘soot’	*lʲiːxːte*	‘to go out’	*rʲiːšːe*	‘to make a row’
kʲiːče	‘look.PST.3SG’	*pʲiːʒan*	‘short tail’	*tʲiːdʲːe*	‘to know’
kʲiːʰče	‘to look’	*pʲiːras*	‘family’	*tʲiːn*	‘your (PL)’
kʲiːje	‘trace.ACC.SG’	*pʲiːŋʲkeɲč*	‘wind.DIM’	*šʲiːg*	‘good’

iː:

kɨdː	‘spring’	*pɨj*	‘put.NPST.3SG’	*pɨrː*	‘around’
kɨʒʲːe	‘to wilt’	*pɨje*	‘to put’	*pɨrs*	‘around’

piʂ:	‘rifle’	*riʤʲ:*	‘road (next to a mountain)’	*šiɬʲ:e*	‘to catch’
piŋ:e	‘to cherish’	*sijp*	‘swing.ACC.SG’	*šišʲ:enʲ*	‘leather’
riʙ:	‘dust’	*sij:p*	‘swing’	*iɣʲ:*	‘year’
riʙʲ:exʲ	‘handkerchief’	*šiɬ*	‘catching’	*iʲ:*	‘night’
riʤ:	‘rib cage’	*šiɬ:muš*	‘catch’	*iɬ:*	‘coal’
				iš:te	‘to sit’

ʲa:

ča:j:	‘tea’	*cʲa:l̥:k*	‘say.NPST.3SG’	*lʲa:j:paj*	‘full of bread’
čalʲ:mʲ	‘eye’	*ja:l*	‘life’	*lʲa:ɱ:ka*	‘strap.DAT.SG’
ča:r:	‘tundra’	*lʲa:j:*	‘be.NPST.3SG’	*tʲa:ŋka*	‘money.DIM’

a: **a**

abʲ:rʲ	‘rain’	*ka:tʲe*	‘close.PST.3SG’	*pa:ɾ:k*	‘bark’
a:gʲ:	‘century’	*kaʰcʲe*	‘to catch’	*ra:n̥ʲ:*	‘injury’
a:ka	‘woman.DIM’	*la:k*	‘(meat) jelly.ACC.SG’	*raŋ̊ʲ:tʲ*	‘chest’
a:kʲ	‘woman.NOM.PL’	*la:ʰk*	‘(meat) jelly’	*saj:*	‘place’
alʲ:kʲ	‘son’	*la:v:ke*	‘to bathe’	*sarʲ:*	‘blueberry’
a:j:t	‘barn’	*ma:d:*	‘worm’	*sa:r:ne*	‘to speak’
a:̊ʰkʲ	‘woman’	*ma:j:t*	‘milk’	*ta:l:*	‘bear’
a:n:e	‘to ask’	*ma:n:*	‘moon’	*tarʲ:vʲ*	‘resin’
aǯ	‘father’	*ma:j:k*	‘big whitefish’	*ta:xʲ:tʲ*	‘bone’
ažʲ:a	‘father.DIM’	*pa:l̥:*	‘ball’	*ta:ʰte*	‘to want’
jax:ta	‘yesterday’	*pa:n:a*	‘tooth.DIM’	*pa:l:*	‘ball’
ka:s:v	‘face’	*pa:nʲ:*	‘tooth’	*va:r:*	‘forest’

o: **o**

co:v:ne	‘to awaken’	*o:ʒe*	‘to search’	*čo:g:*	‘sharp’
ko:l:m	‘three’	*po:n:c*	‘feather’	*čo:lʲ:kʲje*	‘to spit’
ko:r:e	‘to tie’	*po:r:k*	‘blizzard’	*čo:l:ke*	‘to spit’
ko:t:k	‘ant’	*to:l:*	‘fire’	*jo:g:*	‘river’
olkes	‘outside’	*o:l:k*	‘crossbar’	*jo:r:e*	‘to fall’
o:d:	‘new’	*o:m:p*	‘full’	*jo:ŋ:*	‘cowberry’

ua

kuaj:ve	‘to dig’	*puar*	‘horsefly’	*vuaj:pe*	‘to fight’
kuaskan	‘(my) maternal aunt’	*puaz*	‘reindeer.ACC.SG’	*vuag:e*	‘to trot’
kuar:e	‘to sew’	*tuar:*	‘fight’	*ɲual:e*	‘to lick’
pual:	‘button’	*tuar:e*	‘to fight’	*ɲuam:e*	‘to crawl’

u: **u**

kud:	‘six’	*su:l:olma*	‘thief’	*čuj:v*	‘clay’
kun:	‘cinder’	*ucʲ:*	‘small’	*ču:l:t*	‘stump’
ku:c:	‘rotten’	*uk:s*	‘door’	*ču:zxe*	‘to hurt’
pu:lʲ:e	‘to burn’	*ul:*	‘wool’	*ču:ʒʲ:e*	‘to hurt (of body parts)’
sug:e	‘thick’	*jug:e*	‘drink’	*čux:č*	‘capercaillie’
				ɲux:č	‘swan’

ue

cuemp	‘frog’	*lued:*	‘foam’	*ruenn*	‘green’
kuefs	‘dawn’	*luen:*	‘garbage’	*ruep:t*	‘against’
kuedʲ:	‘traditional Saami lodging’	*lueval*	‘shavings’	*suel*	‘island’
		mʲi:ne guejke	‘for us’	*suemʲ:pʲ*	‘cane’
kuem	‘ruminant stomach contents’	*mʲi:ne vuejke*	‘for us’	*šueɲ:*	‘swamp’
		mued:eguejm	‘maternal aunt.COM.PL’	*sʲi:reguejm*	‘game.COM.PL’
kueŋ	‘along’	*nɒvʲteguejm*	‘beast.COM.PL’	*sʲi:re guejke*	‘for games’
kuer:k	‘shallow’	*nuerʲ:j:*	‘seal’	*tʲi:ne guejke*	‘for you’
kuešʲ:	‘pelt’	*pa:rne guejke*	‘for children’	*to:n guejke*	‘for thee’
ku:sʲeguejm	‘guest.COM.PL’	*pa:leguejm*	‘ball.COM.PL’	*tueg:a*	‘behind’
kuev:le	‘to turn out on the front side’	*pu:ʒeguejm*	‘bird.COM.PL’	*tuelʲ:*	‘table’
		puerʲesʲ:	‘old (of humans)’	*va:rʲeguejm*	‘forest.COM.PL’
la:m’peguejm	‘swamp.COM.PL’	*puerxe*	‘to caress’	*vuej:*	‘creek’
lɒnʲteguejm	‘bird.COM.PL’	*rʲi:mʲneguejm*	‘fox.COM.PL’	*vuemʲ:*	‘old (of things)’

vueŋenʲ	‘daugher-in-law.COM.SG’	*čuelʲː*	‘gut’	*juːdʲː*	‘saucer’
vuerː	‘time (event)’	*čueŋːče*	‘to stay’	*juedeŋč*	‘saucer.DIM’
vuesːkan	‘perch’	*čuevːe*	‘to yearn’	*juev*	‘calm’
čuej	‘strip’	*čuez*	‘reindeer herd’	*ɲuesʲː*	‘bad thing’
čuekas	‘road’	*čueʒ*	‘hurt.NPST.3SG’		

ɒː ɒ

kɒːbbkeŋč	‘newlywed wife.DIM’	*lɒgʲː*	‘ten’	*šɒgːe*	‘to blow (of wind)’
kɒːbːe	‘newlywed wife.DAT.SG’	*lɒnʲt*	‘bird.ACC.SG’	*ɒlːk*	‘street’
kɒːvːne	‘to find’	*ɒːsːe*	‘to pitch a tent’	*ɒsːke*	‘to believe’
kɒbʲː	‘pit’	*pɒːʰk*	‘order.NPST.3SG’	*ɒrːe*	‘to sit’
kɒʰče	‘to call’	*pɒnʲː*	‘bottom (of a body of water)’	*vɒːrʲːde*	‘to cherish’
kɒlʲː	‘gold’	*pɒːsːe*	‘to blow (of a person)’	*čɒj*	‘tea’
kɒnʲːte	‘to kill’	*sɒːgː*	‘news’	*čɒːʰpʲesʲ*	‘black’
kɒšʲːkʲ	‘dryness’	*sɒːjːvʲ*	‘South’	*čɒgːe*	‘comb.DAT.SG’
kɒžʲ	‘soot’	*sɒːvʲːj*	‘South’	*ɲɒrːk*	‘cape’
lɒːfːk	‘bag’	*sɒrʲmʲ*	‘death.ACC.SG’	*čɒːgːe*	‘to fit’
lɒːgː	‘ceiling’	*sɒrʲːmʲ*	‘death’	*jɒdʲːe*	‘to go’
lɒːnʲːt	‘bird’	*vɒːʰc*	‘mitten’	*jɒrkse*	‘to turn inside out’
lɒːntexʲ	‘(ripe) cloudberry’	*šɒgː*	‘blow.NPST.3SG’		