An Intra- and Inter-Dialectal Study of Korebaju Vowels

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Abstract

Korebaju (ISO 639-3 coe) [kóˀrèbàjɨ́] is an endangered Tukanoan language spoken in the foothills of the Colombian Amazon. Two fieldworks carried out between 2021 and 2023 on a sample of 24 native speakers (12 females and 12 males) from two different varieties: Tama and Korebaju, located in two different villages, provide new data for improving intra- and inter-dialectal phonetic-phonological description of Korebaju. This acoustic study focuses on the vowel system of each of these two varieties and is the first part of an ongoing project on vowel nasalization and glottalization in Korebaju. The acoustic and statistical analyses indicate that there are no significant interdialectal differences between vowels. However, differences between generations of the same sex and of the same variety have been evidenced in our analyses. These results also suggest that Korebaju speakers' perception of stronger glottalization in the Tama variant refers to a morphological distinction. However, this hypothesis is still being analyzed considering the language's tonal system, nasalization, and morphology.

Index Terms: Language description, Tucanoan, acoustic formant space, acoustic duration, dialectal variation.

1. Introduction

Korebaju is a tonal language spoken in the foothills of the Colombian Amazon, belonging to the western branch of the Tukanoan family. This community today is the result of the historical union of 4 distinct populations: Korebaju, Tama, Macaguaje, and Carijona, who have adopted Korebaju as their own language after their original language became extinct. However, these communities try to sustain their original culture through cultural diasporas. Likewise, cross-dialectal variation seems to be present in Korebaju as each of these communities has settled in different territories in the same geographic area, distinguishing themselves until today through their clan distribution [1]. As claimed by the speakers of these communities, inter-dialectal variations exist and contribute to the identity factors of belonging to a clan. With a global population of around 2,000 native speakers, Korebaju is a definitely endangered language according to the UNESCO Word Atlas of Languages [2]. The Tama (Lat 1.5945, Long -75.41448) and Korebaju (Lat 1.01744, Long -75.2914) communities are located one hour away from each other by canoe with a 15-HP motor, however, they share cultural events, organizational meetings in which all Korebaju communities also participate.

The present investigation is part of a comparative study between two dialectal variants, Tama and Korebaju, which, according to the speakers, present distinctions not only at the prosodic level but also in the production and distribution of glottalization. Two more recent studies suggested that Korebaju has an inventory of six oral vowels /i, e, a, o, u, ɨ/, six nasal vowels /ĩ, ẽ, ã, õ, ũ, ɨ̃ /, and three glottal vowels /aˀ/, /eˀ/ and /oˀ/ [3], as well as 17 consonants /p, t, k, pʰ, tʰ, kʰ, β, ɸ, s, h, w, c, m, n, ɲ, ʰɲ, r/, and a mixed segmental and suprasegmental glottalization system [4].

1.1. Previous analysis without considering dialectal variation

Before our investigation, few previous studies have described the vowels of Korebaju, and none have taken into account the dialectal variations: [5] proposed an inventory of 6 phonemic basic vowels /i, e, a, o, u, ɯ/, a suprasegmental nasalization based on nasal harmony, and suprasegmental glottalization as a consequence of a long vowel elision; [6] advanced a 12-vowel system /i, e, a, o, u, ɯ, ĩ, ẽ, ã, õ, ũ, ɯ̃/; finally, [7] suggested a system with 6 basic vowels /i, e, a, o, u, ɨ/, a suprasegmental nasalization according to [5], and a glottal stop that is part of the consonant inventory. This last description pointed out the presence of two dialectal variants (Tama and Korebaju) but did not provide differential data between these two variants.

1.2. Our recent investigation on the Korebaju variety

[3], [4], [8] described the Korebaju (COE) variant with an inventory of six oral vowels including a high unrounded central vowel /i, e, a, o, u, ɨ/, six nasal vowels /ĩ, ẽ, ã, õ, ũ, ɨ̃/ and three glottal vowels /aˀ, eˀ, oˀ/ as part of a mixed system of glottalization, segmental and suprasegmental, that would depend on the syllabic structure of the language as well as on the tonal contour of the preceding vowel in a CVV syllable.

1.3. Previous studies on the Tama variety

Only one investigation to date has described the Tama (TAM) dialectal variant. [9] proposed a 11-vowel phonemic inventory, and nine corresponding allophones: /i/ [j], /ĩ/, /e/ [ɛ], /ẽ/ [ɛ̃], /a/, /ʉ/ [ɨ] [ɤ], /ʉ̃/ [ɨ̃], /u/ [w], /ũ/, /o/ [ɔ], /õ/ [ɔ̃]. Moreover, [9] indicated that: (1) allophones of unrounded back closed vowels were present when a palatal consonant preceded them, as previously indicated by [3] for back and central closed vowels in the Korebaju variant; (2) the allophones of the mid vowels /e, o/ occurred when they preceded the rhotic [r] or succeeded it, or in stressed syllables; (3) finally, the nasal allophones were found in contexts of nasal consonants. However, no acoustic analyses that could support such phonemic assimilations were presented in this study. We propose, in the present investigation, an acoustic description of the vowel system of Korebaju with both cross-dialectal and social comparisons, by taking gender and two different generations as independent variables.

2. Method

Two fieldworks were conducted for this study. The first one carried out from December 2021 to March 2022, and the second one from December 2022 to February 2023. Our acoustic study was carried out by analyzing production data of native speakers recorded at normal speech rate. These data were obtained from a survey of the vowel system of the TAM and COE varieties, which included an elicitation paradigm based on minimal and quasi-minimal pairs.

2.1. Participants

24 native speakers (12 females and 12 males) divided equally in each dialectal variant TAM and COE (six males and six females), from two different generations (G1 from 18 to 31 years old, and G2 from 42 to 70 years old) were involved in the study. All participants were native speakers of Korebaju and were of Korebaju and Tama descent. They also spoke Spanish as a second language, with the local settlers and at the boarding secondary school of the region. No speaker had left the community for more than two weeks at the time the recording took place.

2.2. Materials

A D800 EGG electroglottograph from Laryngograph was used to gather synchronized sound, electroglottographic, nasal, and oral airflow data. The EGG was connected directly to a laptop computer through a USB port. VoiceSuite 10.4.0 software [10] was used for data collection. Praat software [11] was used for segmentation, transcription, and analyses of the collected data, and R for quantitative and statistical analyses [12]. Recordings were made with an omnidirectional microphone placed inside the Oronasal chamber Teen-Adult mask from Glottal Enterprise and connected to the D800 EGG. The sampling frequency was 24 Khz for each of the four-channel recorded (i.e. wav, EGG, nasal and oral airflows). Recordings were made in an enclosed area and at certain times of the day to avoid background noise and atmospheric sounds of the Amazon rainforest, such as bird songs and other sounds produced by forest animals.

2.3. Procedure and data analysis

Two list of 118 and 145 words, embedded in a carrier sentence, were recorded between 2021 and 2023, respectively. The first list of 118 words was collected for all 24 speakers. This list was designed to obtain the production of minimal and quasi-minimal pairs in as many word contexts as possible. The second list of 145 words was recorded for 12 speakers (three speakers of each variety from both genders and both generations). This second list was conducted in order to complete the identification of minimal and quasi-minimal pairs in all possible contexts among the speakers of each variety and to verify the existence of nasal harmony and tonal contours.

The carrier sentence was constructed as follow:

/cɨ̀kɨ́nà ìkámè ___ kóˀrèbàhɨ́ cɨ́òpí/
{cɨ̀kɨ́nà ìká-mè ___ kóˀrèbàhɨ́ cɨ́òpí}
we say-PL ___ Korebaju language
'We say____in Korebaju'

Measurements were performed through a manual segmentation of words, syllables, and phones, using for each vowel delimitation the beginning and the end of the stable part of the second formant F_2. This task was followed by a fine phonetic and phonological labeling. Then, an automatic extraction of the f_0 and of the first four formants at 30%, 50%, and 70% of the vowel duration was performed.

Statistical analyses were done with different models. For the analysis of oral vowel formants, statistical tests were performed by using three different Generalized Linear Mixed Models (GLMM). For each response variable (F_1, F_2, F_3), we studied the impact of the fixed factors Dialect (COE and TAM), Gender (F and H), Generation (G1 and G2), Vowel (a, e, i, o, u, ɨ), Percentage (30, 50, 70) and their interactions. The factor *Participant* was introduced as a random effect. These models allowed at the same time to take into account the repetition of the measurements, the residual variances that can change between the modalities of the same factor, and also the correlations of the values of the response variables between the percentages. We performed them using the lme function of the nlme package of the statistical software R.

In order to determine if glottalization is part of vowel quality or is a contiguous additional segment, we measured and compared the durations of glottal and non-glottal vowels. We took into account the variation of duration related to speech velocity by dividing vowel length by word length (variable *Ratio*, corresponding to proportional (or relative) vowel duration). We statistically tested the impact of the fixed factors Dialect, Gender, Generation, Vowel, and their interactions, on the response variable i.e. vowel proportional duration (*Ratio*). We performed for this a beta regression with random effect [13]. This model allowed us to take into account the repetition of the measurement (the factor *Participant* was introduced as a random effect in the model), and the fact that the values of the response variable *Ratio* are by definition included in the interval [0,1]. For this, we used the glmmTMB function of the glmmTMB package of the R statistical software.

Once the models were established, we performed contrast analyses with the glht function of the multcomp package, according to the method presented by [14], and using the emmeans package to construct the contrast matrices.

The different figures of the acoustic signal, EGG, and spectrogram were extracted using the Praatfig script [15] and Visible Vowels software [16].

3. Results and discussion

3.1. Oral vowels

Our phonological survey corroborates the six oral vowels described by [3] /i, e, a, o, u, ɨ / for the two dialectal varieties.

Figure 1 presents the distribution of the set of oral vowels in the two F_1-F_2 formants acoustic space for female speakers from the two varieties Korebaju (COE) and Tama (TAM). A centralization of the mid-front unrounded vowel [e] is evident for both varieties resulting in a mid-central allophone [ə] which appeared to be in free variation. A centralization phenomenon is also observed among the productions of the high front unrounded /i/ for COE females.

A large acoustic variability is found for the production of the open vowel /a/ for all 24 speakers. A tendency of vowel backing in the production of /a/ is observed for all the participants.

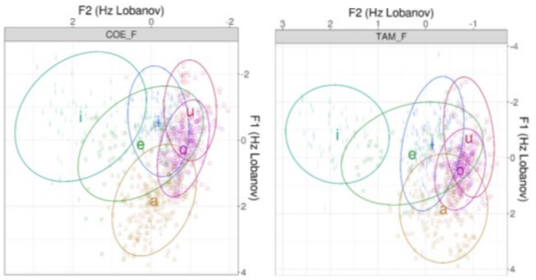

Figure 1: *F1/F2 distribution of the six oral vowels produced by 6 females of each variety (COE and TAM) with a Lobanov [17] normalization.*

Figure 2 displays the acoustic distribution in the F_1/F_2 space of the oral vowel set for the male speakers of the two varieties, COE and TAM. Centralized realizations of the front mid vowel /e/ appear as in the case of female speakers. The vowel fronting allophone of / ɨ / is less evident in males of the COE variant than in males of the TAM variant.

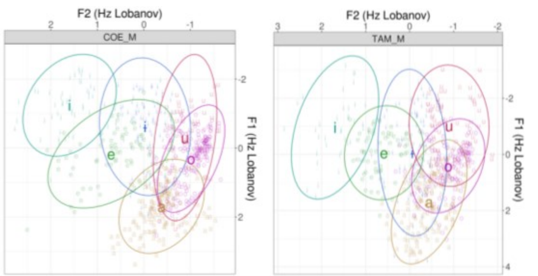

Figure 2: *F_1/F_2 distribution of the six oral vowels produced by 6 males of each variety (COE and TAM), with a Lobanov normalization [17].*

Before palatal consonants, we noted a fronting of the high central unrounded vowel /ɨ/ which presents as a near-high front unrounded allophone [ɪ], and of the high back rounded vowel /u/ which is realized as a near-high back rounded vowel [ʊ] (Table 1). Note that his second allophone differs from the study previously conducted for the Korebaju variant [3].

Table 1: *Mean (and SE) F_1, F_2, F_3 values (Hz) for the allophones [ɪ] and [ʊ], for females and males of the two generations of the two varieties TAM and COE.*

	F_1 (SE)	F_2 (SE)	F_3 (SE)
COE-F-ɪ	522 (121)	1819 (124)	2936 (590)
COE-M-ɪ	414 (121)	1772 (122)	2588 (597)
TAM-F-ɪ	610 (117)	1707 (163)	3015 (627)
TAM-M-ɪ	479 (117)	1835 (146)	2948 (628)
COE-F-ʊ	577 (127)	1182 (119)	2416 (652)
COE-M-ʊ	514 (129)	1203 (103)	2819 (698)
TAM-F-ʊ	542 (118)	1137 (165)	2661 (622)
TAM-M-ʊ	471 (138)	1200 (90)	2398 (710)

Globally, no significant difference between the two language variants was found; neither between the two generations of each variety. However, some significant differences were found between males and females of the same generation and the same variety. Figure 3 displays the differences in F_1 for the vowels [a], [e], [i], [ɨ] [o], and [u], of the two generations of the COE variant taken at 30%, 50%, and 70% of vowel duration.

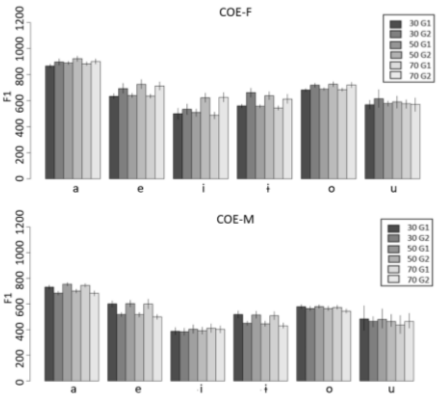

Figure 3: *Mean values (Hz) of F_1 measured at 30%, 50% and 70% of vowel duration with confidence intervals for females and males COE of the two generations.*

Moreover, a significant difference at all three points (30%, 50%, and 70%) of vowel duration between males and females is found for the first formant F_1 for the vowels [a], [e], [i], [ɨ], [o] of COE G2 as well as for vowel [a] for COE G1 and TAM G1; finally, a gender difference is evident for F_1 for the vowel [u] of the TAM G2 (Table 2 and Figure 4).

Table 2: *Z (and P) values for F_1 measured at 50% of the vowel duration, between females and males of the two generations and varieties TAM and COE.*

	[a]	[e]	[i]	[ɨ]	[o]	[u]
COE G1	4,70 **(<0,01)**	1,17 (1)	2,88 (0,45)	1,41 (1)	3,87 (0,21)	2,87 (0,47)
TAM G1	4,03 **(<0,01)**	1,63 (1)	1,19 (1)	1,62 (1)	2,21 (0,97)	0,07 (1)
COE G2	7,61 **(<0,01)**	6,69 **(<0,01)**	6,57 **(<0,01)**	5,83 **(<0,01)**	5,53 **(<0,01)**	2,77 (0,56)
TAM G2	3,58 (0,61)	2,51 (0,81)	2,74 (0,60)	1,70 (1)	3,39 (0,12)	4,51 **(<0,001)**

No significant difference was found between F_2 and F_3 formants for any vowel in any variety, gender or generation.

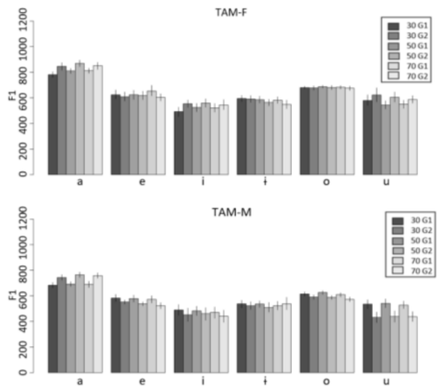

Figure 4: *Mean F_1 values (Hz) and confidence intervals measured at 30%, 50% and 70% of vowel duration for females and males TAM of the two generations.*

Overall, the main F_1 difference found between males and females of COE G2-speakers is +200 Hz for the set of the oral vowels /i, e, a, a, o, u, ɨ/. For TAM G1-speakers, the mean values of F_1 present some differences from +120 Hz to +130 Hz, but only for the vowel /a/ since TAM G1 vowels have approximately more homogeneous formant values.

Our investigation did not find either allophone for the mid-central vowels /e, o/ in rhotic context as described by [9] for the TAM variant. However, our study attests an allophone in free variation for the front unrounded vowel /e/ corresponding to the mid-central vowel [ə] (Table 2).

Table 3: *Mean (and SE) F_1, F_2, F_3 values (Hz) for vowel [ə], for females and males of the two generations and varieties TAM and COE.*

	F_1 (SE)	F_2 (SE)	F_3 (SE)
COE-F-ə	655 (102)	1416 (324)	2407 (457)
COE-M-ə	530 (102)	1591 (101)	2312 (422)
TAM-F-ə	596 (101)	1429 (179)	2473 (358)
TAM-M-ə	561 (101)	1614 (179)	2305 (358)

3.2. Glottal vowels

Analyses of vowel durations indicate no significant differences between non-glottal and glottal vowels of the COE variety supporting the results of previous study [3].

Figures 5 and 6 show boxplots of the proportional duration (*Ratio values*) of modal and their corresponding glottal vowels of the TAM variety. Although there is a tendency for all glottal vowels to be longer in duration, this difference is not significant for the vowel set which suggests that either glottal vowels are phonemic in both varieties or glottalization is suprasegmental [24]. Note also the absence of glottal realizations of /u/ in TAM females, as said above.

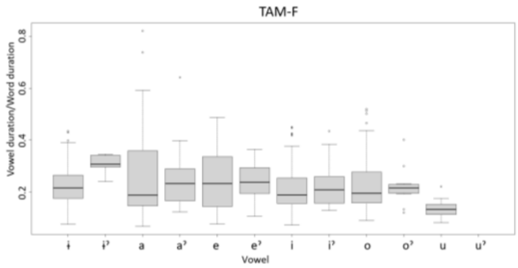

Figure 5: *Median, lower and upper quartiles of the variable Ratio for females TAM.*

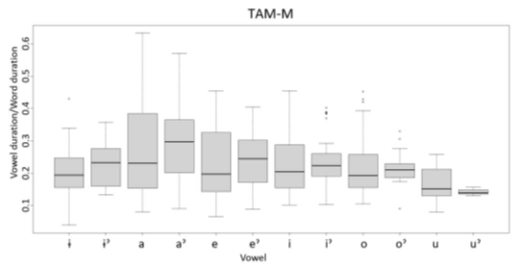

Figure 6: *Median, lower and upper quartiles of the variable Ratio for males TAM.*

Our survey provided a set of 5 phonological glottal vowels for both language variants / iˀ, eˀ, aˀ, oˀ, ɨˀ/. A glottal back-rounded vowel [uˀ] was randomly produced by speakers of both generations and was surprisingly omitted by all females of the TAM variant. This phone can occur in any position but its phonological status has not yet been confirmed. Our investigation supports a phonological contrast between modal and glottal for the peripheral vowels, as proposed by [3], [4], and [8], through minimal pairs in first and second root positions as well as in some affixes. However, it also provides evidence for a phonological status for the high glottal unrounded vowels /ɨˀ/ (a) and /iˀ/ (b) that could not be demonstrated in previous studies on the Korebaju variant ([3], [4], [8]).

a) /sɨ̀sɨ́/ — /sɨ̀ˀsɨ́/
{sɨ̀sɨ́} — {sɨ̀ˀsɨ́}
'Sanguinus Mistax' — 'Opossum Commun'

b) /sìsíà/ — /sìˀsí-á/
{sìsí-à} — {sìˀsí-á}
apophyse mastoid-CL — dirty-CL
'apophyse mastoid' — 'dirty Bactris Gasipaes'

3.3. Nasal vowels

Our examination of the acoustic structure of vowels, which included spectrographic analyses, showed that the nasal formant frequencies belong to the syllable containing the nasal vowel and not to the whole word. As a result, our investigation did not find a nasal harmony affecting the whole word. Nasality seems limited to the domain of the syllable.

Likewise, this study reports 6 nasal vowels [ĩ], [ẽ], [ã], [õ], [ũ], [ɨ̃]. However, no minimal pairs were found to demonstrate their contrastive properties. The minimal pairs given in previous studies show changes at the level of tone or glottalization that appear in certain contexts as evidenced by the examples c, d, e and, f.

c) [pĩ́ã̀] 'chili' — [pĩ̀ʔa] 'bird'; d) [mã̂:] 'macaw' — [màʔ̰á] 'road'

f) [cĩ́õ̀] 'girl' — [cĩ́ʔõ̀] 'crop'; g) [cáɨ̃́] 'jaguar' — [càʔí] 'liane_yare'

Considering that Korebaju is a tonal language [3], [4], [5], [7], [18], and that the intervocalic glottal is still under investigation as there is no consensus on its segmental or suprasegmental status either in the previous descriptions of Korebaju nor in the descriptions in other languages of the Tukanoan family ([19], [20], [21], [22], [23], [24]), such word pairs cannot be categorized as minimal pairs that may distinguish phonemic oral and nasal vowels in Korebaju in either variety.

4. Conclusion

Our study did not find any interdialectal differences between TAM and COE. Intradialectal differences could be observed at the gender level for certain generations and certain vowels.

This study confirms that glottalization seems to be part of the vowel as noted by [3] and [8], although its status as a segmental articulatory feature or a suprasegmental is yet unclear. We found a tendency for glottal vowels to be longer, but this difference was not significant for all set of vowels. Furthermore, this research found two phonemes corresponding to the closed glottal vowels /ɨˀ/ and /iˀ/.

Finally, this study suggests that the possible perceptual cause of a strong glottalization for speakers of the TAM variant may be due to a morphological change of certain words like the word 'narrow' where a possible insertion of a copulative predicate at the second syllable in the TAM variant creates the condition for a resyllabification of the word [má-ʔ̰-**àˀ**-kà-rɨ̀] {CL-COP-narrow-CL}, while the COE variant will produce a modulated tone without insertion of the same copula [**mâˀ**-kà-rɨ̀] {CL-narrow-CL}.

These results are still under investigation. Our ongoing research is looking at the relationship between tone and nasalization and the different types of glottalization present in the language.

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