

Prenasalized Stops in Iha: an acoustic analysis of allophonic variation

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Abstract

This thesis examines the potential (phonetic) motivations for allophonic variation of prenasalized stops in the Papuan language Iha by studying the distribution of prenasalized and plain stops in the language as well as acoustic measurement of their durations. Walker & Himmelmann (2022) report allophonic variation where a prenasalized voiced stop may surface without prenasalization or without voicing or without both. In this study, I used data from a corpus where I measured, for prenasalized and plain stops, the duration of prenasalization, oral closure and burst/aspiration. In this dataset there were no examples reflecting the variation described in earlier literature. Thus, it was not possible to answer questions regarding which variant is the original form and which one is the allophone, but we did gain insights nonetheless. The distribution of prenasalized and plain stops suggested that it is unlikely for the potential allophonic variation to be accounted for by the (word-initial) position of the token. Word-initial tokens were somewhat evenly distributed between plain and prenasalized stops in the data. Word-internal tokens were more likely to be prenasalized than plain, suggesting that variation, if any, would be more likely to occur in that position. Further, a statistical test comparing average oral closure durations between prenasalized stops and plain ones showed that the former are nearly half as long as the latter, which supports the treatment of prenasalized stops as unary segments. Statistical analyses of the effects of multiple potential factors showed no significant effect of any of the factors tested.

1. Introduction

This thesis investigated prenasalized stops in Iha ([ihp], ISO 639-3). More specifically, it looked for phonetic evidence and motivation for what seems to be free allophonic variation in certain cases between prenasalized and plain stops. The corpus data used for this study did not reflect this variation, as the speaker did not show any allophonic variation between his prenasalized and plain stops. However, studying the distributional and durational differences between the prenasalized and plain stops in the dataset helped gain insights to potential factors that may account for allophonic variation, if it does occur.

This section provides some background information on the language Iha (Section 1.1) and its phonemic inventory with a focus on allophonic variation in its prenasalized plosives (Section 1.2). Section 1.3 presents some background information on prenasalization in languages other than Iha that is relevant to the current study. Afterwards, section 2 describes the methodology, section 3 presents the results and section 4 ends with the conclusion and discussion of prospects for future research.

1.1 Language background

Iha is a Papuan language spoken on the Onin peninsula in the West Papua province of Indonesia. Iha is reported to be spoken by approximately 5000 – 6000 speakers (Donohue 2015:405; Voorhoeve 1975:432). However, due to an on-going shift to the lingua franca Papuan Malay and with Indonesian being the main language in schools, there seem to be few fluent speakers among the younger generations under the age of 40 (Walker & Himmelmann, 2022:1).

Iha and closely related Mbahám (Cottet, 2015) form the Nuclear West Bomberai branch of the West Bomberai language family. The two languages have fairly similar phonemic inventories and phonological distributions.

1.2 Iha phonology

Iha has 18 phonemic consonants and six marginal consonants, where the latter are limited to certain (morpho)phonological environments or loanwords. Table 1 shows all 24 Iha consonants, where the marginal consonants are indicated in between brackets. The language has seven vowels as shown in Table 2.

Table 1. Iha consonant inventory (Walker & Himmelmann, 2022:2)

		Labial	Coronal	Dorsal	Labial-dorsal	Glottal
Plosives	Voiceless	p	t̪ (t̪ʰ)	q	q̪p̪	
	Voiced	(b)	ɖ (ɖʒ)	g		
Nasals	Prenasalized	^m b	ⁿ d	^ŋ g	^{ŋm} g̪b̪	
		m	n	ŋ	w	
Sonorants			r (l)	j		
Fricatives	Voiceless	(f)	(s)			h
	Voiced	β				

Table 2. Iha vowel inventory (Walker & Himmelmann, 2022:3)

	Front	Central	Back
Close	/i/		/u/
Close mid	/e/		/o/
Open mid	/ɛ/		/ɔ/
Open		/a/	

As seen in Table 1, Iha has four prenasalized stops: bilabial /^mb/, alveolar /ⁿd/, dorsal /^ŋg/ and labio-dorsal /^{ŋm}g̪b̪/. Walker & Himmelmann (n.d.) state that it is difficult to determine whether these nasal-stop sequences are unary segments or clusters of a nasal and a plain stop. However, they do argue that, at least from a phonological point of view, a unary segment analysis makes more sense than a nasal-stop cluster. They base their arguments mostly on the phonotactics of the language. They state, for example, that codas are very rare in the first syllable of disyllabic lexical bases, making it unlikely that the nasal-stop sequences that do occur in that position are clusters of two segments. Another phonotactic argument that they present is that Iha consonant clusters rarely occur in medial positions. So, the fact that prenasalized stops do occur in medial positions of lexical bases suggests that they are not clusters. Furthermore, they argue that the lack of variety in the types of consonants that follow nasals in medial positions of lexical bases is another indicator that these sequences are unary segments; homorganic stops are the only consonants that may be preceded by a nasal in that position. That being said, the authors do acknowledge that these arguments do not constitute hard evidence in favor of a unary analysis, but do motivate their decision for such.

According to Walker & Himmelmann (2022:3), prenasalized stops allow for a broad range of phonetic realizations. They illustrate this using the example of *mbedén* ‘season’ which is attested with four different initial consonants, including (non-)prenasalized voiced and voiceless plosives: [mbɛ'ɖɛn] ~ [mpɛ'ɖɛn] ~ [bɛ'ɖɛn] ~ [pɛ'ɖɛn]. Interestingly, there are items, presumed to be phonological plain stops, that do not seem to allow for such variation. For

example, the word-initial consonant in *pehér* ‘sea.water’ seems to always surface as a plain voiceless stop, not showing much allophonic variation.

The goal of this study is to investigate whether there is phonetic evidence to support the claim that, for items with near-free allophonic variation, the prenasalized variant is the default and the non-prenasalized one is the deviation. Additionally, the study aims to identify possible motivations for these variations, as a step towards the ultimate goal of improving our understanding of allophonic variation in the prenasalized stops of Iha.

1.3 Prenasalization in other languages

This section provides brief descriptions of prenasalized consonants in languages other than Iha. Although uncommon cross-linguistically, prenasalization is common as a regional feature in Melanesia (Maddieson, 2013). Section 1.3.1 introduces prenasalization in a closely related language to Iha, while section 1.3.2 describes prenasalization in another Papuan language, genetically unrelated to Iha.

1.3.1 Prenasalization in Mbahám

As mentioned earlier, Mbahám is the closest related language to Iha, the two languages are said to share a common historical origin (Usher & Schapper, 2021) which is reflected in their similar phonemic inventories. Analogous to Iha, Mbahám has four prenasalized consonants differing in place of articulation; bilabial /^mb/, alveolar /ⁿd/, dorsal /^ŋg/ and labio-dorsal /^ŋg^w/. Note that the prenasalized labio-dorsal stop in Iha is conventionally transcribed as /^ŋm^gb̄/, but both correspond to the same phoneme in the historical ancestor of the two languages (Robinson & Holton, 2012).

In Mbahám, prenasalized stops, as well as voiceless stops are more frequent in word-initial position than voiced stops (Cottet, 2015). Further, Mbahám prenasalized consonants, similar to voiceless consonants, are affected by assibilation processes, such that an underlying /ⁿd/ may surface as [ndʒ] in certain environments. Acoustic measurement of frication duration and nasal closure duration in these processes shows that voiceless stops have longer frication duration than prenasalized voiced stops, although the frication itself is voiceless in both types of consonants (Cottet, 2015).

Cottet (2015) does not report any allophonic variation in Mbahám prenasalized stops that is analogous to what Walker & Himmelmann (2022) observe in Iha. However, she does point out that, in word-initial positions, the contrast between plain voiced stops and prenasalized voiced stops in Mbahám carries ‘a very low functional load’ (Cotter, 2015:268). This is because plain voiced stops are very rare in that position in comparison to prenasalized

stops, suggesting that if a Mbahám speaker mistakenly leaves out the nasalization from a word-initial prenasalized stop, listeners are unlikely to be confused as to what target the speaker is trying to produce. Thus, although variation is not reported in Mbahám prenasalized stops, such distribution differences may account for the variation in Iha.

1.3.2 Prenasalization in Qaqet

Qaqet ([byx], ISO 639-3) is a Papuan language, genetically unrelated to Iha, spoken in New Britain, Papua New Guinea. In Qaqet, prenasalization is described as strictly phonetic variation of plain voiced stops i.e. prenasalized stops never contrast plain stops (Tabain & Hellwig, 2022:5). Measurement of the durations of nasalization and closure of prenasalized and plain stops shows that the prenasalized allophones of Qaqet stops have longer overall durations than their plain counterparts (Tabain & Hellwig, 2022:6). It is noteworthy that, between the plain stops of this language, voiceless stops, which descend from historical geminates, have generally longer durations than voiced stops. Thus, it is argued that voiced stops undergo phonetic prenasalization to match the duration of voiceless stops (Tabain & Hellwig, 2022:6).

2. Methodology

This section describes how the research questions were addressed. First, I describe the data source and the relevant software used to access and annotate the data and prepare them for analysis (Section 2.1). Then I describe and motivate the statistical methods and tests used to answer the questions (Section 2.2).

2.1 Data, annotation and measurements

The data for this study come from a partially published corpus of Iha spoken data (Narfafan & Tutuop, 2009). The recordings used for this analysis contain semi-structured elicitations of one adult male speaker. The data were transcribed and translated into Indonesian by a native Iha speaker using ELAN software (Elan, 2022). A dictionary including English translations as well as updated and more accurate spellings of lexical items was made available by the authors of Walker & Himmelmann (2022).

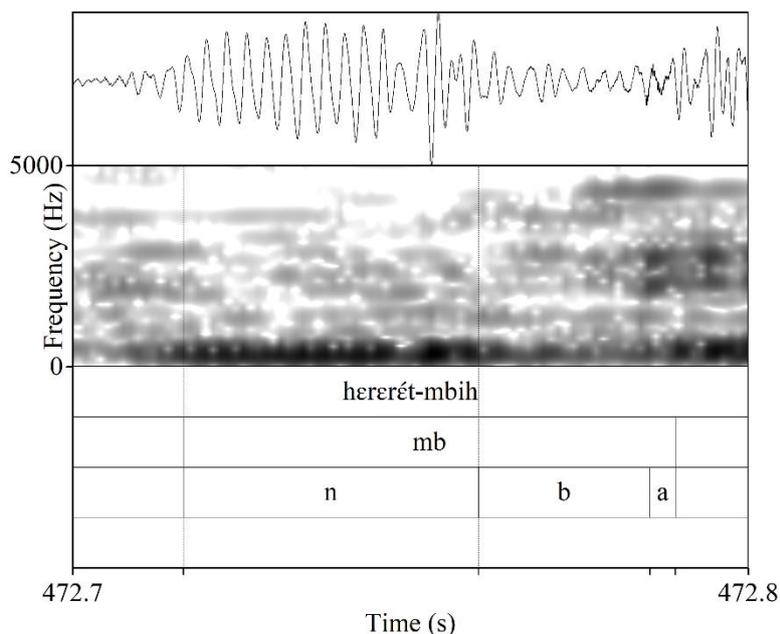
The workflow of identifying the targeted phonemes starts by going through all the utterances in an ELAN file while looking for lexical items with a nasal-stop (NC) sequence. These lexical items are identifiable in the orthographic spelling when an <m> is followed by a or <p> for the bilabial NC sequence, the alveolar phonemes are identified when an <n> is followed by a <d> or <t>, the dorsal nasal-stop has an <ng> followed by <g> or <k>, while the labial-dorsal sequence is signified by a <nm> followed by <qp>, <kp> or <gb>. Once a lexical

item containing a NC sequence was identified it was annotated following a number of conventions.

The data labelling and annotation was done using the speech analysis software Praat (Boersma & Weenink, 2022). The annotation of each phoneme occurred in three tiers (Figure 1). The first tier has its first boundary at the beginning of the lexical item containing the NC sequence and its closing boundary at the endpoint of the lexical item. The second tier of one lexical item has boundaries denoting the beginning and endpoint of the target segment. The third tier for one token contains three intervals, one denoting the prenasalization phase, if there is one, followed by an interval marking the closure duration of the stop and ends with an interval measuring the burst/aspiration duration. A fourth tier is sometimes utilized to highlight any discrepancy between the typical transcription of a lexical entry and how it was phonetically realized, e.g. if a typically voiced consonant was pronounced as voiceless.

The criteria for determining each boundary used for this study follow those used by Downing & Hamann (2021:11). The start and end of a nasal are determined by the abrupt changes in the amplitude and shape of the waveform and the change in formants. Oral closures start after the end of the nasalization and end at the start of the release phase. The release phase, also referred to as burst/aspiration, is often identified by a distortion in the waveform and ends with the start of the following segment.

Figure 1. Illustration of annotation of prenasalized stop

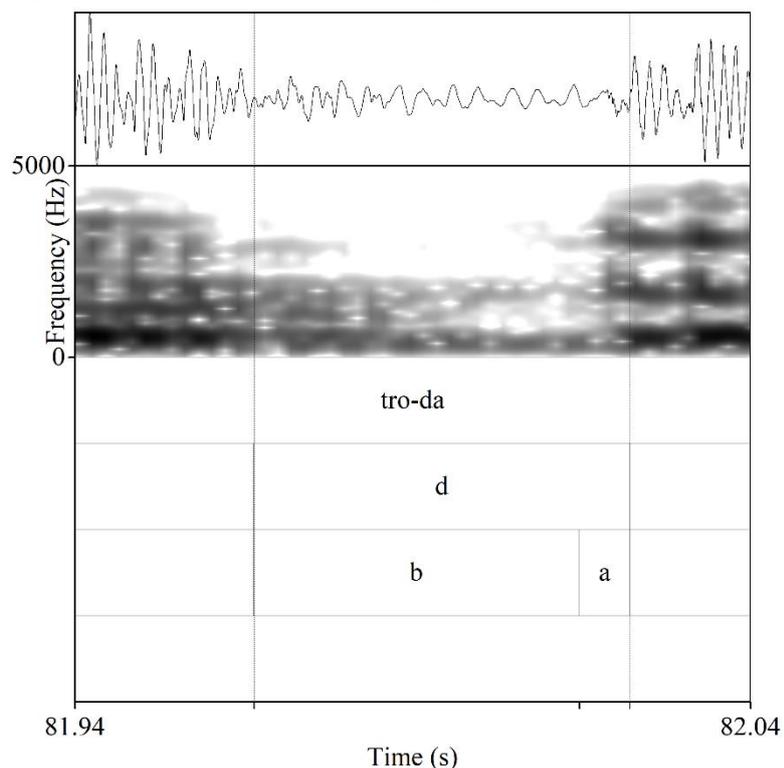


Essentially, three acoustic events were annotated and measured for each nasal-stop sequence: nasal closure (n), voiced or voiceless oral closure (b/p) where (b) stands for voiced

and (p) stands for voiceless oral closure, and burst plus possible aspiration (a). Figure 1 illustrates the annotation of the three acoustic events in a nasal-stop sequence.

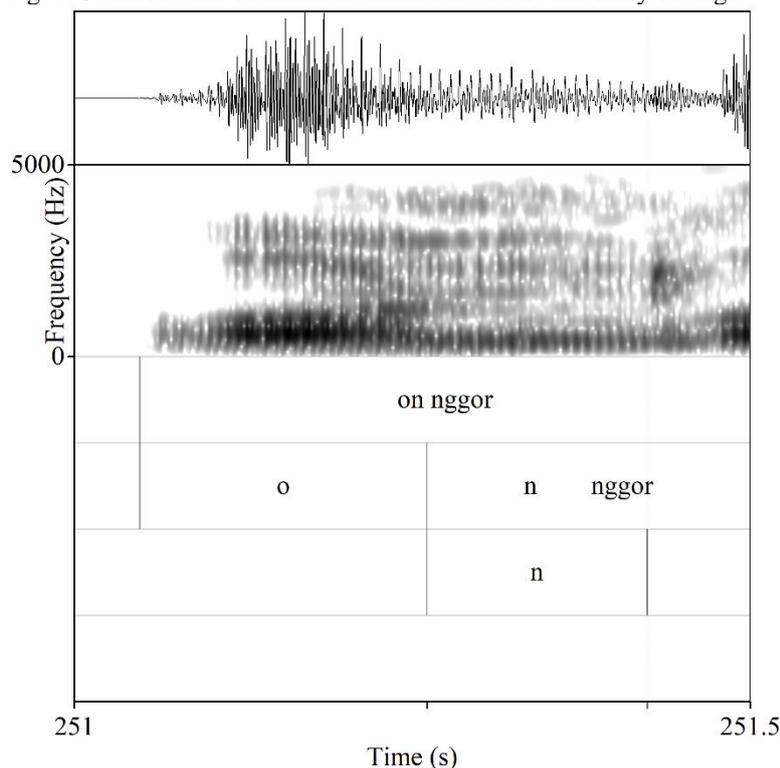
The same procedure and conventions were followed for the plain (i.e. non-prenasalized) stops. The only difference between the two, because the plain stops do not have phonetic prenasalization, is that the interval corresponding to the nasal in the third tier is simply removed, as in Figure 2.

Figure 2. Illustration of annotation of a plain stop



Certain problematic tokens had to be excluded from the analysis because their boundaries were difficult to discern. For example, as illustrated by Figure 3, some word-initial NC sequences were preceded by a word that ends with a nasal segment, making it near impossible to locate where the preceding word ends and where the NC sequence begins. The third tier in Figure 3 labeled <n> delimits a period of nasalization that includes the nasal from the previous word and the nasal from the word-initial NC sequence. The spectrogram and waveform are consistent throughout that interval, which complicated discerning the start point of the NC sequence. Additionally, word-final stops were also excluded because they tend to be unreleased, making it very difficult to discern the boundaries for the closure and burst. Other non-word-final stops were also excluded for similar reasons involving ambiguity of boundaries.

Figure 3. Illustration of excluded token due to discernability of targeted nas



Once all the tokens were annotated, a Praat script was run to extract all the measured values and their relevant metadata (See Appendix 1 for full script). When selecting a TextGrid file in Praat before running the script, the script outputs a table, for that TextGrid, listing all the info for each annotated segment in the TextGrid. This information includes the name of each item or segment and the word in which the segment was located. Further, the script outputs the start time of the segment in the audio recording, such that it can easily be traced back in the original file. In addition, the script notates whether the segment has a nasal or not, and if it does, the duration of nasalization is listed in milliseconds. Information about the voicing of segments is also listed where the script output would show if the segment is voiced and <p> if voiceless. The durations of the closure and burst of the plosive are both notated in milliseconds, each in its own column. If a segment does not have a measurable closure period, that column would read <a> which denotes aspiration, as it was not preceded by a closure. Finally, whenever there was a discrepancy between the original transcription and the phonetic realization of the segment, e.g. a voiceless /t/ surfacing as [t̚], the last column provides the alternative transcription.

Additional columns were added manually at a later point, such as the height of the following vowel and the place of articulation. This information is available in the ‘word’ column but did not have their own rows, before there were manually added, such that they can

be used as variables. Finally, more manual modification involved translating the coded information, such that and <p> were translated into ‘voiced’ and ‘voiceless’ respectively. Because prenasalized consonants were always voiced in the dataset, they were marked as such. Table 3 below shows a few rows of the script’s output with the manually added and modified columns.

Table 3. A few rows from the script output after manual modification

file	item	place	word	vowel	start	nasal	nasal_dur_ms	voice	clos_dur_ms	asp_dur_ms	comment
toneContrastLong	d	alveolar	qpaw5-da	Non-High	139.153	plain	0	Voiced	58.823	5.531	
toneContrastLong	k	velar	#kra	Non-High	44.775	plain	0	Voiceless	23.951	17.068	
re_1_verb_1	mb	bilabial	#mbih	High	501.426	prenasalized	69.852	Prenasalized (voiced)	27.182	7.640	
re_1_verb_1	nt	alveolar	nantéren	Non-High	1074.573	prenasalized	44.995	Prenasalized (voiced)	28.244	17.951	nandéren

3. Results

In this section I present the results of the study. The section starts with an overview of the distribution of the plain and prenasalized stops that were analysed. I also describe some observations about the presence and lack thereof of prenasalized stops in certain contexts. Finally, I report the statistical tests that I performed, including testing the effect of different potential factors that may affect the durations that I measured.

The total number of annotated tokens from the dataset was 255 out of which 147 were nasal-stop sequences and 108 were plain stops. Table 4 below illustrates the division of the tokens based on the place of articulation, while Table 5 shows the division based on the position of the token in relation to the word in which it occurred. As can be seen in Table 4, Labio-dorsal nasal-stop sequences were very rare in comparison with their plain counterparts or nasal-stops in other places of articulation. Therefore, for the rest of the analysis, labio-dorsal tokens were grouped with dorsals because the beginning of their closure is dorsal. This choice was probably more justified for measurements of nasal and oral closure durations, but less so for burst/aspiration durations (see discussion in section 4).

Table 4. Overview of number of tokens based on place of articulation

	Labial	Alveolar	Dorsal	Labio-dorsal	Total
NC	93	37	14	3	147
C	15	20	45	28	108
Total	108	57	59	31	255

One interesting finding is that this dataset did not show a lot of allophonic variation within and between nasal-stop sequences and plain stops. In terms of voicing, only 12 tokens out of

all 255 had a mismatch between the typical transcription and the actual phonetic realization, e.g. a word typically transcribed with a /p/ surfaced as [b]. All 12 of these tokens were of items that are normally transcribed as voiceless and seem to have undergone voice assimilation when surrounded by two vowels or a vowel and another voiced segment. Of the 12 tokens, nine were word-internal (four at morpheme boundaries and five within lexical bases), the remaining three were word-initial. It is interesting to note that all of the word-internal tokens that underwent voice assimilation did so consistently through all repetitions, whereas the word-initial voice assimilations were exceptional, as all other repetitions of these tokens remained voiceless. As for nasalization, there were no cases where a typically prenasalized stop did not have any phonetic nasalization at all, nor did any plain stop contain prenasalization. A table of the full dataset is available in Appendix 2.

The dataset had a total of 129 word-initial tokens and 126 that occurred word-internally. Note that in Table 5 the number between parentheses indicates the numbers of word-internal tokens that start after a morpheme boundary.

Table 5. Overview of number of tokens based on their position

	Word-initial	Word-internal	Total
NC	55	92 (23)	147
C	74	34 (9)	108
Total	129	126 (32)	255

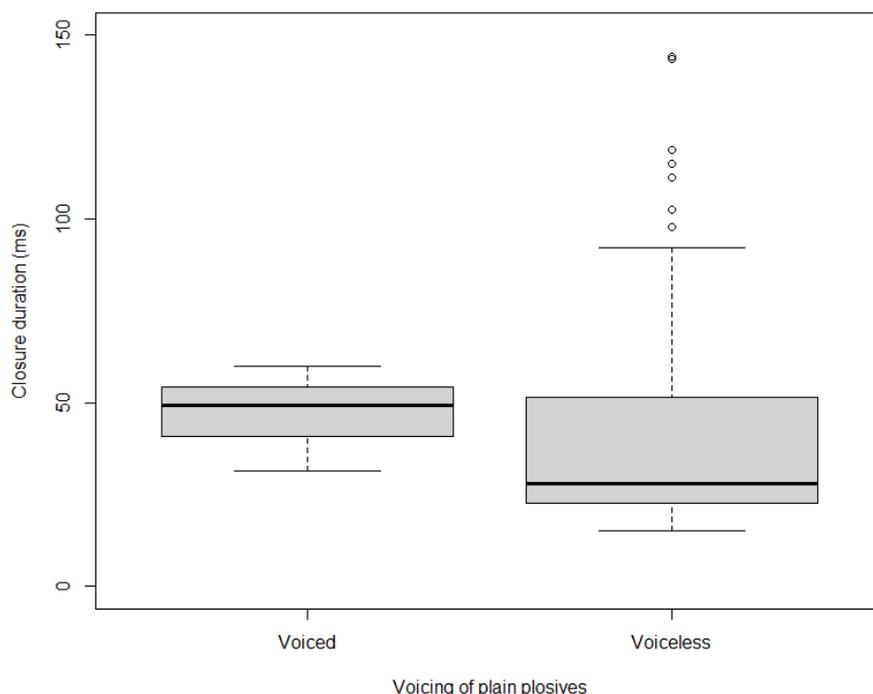
The examples that Walker & Himmelmann (2022:3) provide for the allophonic variation they observed in prenasalized stops involve variation that occurs word-initially. Based on the dataset used for this study, which did not contain any examples of the variation that Walker & Himmelmann (2022) described, it is very unlikely that the variation they report is based on lack of contrastive function. Out of all 129 word-initial stops in the analysed dataset, 57% were plain (n=74) and 43% were prenasalized (n=55). This is unlike the neighbouring language Mbahám (see Section 1.3.1) where plain consonants were rare word-initially, such that variation in phonetic realization is unlikely to cause confusion. Although, this was the case for word-internal stops in the dataset where plain stops accounted for only 27% (n=34) out of all word-internal tokens, while prenasalized stops accounted for 74% (n=92).

The statistical analyses were carried out using linear mixed-effects models by using the lmerTest package (Kuznetsova et al., 2017) in the statistical computing software R (R Core Team, 2022). Before running the main analysis comparing closure durations between prenasalized and plain stops, I ran a few tests to determine whether certain factors needed to be taken into account.

First, I evaluated the effect of voicing on the closure duration of plain plosives only. If the effect is not significant there is no need to include a voicing contrast as a variable when comparing plain plosive with prenasalized ones. The plain voiceless plosives had an average closure duration shorter than plain voiced plosives by 11.524 milliseconds (95% confidence interval between -2.504 and 25.391 milliseconds). However, this difference was not significant ($t[105]= 1.633, p = 0.105$). Therefore, it cannot be concluded that closure durations are affected by voicing.

Visually, the graph Figure 4 may suggest that there is a tendency for plain voiceless plosives to have a shorter closure duration than their voiced counterparts. However, it is important to note that this analysis was based on a somewhat imbalanced sample. The dataset had much fewer plain voiced plosives ($n=19$) than plain voiceless ones ($n=89$). This is unlikely to be a limitation of the dataset, but rather a reflection of the relative infrequency of plain voiced plosives in the language in general. The consonant inventory of Iha (see Table 1) has two phonemic plain voiced plosives and twice as many plain voiceless plosives.

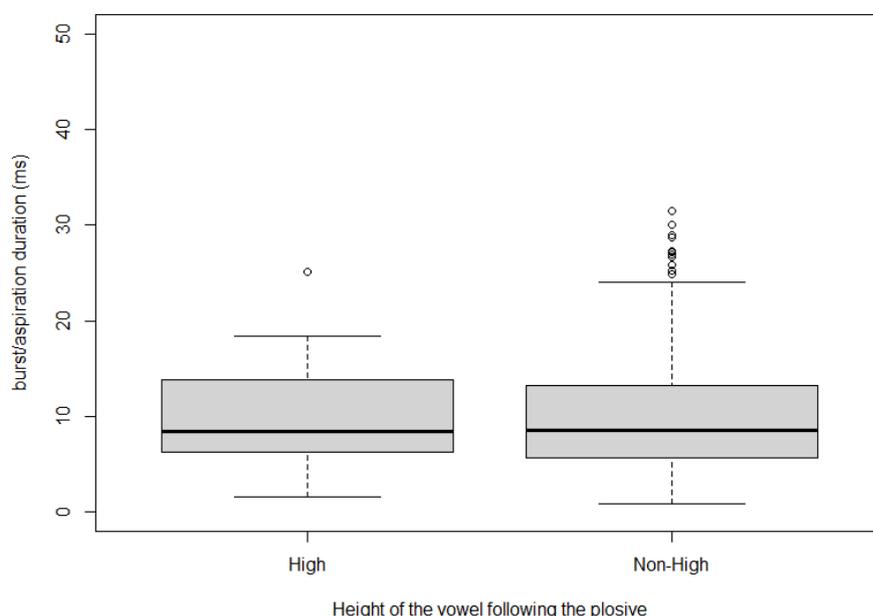
Figure 4. Closure duration of plain plosives divided by voicing



As for burst/aspiration durations, I considered the effect of vowel height of the following vowel, as high vowels tend to correlate with longer burst/aspiration durations than lower vowels (Yavaş, 2009). Since I excluded word-final plosives, all the plosives in the dataset were followed by a vowel. This includes both plain ($n=108$) and prenasalized plosives ($n=147$). The vowels that followed these plosives were divided by height into two categories: high (/i/

and /u/) and non-high (/e/, /o/, /ɛ/, /ɔ/, /a/). There was no need to divide the non-high vowels of different heights into more categories because the effect is expected for high vowels only (Yavaş, 2009:247). Because the comparison involves a category of two vowels and a category of five, it is unsurprising that the sample is not balanced. In the dataset, there was a total of 27 plosives followed by high vowels and 228 plosives followed by non-high ones. Based on this sample, there was a very minimal difference between the burst durations of the two categories, where plosives that were followed by a high vowel had an average burst duration of 0.867 milliseconds longer than the ones that were followed by non-high vowels (95% confidence interval from -3.173 to 4.913 milliseconds). This difference was also not significant ($t[97]=0.419$, $p=0.676$), meaning that we cannot conclude that vowel height has an influence on the burst/aspiration duration of the preceding stop. The similarity in burst/aspiration between the two categories is illustrated by the graph in Figure 5. It might be noteworthy that the 27 plosives that were followed by high vowels were all prenasalized ones, meaning that the dataset did not have any plain stops that were followed by high vowels. It is difficult to say whether a more representative sample would be predicted to yield different results.

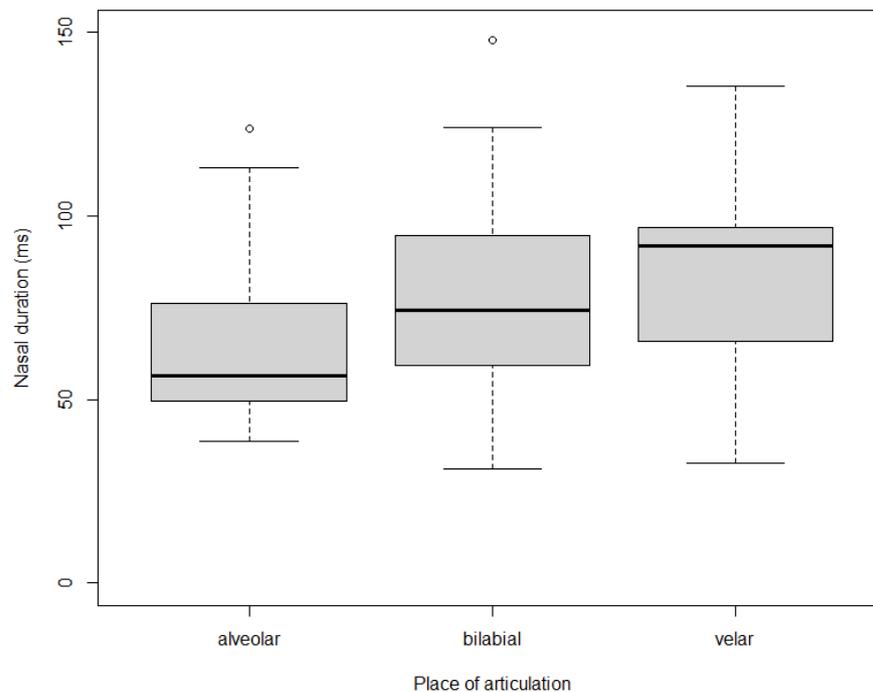
Figure 5. Burst/aspiration duration of plosives divided by height of the following vowel



When it comes to the duration of nasalization in the prenasalized stops, I tested the effect of place of articulation. To this end, I divided the prenasalized stops ($n=147$) into three categories: bilabial ($n=93$), alveolar ($n=37$) and velar ($n=17$). Labio-velar stops were treated as velar ones for this analysis and were included in that category. Based on this sample, the average nasalization durations increased gradually depending on place of articulation, with

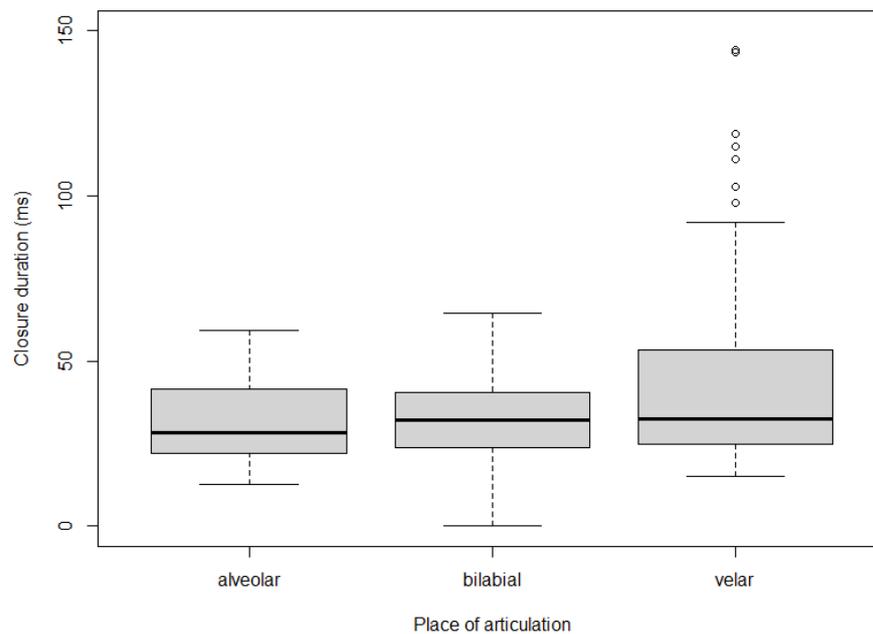
alveolar being the shortest, velar the longest and bilabial in between as shown in Figure 6. However, the difference was not statistically significant ($t[30]=0.447$, $p=0.658$), which means that it cannot be concluded that place of articulation affects nasalization duration of prenasalized stops.

Figure 6. Comparison of nasalization duration of prenasalized stops by place of articulation



Further, I tested the effect of place of articulation on the closure duration of plosives. I divided all of the plosives in the dataset ($n=255$) based on their place of articulation into bilabial ($n=108$), alveolar ($n=57$) and velar ($n=90$). Similar to what was done in the test of place of articulation effect on nasalization duration, labio-velars were grouped with velars here as well. This analysis showed that the difference between the average closure duration of the longest category, velars, was minimally longer than the shortest category, alveolars, by 8.957 milliseconds (95% confidence interval from -12.157 to 30.270) and this difference was not significant ($t[71]= 0.829$, $p=0.41$). Thus, it cannot be concluded that place of articulation has an effect on the closure duration of plosives in Iha.

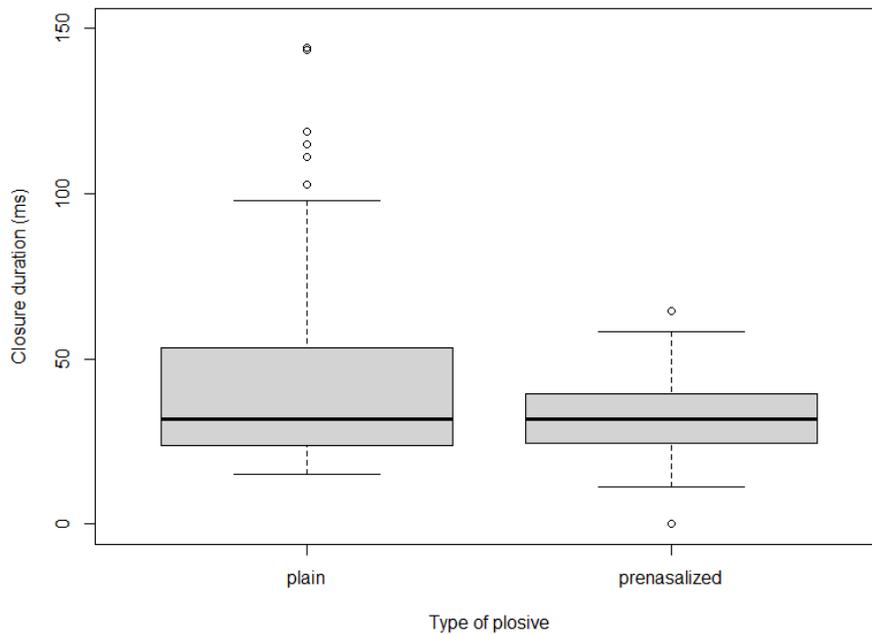
Figure 7. Closure duration of stops divided by place of articulation



Having tested for the effect of voicing on closure durations of plain plosives (Figure 4), vowel height on the burst/aspiration duration of the preceding plosive (Figure 5), place of articulation on the duration of nasalization in prenasalized plosives (Figure 6) and on closure duration of prenasalized and plain plosives (Figure 7) I have found no significant effect of any of those factors on their respective durations. Although not finding significant effects is no proof of absence of the effect, it is reasonable to believe that those factors will not influence the comparisons between the plain and prenasalized plosives in the dataset.

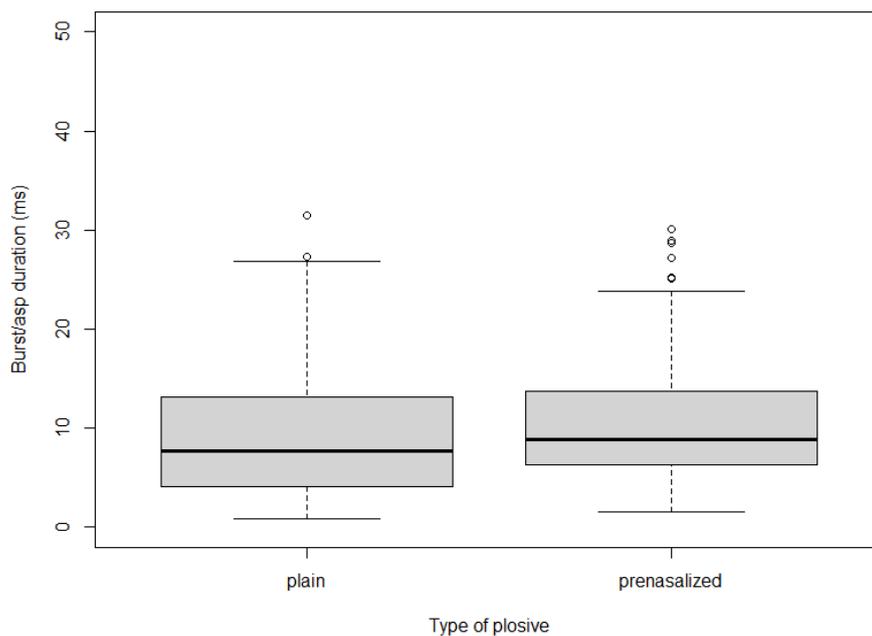
I compared the plain plosives ($n=108$) with the prenasalized ones ($n=147$) in terms of closure durations. The test showed that plain plosives had an average closure duration 21.459 milliseconds longer than prenasalized plosives (95% confidence interval between 13.523 and 29.516 milliseconds). This effect was significantly different from zero ($t[157]=6.029$, $p=1.13 \times 10^{-08}$). Figure 8 illustrates how, although some plain tokens have closer durations in the same range as prenasalized ones, the plain plosives have a much wider range of durations than prenasalized ones, which accounts for the average duration of plain plosives being significantly longer than that of prenasalized ones.

Figure 8. Comparison of closure duration between plain and prenasalized plosives



As for the duration of burst/aspiration for the same two categories, I ran the same test and found that plain plosives have an average burst/aspiration duration shorter than prenasalized plosives by 1.039 milliseconds (95% confidence interval from -3.395 to 1.338 milliseconds). However, this effect was not statistically significant ($t[99]=0.869$, $p=0.387$). The boxplot in Figure 9 reflects the small size of the effect as the two boxes have similar sizes that cover similar ranges.

Figure 9. Comparison of burst/aspiration duration between plain and prenasalized plosives



Durational differences between word-initial tokens and word-internal ones were not possible to test statistically or visualize in this study due to practical and temporal limitations. However, superficial inspection of the data from these tokens suggests that the token's position in the word does not affect its nasalization, closure or release durations. This is because each word-position category showed a range of durations consistent with the statistically tested ranges of their respective type of stop. The same seemed to apply even for the word-internal tokens that started after a morpheme boundary. However, this still needs to be verified with statistical tests.

4. Conclusion and discussion

This section provides conclusive remarks based on the findings of this study. It also discusses the possible shortcomings and limitations of this research and makes suggestions for future research prospects concerning nasal-stop sequences in Iha.

The goal of this paper was to provide insights into the phonetic nature of the allophonic variation in prenasalized stops in Iha (Walker & Himmelmann, 2022:3). The acoustic measurements in this study could not confirm nor deny the observations of Walker & Himmelmann (2022) about the allophonic variation in prenasalized consonants in Iha. The dataset used for this study showed absolutely no allophonic variation in terms of prenasalization and very little in terms of voicing. Therefore, obviously, it was not possible to answer the question of what form is the origin and what form is the deviation in cases of allophonic variation. One thing that can be said about the earlier observations based on the findings of this study is that the observed allophonic variation is unlikely to be consistently induced by the factors accounted for in the study, such as place of articulation, position in the word and voicing. This suggests that the variation is probably not purely phonetic, but rather socio-phonetic. A larger, varied sample of speakers is needed to test this prediction.

Additionally, the durational measurements add valuable insights into the discussion of whether the nasal-stop sequences in Iha are unary segments or a cluster. It was found that, at least for the one speaker in this dataset, prenasalized stops had an average closure duration of a little more than half of the average closure duration of plain stops. This supports Walker & Himmelmann's (2022) treatment of these sequences as unary segments, following Cohn & Riehl's (2012) expectations for unary nasal-stop sequences to have a duration close to that of a plain stop. Interestingly, the nasal durations in these nasal-stop sequences were ranging at higher durations than stop part. This asymmetry between the durations of nasal closure (prenasalization) and oral closure is not surprising for unary nasal-stop sequences (Cohn &

Riehl, 2012:1). However, according to Cohn & Riehl (2012) the fact that the nasal is longer than the oral closure, instead of the other way around, is unexpected for prenasalized stops. They would likely argue that this suggests the unary nasal-stop segments in Iha may better be described as ‘postploded nasals’ (N^D) rather than ‘prenasalized stops’ ($^N D$). The distinction between the two terms is not within the scope of this study, but it does have the potential of improving our understanding of the phenomenon. If a future study wants to investigate the ratio between the nasal and the oral parts of a nasal-stop sequence, it is advisable to take the duration of the preceding vowel into account, as it is shown to affect the duration of nasalization (Riehl, 2008: 108-116).

It is mentioned throughout the paper that the main limitation is that the data are based on only one speaker in one type of setting, which means that the study could not reveal or test potential inter- or intraspeaker factors, such as age and sex, which may be playing a role in allophonic variation. Future studies of prenasalization in Iha would benefit from having a larger sample, preferably representing speakers from different sex and age groups.

Obviously, this was not the only shortcoming of the study. A remarkable limitation is not being able to test the effect of the position of the stop within the word and with respect to morpheme boundaries, contrary to the original plan. During annotation, the stop’s position was indicated based on whether it occurs word-initially or not, where words that had word-initial tokens had a hashtag sign (#) at the beginning. Words that had morpheme-initial tokens were also indicated by a hyphen (-) marking the morpheme boundary. However, those were not coded in a way that can automatically be extracted by a script and had to be extracted manually. Unfortunately, this was not possible due to time constraints. Valuable insights are expected to be gained if a future study tests the effect of word and/or morpheme boundaries on the durations of stops in Iha.

Moreover, while there was an argument to group labio-velars with velars when measuring the effect of place of articulation on the duration of the nasalized segments, the same does not necessarily hold for the measurement of the effect on the duration of closure and/or burst/aspiration. This is because the release of labio-velars is more labial than velar. Future research is thus advised to treat labio-velars as their own category and contrast them with other places of articulation. If the occurrence of labio-velars in a dataset is not frequent enough to create a balanced sample, as was the case in this study, it is better to exclude them from the analysis completely than group them with another category.

This study was one of the first efforts towards understanding the phonetics of prenasalized stops in Iha using acoustic measurements. In spite of the limitations discussed earlier in this

section, this investigation contributed towards improving our understanding of the phenomenon and forms a good basis for future advancements.

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Appendix 1: Praat script

```
# Praat script Iha_NC.praat
# Silke Hamann, 7 June 2022
# textgrid has to be selected

form
    word Filename
endform
textgrid = selected ("TextGrid")

appendInfoLine: "file", tab$, "item", tab$, "word", tab$, "start", tab$, "nasal", tab$, "nasal_dur_ms", tab$,
"plosive", tab$, "clos_dur_ms", tab$, "asp_dur_ms", tab$, "comment"
select textgrid
n = Get number of intervals: 2
for i to n
    components$ = Get label of interval: 2, i
    if components$ <> ""
        t1 = Get starting point: 2, i
        interval1 = Get interval at time: 1, t1
        word$ = Get label of interval: 1, interval1
        interval4 = Get interval at time: 4, t1
        comment$ = Get label of interval: 4, interval4
        interval3 = Get interval at time: 3, t1
        nasal$ = Get label of interval: 3, interval3
        if nasal$ = "n" or nasal$ = "m"
```

```

        nasallabel$ = "yes"
        t2 = Get end time of interval: 3, interval3
        durnas = (t2-t1)*1000
        ploslabel$ = Get label of interval: 3, interval3+1
        t3 = Get end time of interval: 3, interval3+1
        if ploslabel$ = "b" or ploslabel$ = "p"
            durplos = (t3-t2)*1000
            t4 = Get end time of interval: 3, interval3+2
            durasp = (t4-t3)*1000
        else
            durplos = 0
            durasp = (t3-t2)*1000
        endif
    else
        nasallabel$ = "no"
        durnas = 0
        ploslabel$ = Get label of interval: 3, interval3
        t2 = Get end time of interval: 3, interval3
        durplos = (t2-t1)*1000
        t3 = Get end time of interval: 3, interval3+1
        durasp = (t3-t2)*1000
    endif
    appendInfoLine: filename$, tab$, components$, tab$, word$, tab$, t1, tab$, nasallabel$, tab$,
durnas, tab$, ploslabel$, tab$, durplos, tab$, durasp, tab$, comment$
endif
endfor
select textgrid

```

Appendix 2: Complete dataset table

<i>file</i>	<i>ite</i> <i>m</i>	<i>plac</i> <i>e</i>	<i>word</i>	<i>vow</i> <i>el</i>	<i>start</i>	<i>nasal</i>	<i>nasal_dur_</i> <i>ms</i>	<i>Voice</i>	<i>clos_dur_</i> <i>ms</i>	<i>asp_dur_m</i> <i>s</i>	<i>com</i> <i>ment</i>
<i>toneCont</i>	d	alve	qpawó-	Non-	139.15346	plain	0	Voiced	58.822752	5.5309142	
<i>rastLong</i>		olar	da	High	971525096				6977505	67296794	
<i>toneCont</i>	d	alve	qpawó-	Non-	142.75361	plain	0	Voiced	50.335785	4.3956089	
<i>rastLong</i>		olar	da	High	966666438				46326112	48982499	
<i>toneCont</i>	d	alve	qpawó-	Non-	146.67430	plain	0	Voiced	59.211008	5.6209215	
<i>rastLong</i>		olar	da	High	020943564				51307415	64400305	
<i>toneCont</i>	d	alve	qpawó-	Non-	150.60149	plain	0	Voiced	50.547103	4.7279584	
<i>rastLong</i>		olar	da	High	694444442				17463673	51582026	
<i>toneCont</i>	d	alve	tro-da	Non-	76.083437	plain	0	Voiced	31.423250	6.5420199	
<i>rastLong</i>		olar		High	83174098				191792818	19066888	
<i>toneCont</i>	d	alve	tro-da	Non-	78.337421	plain	0	Voiced	41.027030	7.7361959	
<i>rastLong</i>		olar		High	83265583				02932628	08591981	
<i>toneCont</i>	d	alve	tro-da	Non-	81.961954	plain	0	Voiced	49.238650	7.6416533	
<i>rastLong</i>		olar		High	75260416				17362061	11964092	
<i>re_1_ver</i>	g	vela	#geh-ɔ-	Non-	353.95366	plain	0	Voiced	54.538743	1.3027448	
<i>b_1</i>	r	mbɔɔ		High	402116406				81294099	292746158	
<i>re_1_ver</i>	g	vela	#geh-ɔ-	Non-	358.93048	plain	0	Voiced	36.287451	7.8075326	
<i>b_1</i>	r	mbɔɔ		High	75283447				150656125	37229997	
<i>re_1_ver</i>	g	vela	#geh-ɔ-	Non-	369.84807	plain	0	Voiced	31.731147	6.8738948	
<i>b_1</i>	r	mbɔɔ		High	029478463				1596895	57051255	
<i>re_1_ver</i>	g	vela	#geh-ɔ-	Non-	422.93157	plain	0	Voiced	51.043980	6.0515891	
<i>b_1</i>	r	mbɔɔ		High	164453083				335521155	45727121	
<i>re_1_ver</i>	g	vela	#geh-ɔ-	Non-	441.05192	plain	0	Voiced	59.991107	6.9365079	
<i>b_1</i>	r	mbɔɔ		High	877150864				554139944	36529779	
<i>toneCont</i>	g	vela	kra-ge	Non-	77.798330	plain	0	Voiced	38.938366	8.6558033	
<i>rastLong</i>		r		High	96590909				718028306	76839799	
<i>re_1_ver</i>	k	vela	#kendé	Non-	606.14510	plain	0	Voiceless	53.481422	4.2277562	
<i>b_1</i>	r	p		High	93474427				198501605	654362555	
<i>re_1_ver</i>	k	vela	#kendé	Non-	609.49323	plain	0	Voiceless	37.681961	4.0231850	
<i>b_1</i>	r	p		High	50718066				673570186	31542198	

<i>re_1_ver</i> <i>b_1</i>	k	vela	#kendé	Non-High	619.47128	plain	0	Voiceless	27.547110	11.896073
		r	p	High	11791384				798309404	883008285
<i>re_1_ver</i> <i>b_1</i>	k	vela	#kendé	Non-High	630.67991	plain	0	Voiceless	60.659983	4.7129215
		r	p	High	94414608				29165723	76810913
<i>re_1_ver</i> <i>b_1</i>	k	vela	#kendé	Non-High	635.16201	plain	0	Voiceless	24.560090	7.8528744
		r	p	High	81405896				7029484	830919095
<i>re_1_ver</i> <i>b_1</i>	k	vela	#kendé	Non-High	653.70395	plain	0	Voiceless	26.793424	13.019937
		r	p	High	12471656				036213764	205740462
<i>re_1_ver</i> <i>b_1</i>	k	vela	#kendé	Non-High	701.29985	plain	0	Voiceless	32.331821	16.021507
		r	p	High	26077098				61750392	592995476
<i>re_1_ver</i> <i>b_1</i>	k	vela	#kendé	Non-High	727.58968	plain	0	Voiceless	40.691222	13.802231
		r	p	High	67508909				003715666	063209547
<i>re_1_ver</i> <i>b_1</i>	k	vela	#kendé	Non-High	734.27777	plain	0	Voiceless	28.599287	2.9114660
		r	p	High	93974733				334031942	355844535
<i>re_1_ver</i> <i>b_1</i>	k	vela	#kendé	Non-High	754.29944	plain	0	Voiceless	53.910304	4.0677752
		r	p	High	94834971				8627112	5824964
<i>re_1_ver</i> <i>b_1</i>	k	vela	#kendé	Non-High	858.49129	plain	0	Voiceless	21.101862	6.9367191
		r	p	High	34292491				200907817	3199978
<i>re_1_ver</i> <i>b_1</i>	k	vela	#kendé	Non-High	867.63845	plain	0	Voiceless	72.703537	5.0167577
		r	p	High	62596969				55529868	57971391
<i>re_1_ver</i> <i>b_1</i>	k	vela	#kendé	Non-High	870.61105	plain	0	Voiceless	27.640463	2.5277147
		r	p	High	44217687				59288841	896076713
<i>re_1_ver</i> <i>b_1</i>	k	vela	#kendé	Non-High	876.53445	plain	0	Voiceless	36.632348	4.3275007
		r	p	High	7346157				98033352	8675781
<i>toneCont</i> <i>rastLong</i>	k	vela	#ke	Non-High	174.23945	plain	0	Voiceless	26.264552	10.027869
		r		High	386904762				633364247	985663074
<i>toneCont</i> <i>rastLong</i>	k	vela	#kenen	Non-High	85.507628	plain	0	Voiceless	23.877395	11.232614
		r		High	68107769				31120303	087290926
<i>toneCont</i> <i>rastLong</i>	k	vela	#kenen	Non-High	88.164198	plain	0	Voiceless	39.796340	9.6302083
		r		High	4508547				81197503	33334167
<i>toneCont</i> <i>rastLong</i>	k	vela	#kenen	Non-High	124.69753	plain	0	Voiceless	23.305553	2.8261571
		r		High	519144145				750859076	45548791
<i>toneCont</i> <i>rastLong</i>	k	vela	#kenen	Non-High	155.76142	plain	0	Voiceless	31.579810	2.9370243
		r		High	875				231050942	46067574
<i>toneCont</i> <i>rastLong</i>	k	vela	#kenev	Non-High	25.257197	plain	0	Voiceless	19.923437	31.515147
		r	on	High	916666666				50000103	569443513
<i>toneCont</i> <i>rastLong</i>	k	vela	#kra	Non-High	44.775413	plain	0	Voiceless	23.950721	17.067957
		r		High	37719298				64422629	899385533
<i>toneCont</i> <i>rastLong</i>	k	vela	#kra	Non-High	46.257789	plain	0	Voiceless	22.660515	8.8213105
		r		High	007056274				68546601	91592635
<i>toneCont</i> <i>rastLong</i>	k	vela	#kra	Non-High	49.031559	plain	0	Voiceless	19.786805	16.554734
		r		High	027777774				55556167	848483577
<i>toneCont</i> <i>rastLong</i>	k	vela	#kra	Non-High	60.132550	plain	0	Voiceless	28.138022	13.365683
		r		High	459956704				747697278	962270225
<i>toneCont</i> <i>rastLong</i>	k	vela	#kra	Non-High	65.968519	plain	0	Voiceless	30.167515	24.015139
		r		High	53125				851459825	75155467
<i>toneCont</i> <i>rastLong</i>	k	vela	#kra	Non-High	67.522661	plain	0	Voiceless	26.356638	10.955976
		r		High	0576923				090831552	378028254
<i>toneCont</i> <i>rastLong</i>	k	vela	#kra	Non-High	69.611309	plain	0	Voiceless	20.051245	22.332435
		r		High	027777778				210723323	3448362
<i>toneCont</i> <i>rastLong</i>	k	vela	#kra	Non-High	72.915468	plain	0	Voiceless	24.942229	19.285675
		r		High	75				038842356	001569302
<i>toneCont</i> <i>rastLong</i>	k	vela	#kra	Non-High	80.463218	plain	0	Voiceless	15.189210	14.274281
		r		High	75				199011427	864487648
<i>toneCont</i> <i>rastLong</i>	k	vela	#kra	Non-High	84.934725	plain	0	Voiceless	21.248084	26.648503
		r		High	694444445				291173086	873062168
<i>toneCont</i> <i>rastLong</i>	k	vela	#kra	Non-High	87.792078	plain	0	Voiceless	33.214685	9.7513802
		r		High	4692896				47230211	62244425
<i>toneCont</i> <i>rastLong</i>	k	vela	#kra	Non-High	89.993625	plain	0	Voiceless	23.682815	19.452642
		r		High	45289854				330630547	118380936
<i>toneCont</i> <i>rastLong</i>	k	vela	#kra-ge	Non-High	77.409339	plain	0	Voiceless	22.815408	27.312468
		r		High	22101449				61514486	9475992
<i>toneCont</i> <i>rastLong</i>	k	vela	#kra-ya	Non-High	75.251574	plain	0	Voiceless	21.609129	12.783855
		r		High	58305054				070668587	200467542
<i>toneCont</i> <i>rastLong</i>	k	vela	poun-ke	Non-High	119.45076	plain	0	Voiceless	42.880702	25.843972
		r		High	11882716				02971994	79390771
<i>toneCont</i> <i>rastLong</i>	k	vela	uk-n-ya	Non-High	107.53838	plain	0	Voiceless	51.595057	12.458467
		r		High	405797102				972875225	389450334
<i>toneCont</i> <i>rastLong</i>	k	vela	uk-n-ya	Non-High	116.71199	plain	0	Voiceless	53.545180	12.287632
		r		High	069940477				22485877	27513241

<i>toneCont</i>	k	vela	uk-n-ya	Non-High	119.98648	plain	0	Voiceless	33.287269	21.913580
<i>rastLong</i>	r				317787287				65798978	24691681
<i>toneCont</i>	k	vela	uk-n-ya	Non-High	123.13376	plain	0	Voiceless	30.476728	15.066725
<i>rastLong</i>	r				11882716				395058217	146198223
<i>re_1_ver</i>	m	bial	#mbih	High	501.42590	prenasalize	69.852078	Prenasalized (voiced)	27.182315	7.6402697
<i>b_1</i>	b	bial			90909091	d	42353702		7537483	83109943
<i>re_1_ver</i>	m	bial	hoqpɔt-mbih	High	264.58863	prenasalize	67.781747	Prenasalized (voiced)	45.051594	15.734897
<i>b_1</i>	b	bial			8425067	d	94050074		76298104	841525708
<i>re_1_ver</i>	m	bial	hoqpɔt-mbih	High	267.14907	prenasalize	94.922887	Prenasalized (voiced)	41.428975	13.754719
<i>b_1</i>	b	bial			004283197	d	67359014		63065162	469034171
<i>re_1_ver</i>	m	bial	hoqpɔt-mbih	High	270.54440	prenasalize	110.23688	Prenasalized (voiced)	23.055555	9.3947124
<i>b_1</i>	b	bial			597667644	d	04664593		55551564	30434993
<i>re_1_ver</i>	m	bial	hɛrɛrɛt-mbih	High	470.65607	prenasalize	107.60625	Prenasalized (voiced)	37.808616	6.3987916
<i>b_1</i>	b	bial			91799713	d	716653749		26586329	77611371
<i>re_1_ver</i>	m	bial	hɛrɛrɛt-mbih	High	472.68953	prenasalize	78.573821	Prenasalized (voiced)	45.697281	8.4457946
<i>b_1</i>	b	bial			8606403	d	36387514		90938349	76049445
<i>re_1_ver</i>	m	bial	hɛrɛrɛt-mbih	High	478.07201	prenasalize	76.467976	Prenasalized (voiced)	25.972963	16.974656
<i>b_1</i>	b	bial			710987425	d	46799541		544404593	529271215
<i>re_1_ver</i>	m	bial	hɛrɛrɛt-mbih	High	481.77720	prenasalize	109.35410	Prenasalized (voiced)	40.932374	13.839873
<i>b_1</i>	b	bial			44759933	d	299390469		84119072	239305689
<i>re_1_ver</i>	m	bial	hɛrɛrɛt-mbih	High	498.54757	prenasalize	77.529313	Prenasalized (voiced)	32.818090	9.4341612
<i>b_1</i>	b	bial			020757023	d	71982186		19898674	61424379
<i>re_1_ver</i>	m	bial	hoqpɔt-mbih	High	790.65899	prenasalize	107.92326	Prenasalized (voiced)	48.946178	4.8592770
<i>b_1</i>	b	bial			62367926	d	434125243		471396706	44033661
<i>re_1_ver</i>	m	bial	#mbe	Non-High	50.584337	prenasalize	93.035016	Prenasalized (voiced)	50.940867	9.5843791
<i>b_1</i>	b	bial			66913358	d	05160136		1861209	59029766
<i>re_1_ver</i>	m	bial	#mbe	Non-High	274.23831	prenasalize	103.13212	Prenasalized (voiced)	25.361148	28.957727
<i>b_1</i>	b	bial			478045764	d	752367917		57468874	669364886
<i>re_1_ver</i>	m	bial	#mbe	Non-High	485.67998	prenasalize	82.846062	Prenasalized (voiced)	58.317193	13.614342
<i>b_1</i>	b	bial			027721274	d	76282602		461220995	165283233
<i>re_1_ver</i>	m	bial	#mbe	Non-High	613.83988	prenasalize	191.13313	Prenasalized (voiced)	52.937695	15.598324
<i>b_1</i>	b	bial			17622287	d	896980344		713353605	90613644
<i>re_1_ver</i>	m	bial	#mbe	Non-High	728.32095	prenasalize	61.147913	Prenasalized (voiced)	33.483227	11.122594
<i>b_1</i>	b	bial			08692366	d	938611964		40680487	336825387
<i>re_1_ver</i>	m	bial	#mbe	Non-High	734.88792	prenasalize	55.247513	Prenasalized (voiced)	42.672944	5.8924522
<i>b_1</i>	b	bial			8262214	d	84359661		38295721	18972721
<i>re_1_ver</i>	m	bial	#mbe	Non-High	754.89987	prenasalize	112.80743	Prenasalized (voiced)	16.333711	11.236761
<i>b_1</i>	b	bial			01929752	d	36310192		262291217	371264947
<i>re_1_ver</i>	m	bial	#mbe	Non-High	764.56594	prenasalize	124.05487	Prenasalized (voiced)	36.423582	4.9230914
<i>b_1</i>	b	bial			1043084	d	528337744		76647428	58863382
<i>re_1_ver</i>	m	bial	#mbe	Non-High	770.70038	prenasalize	96.333459	Prenasalized (voiced)	47.970521	10.495965
<i>b_1</i>	b	bial			98966994	d	30967607		541856215	828226872
<i>re_1_ver</i>	m	bial	#mbe	Non-High	784.80348	prenasalize	83.267389	Prenasalized (voiced)	38.024648	3.8621315
<i>b_1</i>	b	bial			30186757	d	0897695		9238516	193267947
<i>re_1_ver</i>	m	bial	#mbe	Non-High	835.72764	prenasalize	31.834060	Prenasalized (voiced)	29.072284	7.7346322
<i>b_1</i>	b	bial			34412149	d	629194028		43416443	51072071
<i>re_1_ver</i>	m	bial	#mbe	Non-High	844.59483	prenasalize	30.981148	Prenasalized (voiced)	39.511329	9.1351218
<i>b_1</i>	b	bial			83353341	d	577666318		8952765	21032044

<i>re_1_ver</i> <i>b_1</i>	m b	bila bial	#mbe	Non- High	901.35486 39455782	prena salize d	112.28823 381213715	Prenasaliz ed (voiced)	33.604293 74151863	8.8158098 87664727	
<i>re_1_ver</i> <i>b_1</i>	m b	bila bial	#mbe	Non- High	919.47140 01156018	prena salize d	36.121426 34835891	Prenasaliz ed (voiced)	28.634920 63488593	8.6203604 24856699	
<i>re_1_ver</i> <i>b_1</i>	m b	bila bial	#mbe	Non- High	934.89836 35676493	prena salize d	116.12912 865405178	Prenasaliz ed (voiced)	27.173455 005709002	7.3380519 98317496	
<i>re_1_ver</i> <i>b_1</i>	m b	bila bial	#mbe	Non- High	939.70242 9138322	prena salize d	103.47789 115644446	Prenasaliz ed (voiced)	17.653287 981829635	8.1970521 54287121	
<i>re_1_ver</i> <i>b_1</i>	m b	bila bial	#mbeh	Non- High	44.043267 77087646	prena salize d	50.073340 76199044	Prenasaliz ed (voiced)	45.429477 81494178	8.2813010 70255154	
<i>re_1_ver</i> <i>b_1</i>	m b	bila bial	#mbeh	Non- High	79.561603 23080027	prena salize d	32.399633 503345626	Prenasaliz ed (voiced)	26.390036 446443332	5.6238973 45628848	
<i>re_1_ver</i> <i>b_1</i>	m b	bila bial	#mbeh	Non- High	82.252030 36192832	prena salize d	148.07738 536487136	Prenasaliz ed (voiced)	36.866072 53777652	4.2178093 63098013	
<i>re_1_ver</i> <i>b_1</i>	m b	bila bial	#mbeh	Non- High	96.818495 58214091	prena salize d	41.526683 79357749	Prenasaliz ed (voiced)	53.544388 79757595	30.049530 818317294	
<i>re_1_ver</i> <i>b_1</i>	m b	bila bial	#mbeh	Non- High	185.17210 108604843	prena salize d	108.08738 547544294	Prenasaliz ed (voiced)	22.782542 96888349	4.9695818 20120084	#mbo h
<i>re_1_ver</i> <i>b_1</i>	m b	bila bial	#mbeh	Non- High	194.66536 048607475	prena salize d	102.55334 612480738	Prenasaliz ed (voiced)	32.488823 281937584	4.0439339 65107271	
<i>re_1_ver</i> <i>b_1</i>	m b	bila bial	#mbeh	Non- High	197.01127 437641722	prena salize d	113.44160 997731478	Prenasaliz ed (voiced)	35.461208 29287247	5.7392830 1477622	#mbo h
<i>re_1_ver</i> <i>b_1</i>	m b	bila bial	#mbeh	Non- High	221.37727 955333077	prena salize d	105.56934 380386451	Prenasaliz ed (voiced)	25.336504 009942473	9.3524960 8949107	#mbo h
<i>re_1_ver</i> <i>b_1</i>	m b	bila bial	#mbeh	Non- High	294.82087 6108019	prena salize d	78.025173 42383908	Prenasaliz ed (voiced)	29.097584 770340745	10.110892 310137842	
<i>re_1_ver</i> <i>b_1</i>	m b	bila bial	#mbeh	Non- High	358.61797 72284501	prena salize d	65.726417 11068172	Prenasaliz ed (voiced)	47.405785 8660899	6.0937431 76279531	
<i>re_1_ver</i> <i>b_1</i>	m b	bila bial	geh-ɔ- mbɔɔ	Non- High	354.31873 198741863	prena salize d	60.463023 91928293	Prenasaliz ed (voiced)	46.352445 74018316	14.139679 037668884	
<i>re_1_ver</i> <i>b_1</i>	m b	bila bial	geh-ɔ- mbɔɔ	Non- High	359.29199 937011845	prena salize d	80.697683 93613685	Prenasaliz ed (voiced)	18.978588 424658938	6.3657407 40761794	
<i>re_1_ver</i> <i>b_1</i>	m b	bila bial	geh-ɔ- mbɔɔ	Non- High	370.23788 49721707	prena salize d	64.286832 72145008	Prenasaliz ed (voiced)	19.304007 655080113	18.891858 33067586	
<i>re_1_ver</i> <i>b_1</i>	m b	bila bial	geh-ɔ- mbɔɔ	Non- High	423.34706 11415298	prena salize d	55.456945 06992049	Prenasaliz ed (voiced)	25.581875 60737224	6.8000584 0723652	
<i>re_1_ver</i> <i>b_1</i>	m b	bila bial	geh-ɔ- mbɔɔ	Non- High	441.32958 38172668	prena salize d	73.897791 82710754	Prenasaliz ed (voiced)	38.307369 12368593	15.116880 900336582	
<i>re_1_ver</i> <i>b_1</i>	m b	bila bial	heɾeɾét- mbɔɔ	Non- High	496.21436 59350533	prena salize d	86.365254 39220577	Prenasaliz ed (voiced)	30.141826 427552587	8.7775716 34652759	
<i>re_1_ver</i> <i>b_1</i>	m b	bila bial	heɾeɾét- mbɔɔ	Non- High	499.75364 00856639	prena salize d	103.21546 506702362	Prenasaliz ed (voiced)	31.244546 450864163	6.7411726 59531003	
<i>re_1_ver</i> <i>b_1</i>	m b	bila bial	heɾeɾét- mbɔɔ	Non- High	394.29858 58585859	prena salize d	81.566956 16321485	Prenasaliz ed (voiced)	39.815054 273788064	14.211058 36203651	
<i>re_1_ver</i> <i>b_1</i>	m b	bila bial	hoqpɔt- mbɔɔ	Non- High	633.27210 91215185	prena salize d	91.680749 98569864	Prenasaliz ed (voiced)	39.492774 88766256	17.938064 114559893	

<i>re_1_ver</i> <i>b_1</i>	m b	bila bial	hoqpɔt- mbɔn	Non- High	636.33584 50491307	prena salize d	107.03978 786420976	Prenasaliz ed (voiced)	28.731439 145190052	8.1380700 42832624	
<i>re_1_ver</i> <i>b_1</i>	m b	bila bial	mɔmbɛ h	Non- High	30.438785 993333035	prena salize d	55.381863 79143184	Prenasaliz ed (voiced)	47.364755 92075351	6.9909992 9827085	
<i>re_1_ver</i> <i>b_1</i>	m b	bila bial	mɔmbɛ h	Non- High	33.009569 402228976	prena salize d	69.298752 63068652	Prenasaliz ed (voiced)	20.031381 298437623	6.3061651 70045119	
<i>re_1_ver</i> <i>b_1</i>	m b	bila bial	mɔmbɛ h	Non- High	59.872786 98619888	prena salize d	58.862864 752732946	Prenasaliz ed (voiced)	36.183453 31026518	8.8664311 87854573	
<i>re_1_ver</i> <i>b_1</i>	m b	bila bial	mɔmbɛ h	Non- High	116.90315 783148898	prena salize d	52.761554 99220181	Prenasaliz ed (voiced)	35.552365 340109304	7.6354288 287490135	
<i>re_1_ver</i> <i>b_1</i>	m b	bila bial	mɔmbɛ h	Non- High	122.29345 293965532	prena salize d	73.828625 45298963	Prenasaliz ed (voiced)	22.608412 215959106	19.174378 576835238	
<i>re_1_ver</i> <i>b_1</i>	m b	bila bial	mɔmbɛ h	Non- High	131.53876 481410174	prena salize d	59.162067 34264051	Prenasaliz ed (voiced)	43.019452 64481333	8.8238491 1636791	
<i>re_1_ver</i> <i>b_1</i>	m b	bila bial	mɔmbɛ h	Non- High	153.14656 945241282	prena salize d	199.27112 45587202	Prenasaliz ed (voiced)	55.134113 980102484	9.6506676 25521692	mmb ɛh
<i>re_1_ver</i> <i>b_1</i>	m b	bila bial	mɔmbɛ h	Non- High	190.39517 157923066	prena salize d	52.728978 60191961	Prenasaliz ed (voiced)	43.249611 66227581	11.990602 45286887	mem bɔh
<i>re_1_ver</i> <i>b_1</i>	m b	bila bial	mɔmbɛ h	Non- High	200.82568 901967778	prena salize d	111.76677 745589814	Prenasaliz ed (voiced)	24.792279 223788682	4.9482591 11017705	
<i>re_1_ver</i> <i>b_1</i>	m b	bila bial	mɔmbɛ h	Non- High	227.80103 713432567	prena salize d	94.655954 50404862	Prenasaliz ed (voiced)	32.176264 03963436	9.7583648 8441928	
<i>re_1_ver</i> <i>b_1</i>	m b	bila bial	mɔmbɛ h	Non- High	244.93225 252169833	prena salize d	40.269872 60218107	Prenasaliz ed (voiced)	23.432146 24588086	14.312389 27079903	
<i>re_1_ver</i> <i>b_1</i>	m b	bila bial	mɔmbɛ h	Non- High	263.59573 197278917	prena salize d	66.599848 82838899	Prenasaliz ed (voiced)	0	28.659432 026813647	mɔm bɔh
<i>re_1_ver</i> <i>b_1</i>	m b	bila bial	mɔmbɛ h	Non- High	305.12119 814843237	prena salize d	62.208466 24603382	Prenasaliz ed (voiced)	29.237197 232362178	12.501466 539617923	
<i>re_1_ver</i> <i>b_1</i>	m b	bila bial	mɔmbɛ h	Non- High	309.17613 63063744	prena salize d	61.757833 737772216	Prenasaliz ed (voiced)	45.140723 83341272	1.5505952 380863164	mɔm bɔh
<i>re_1_ver</i> <i>b_1</i>	m b	bila bial	mɔmbɛ h	Non- High	314.57722 7024143	prena salize d	78.181534 62937971	Prenasaliz ed (voiced)	33.656653 519472	9.1915723 75357282	mɔm bɔh
<i>re_1_ver</i> <i>b_1</i>	m b	bila bial	mɔmbɛ h	Non- High	349.42204 439133013	prena salize d	62.434066 71978846	Prenasaliz ed (voiced)	24.307196 56280189	11.680709 710844894	
<i>re_1_ver</i> <i>b_1</i>	m b	bila bial	mɔmbɛ h	Non- High	422.57876 33235113	prena salize d	90.517506 76957226	Prenasaliz ed (voiced)	35.126111 98323157	11.636141 636188313	mem bɛh
<i>re_1_ver</i> <i>b_1</i>	m b	bila bial	mɔmbɛ h	Non- High	437.77793 508531425	prena salize d	56.752687 230698484	Prenasaliz ed (voiced)	42.515679 206189816	5.9618749 856440445	
<i>re_1_ver</i> <i>b_1</i>	m b	bila bial	mɔmbɛ h	Non- High	463.44918 26427541	prena salize d	73.167602 89967306	Prenasaliz ed (voiced)	37.116473 88189476	10.263439 19448891	
<i>re_1_ver</i> <i>b_1</i>	m b	bila bial	mɔmbɛ h	Non- High	534.80949 75302782	prena salize d	61.354699 50254446	Prenasaliz ed (voiced)	35.531639 74549989	5.9138463 08089887	
<i>re_1_ver</i> <i>b_1</i>	m b	bila bial	mɔmbɛ h	Non- High	545.38863 89259754	prena salize d	50.173575 456142316	Prenasaliz ed (voiced)	30.689992 8995108	8.3507697 8160032	
<i>re_1_ver</i> <i>b_1</i>	m b	bila bial	mɔmbɛ h	Non- High	731.15957 47951533	prena salize d	65.989023 594625	Prenasaliz ed (voiced)	24.697196 052329673	7.2585115 28903	

<i>re_1_ver</i> <i>b_1</i>	m b	bila bial	mɔmbɛ h	Non- High	840.94702 45957265	prena salize d	73.855875 18331249	Prenasaliz ed (voiced)	32.852711 25196232	8.1334432 76392427
<i>re_1_ver</i> <i>b_1</i>	m b	bila bial	mɔmbɛ h	Non- High	877.65049 28473447	prena salize d	74.877358 70881806	Prenasaliz ed (voiced)	31.301967 577860523	4.2480372 7150902
<i>re_1_ver</i> <i>b_1</i>	m b	bila bial	mɔmbɛ h	Non- High	923.15334 25370149	prena salize d	88.087379 58463553	Prenasaliz ed (voiced)	27.454720 58870746	5.3165027 27282568
<i>re_1_ver</i> <i>b_1</i>	m b	bila bial	mɔmbɛ h	Non- High	995.15572 64634249	prena salize d	77.077478 66481895	Prenasaliz ed (voiced)	26.514526 03834059	5.9416932 84171379
<i>re_1_ver</i> <i>b_1</i>	m b	bila bial	mɔmbɛ h	Non- High	1051.1909 5143613	prena salize d	63.033824 641024694	Prenasaliz ed (voiced)	35.600140 9570581	7.3620439 16828043
<i>re_1_ver</i> <i>b_1</i>	m b	bila bial	mɔmbɛ h	Non- High	1077.1379 871868428	prena salize d	104.89117 817837723	Prenasaliz ed (voiced)	54.078862 31409975	11.838993 375249629
<i>re_1_ver</i> <i>b_1</i>	m b	bila bial	mɔmbɛ h	Non- High	1098.0034 36041083	prena salize d	49.694470 38092767	Prenasaliz ed (voiced)	29.876858 150601038	4.2176870 74742571
<i>re_1_ver</i> <i>b_1</i>	m b	bila bial	mombɛ h	Non- High	103.37497 917534361	prena salize d	47.918699 85585606	Prenasaliz ed (voiced)	37.240584 224704776	27.162509 44823173
<i>re_1_ver</i> <i>b_1</i>	m b	bila bial	pyembɔ t	Non- High	259.75437 31990613	prena salize d	56.986085 39324823	Prenasaliz ed (voiced)	19.614950 650122864	15.425493 545535574
<i>re_1_ver</i> <i>b_1</i>	m b	bila bial	pyembɔ t	Non- High	381.91248 84666511	prena salize d	58.482326 22446403	Prenasaliz ed (voiced)	22.936120 317069708	7.1593639 65229204
<i>re_1_ver</i> <i>b_1</i>	m b	bila bial	pyembɔ t	Non- High	420.94075 64546287	prena salize d	37.401732 98177751	Prenasaliz ed (voiced)	56.236617 113484044	9.6471453 89465095
<i>re_1_ver</i> <i>b_1</i>	m b	bila bial	pyembɔ t	Non- High	629.67646 88574674	prena salize d	72.945581 70895016	Prenasaliz ed (voiced)	14.252896 610400967	6.2856760 3916963
<i>re_1_ver</i> <i>b_1</i>	m b	bila bial	pyembɔ t	Non- High	634.39600 42112083	prena salize d	53.458877 73103186	Prenasaliz ed (voiced)	11.247519 628454938	12.585990 071784181
<i>re_1_ver</i> <i>b_1</i>	m b	bila bial	tɔmbɔn	Non- High	550.09524 44977992	prena salize d	59.063279 36577327	Prenasaliz ed (voiced)	47.739589 930074544	4.5380792 04735368
<i>re_1_ver</i> <i>b_2</i>	m b	bila bial	rɔh- mbon	Non- High	724.89494 34579026	prena salize d	90.073065 50267913	Prenasaliz ed (voiced)	23.922756 010165358	25.205656 336538595
<i>re_1_ver</i> <i>b_3</i>	m b	bila bial	nɔwɔ- mbon	Non- High	958.23622 92310864	prena salize d	74.181139 4115075	Prenasaliz ed (voiced)	35.644807 128619505	13.094482 23742038
<i>toneCont</i> <i>rast</i>	m b	bila bial	kɔmbɔr	Non- High	90.576877 43263473	prena salize d	38.252706 254155555	Prenasaliz ed (voiced)	52.325714 28571475	18.837272 831831342
<i>toneCont</i> <i>rast</i>	m b	bila bial	kɔmbɔr	Non- High	94.331949 73958334	prena salize d	67.188882 21153918	Prenasaliz ed (voiced)	35.739583 333324276	12.685466 746802376
<i>toneCont</i> <i>rast</i>	m b	bila bial	kɔmbɔr	Non- High	97.991385 83333333	prena salize d	75.121405 36722711	Prenasaliz ed (voiced)	38.505351 87915227	11.105615 942028635
<i>toneCont</i> <i>rast</i>	m b	bila bial	kombɔr	Non- High	83.543952 89702582	prena salize d	82.256593 71491645	Prenasaliz ed (voiced)	26.108896 940428394	17.102256 25822659
<i>toneCont</i> <i>rast</i>	m b	bila bial	kombɔr	Non- High	85.827604 36320754	prena salize d	81.332485 75079222	Prenasaliz ed (voiced)	21.166821 676587233	23.849027 452513383
<i>toneCont</i> <i>rast</i>	m b	bila bial	kombɔr	Non- High	87.609486 06220657	prena salize d	65.290067 73692458	Prenasaliz ed (voiced)	21.527541 581164655	11.031215 676069905
<i>toneCont</i> <i>rastLong</i>	m b	bila bial	#mbyar	Non- High	331.73599 211543615	prena salize d	76.543176 46449726	Prenasaliz ed (voiced)	31.891025 699053444	17.245133 45578771

<i>toneCont rastLong</i>	m b	bila bial	#mbyar	Non- High	333.68694 674045224	prena salize d	77.494114 80358503	Prenasaliz ed (voiced)	64.536407 67330171	5.9315965 83593546	
<i>re_1_ver b_1</i>	m b	bila bial	#mbon	Non- High	501.90224 615772235	prena salize d	74.455378 23798531	Prenasaliz ed (voiced)	47.885981 58637569	16.675521 002071036	
<i>re_1_ver b_1</i>	nd	alve olar	#ndira	High	606.49005 56740109	prena salize d	57.394368 506152205	Prenasaliz ed (voiced)	35.953463 029272825	25.142979 714473768	
<i>re_1_ver b_1</i>	nd	alve olar	#ndira	High	609.77798 0147205	prena salize d	85.090703 77692751	Prenasaliz ed (voiced)	24.678713 960383902	6.1185378 54376882	
<i>re_1_ver b_1</i>	nd	alve olar	#ndira	High	619.73558 68480726	prena salize d	93.403609 22146829	Prenasaliz ed (voiced)	37.649281 93504602	5.4713041 93292781	
<i>re_1_ver b_1</i>	nd	alve olar	#ndira	High	630.93145 48546691	prena salize d	86.696459 91074049	Prenasaliz ed (voiced)	16.528932 52469312	5.4538276 8939362	
<i>re_1_ver b_1</i>	nd	alve olar	#ndira	High	635.39140 40060469	prena salize d	71.208300 13695922	Prenasaliz ed (voiced)	35.852546 4239392	7.2585765 48792917	
<i>re_1_ver b_1</i>	nd	alve olar	#ndira	High	653.93454 67980296	prena salize d	108.34750 784090375	Prenasaliz ed (voiced)	54.362685 815021905	7.5326466 65254106	
<i>re_1_ver b_1</i>	nd	alve olar	#ndira	High	701.56584 90803729	prena salize d	84.332571 99828859	Prenasaliz ed (voiced)	54.351335 42709991	5.8004163 96709807	
<i>re_1_ver b_1</i>	nd	alve olar	#ndira	High	727.92761 97145525	prena salize d	65.834707 21614049	Prenasaliz ed (voiced)	16.066386 554712153	10.580126 359513997	
<i>re_1_ver b_1</i>	nd	alve olar	#ndira	High	734.55121 08843538	prena salize d	56.573192 239739	Prenasaliz ed (voiced)	36.502177 5905916	6.9881704 79303335	
<i>re_1_ver b_1</i>	nd	alve olar	#ndira	High	754.57323 04203733	prena salize d	51.052378 46055388	Prenasaliz ed (voiced)	16.796323 29114611	8.3868045 96511865	
<i>re_1_ver b_1</i>	nd	alve olar	#ndira	High	858.79046 18291761	prena salize d	74.102557 98231447	Prenasaliz ed (voiced)	16.688546 763703016	8.3249194 41520251	
<i>re_1_ver b_1</i>	nd	alve olar	#ndira	High	867.97089 98687195	prena salize d	123.87426 315547145	Prenasaliz ed (voiced)	20.898581 65493297	5.2607709 75041851	
<i>re_1_ver b_1</i>	nd	alve olar	#ndira	High	870.84967 98185942	prena salize d	45.860479 82979835	Prenasaliz ed (voiced)	35.186584 922030306	1.5385907 44985413	
<i>re_1_ver b_1</i>	nd	alve olar	#ndira	High	876.82855 43419246	prena salize d	81.575773 61373569	Prenasaliz ed (voiced)	20.214616 949260744	9.6725726 8018784	
<i>toneCont rastLong</i>	nd	alve olar	#ndur	High	306.37631 73361033	prena salize d	108.15418 011117117	Prenasaliz ed (voiced)	25.579243 8308049	17.198094 415107334	#ndur u
<i>toneCont rastLong</i>	nd	alve olar	#ndur	High	309.09077 83710084	prena salize d	38.655620 028805515	Prenasaliz ed (voiced)	25.670811 3311106	18.400747 026134923	#ndur u
<i>toneCont rastLong</i>	nd	alve olar	#ndur o	High	312.40536 88556651	prena salize d	47.891022 67199041	Prenasaliz ed (voiced)	33.396457 848539285	14.239058 145221861	
<i>re_1_ver b_1</i>	nd	alve olar	kendép	Non- High	609.59535 96292319	prena salize d	54.034503 42112137	Prenasaliz ed (voiced)	12.687176 060921956	5.9733191 97892124	
<i>re_1_ver b_1</i>	nd	alve olar	kendép	Non- High	619.55003 16266858	prena salize d	44.629267 97509681	Prenasaliz ed (voiced)	23.562688 10558504	9.1590618 33656779	
<i>re_1_ver b_1</i>	nd	alve olar	kendép	Non- High	635.23907 91784187	prena salize d	49.515050 48165927	Prenasaliz ed (voiced)	25.010831 101212716	17.091016 40881272	
<i>re_1_ver b_1</i>	nd	alve olar	kendép	Non- High	701.41219 67750064	prena salize d	45.846812 799140935	Prenasaliz ed (voiced)	17.469855 66717285	8.5349314 32791382	

<i>re_1_ver_b_1</i>	nd	alveolar	kendép	Non-High	727.68974 94024637	prenasalized	55.251667 14653551	Prenasalized (voiced)	23.533825 829417765	9.2503105 96826239
<i>re_1_ver_b_1</i>	nd	alveolar	kendép	Non-High	754.40780 10502446	prenasalized	49.456779 97079656	Prenasalized (voiced)	41.618061 6047086	11.188356 101342833
<i>re_1_ver_b_1</i>	nd	alveolar	kendép	Non-High	858.57787 24596757	prenasalized	60.490618 889048164	Prenasalized (voiced)	27.484835 56456449	6.0038027 47954978
<i>re_1_ver_b_1</i>	nd	alveolar	kendép	Non-High	867.75561 91590166	prenasalized	55.620930 96159515	Prenasalized (voiced)	41.048269 81017595	6.5205593 34830978
<i>re_1_ver_b_1</i>	nd	alveolar	kendép	Non-High	870.69261 22021137	prenasalized	48.208376 11771367	Prenasalized (voiced)	15.113405 425040582	3.7842493 159132573
<i>re_1_ver_b_1</i>	nd	alveolar	kendép	Non-High	876.62457 07929637	prenasalized	53.924509 91939768	Prenasalized (voiced)	23.438091 94383084	7.8977306 05805009
<i>toneCont_rast</i>	nd	alveolar	kondón	Non-High	30.215752 40906623	prenasalized	57.589139 036750225	Prenasalized (voiced)	18.106142 11440864	8.3697380 98018331
<i>toneCont_rast</i>	nd	alveolar	kondón	Non-High	22.902944 20252647	prenasalized	68.618813 15009555	Prenasalized (voiced)	31.688922 307928635	13.851061 669722498
<i>toneCont_rast</i>	nd	alveolar	kondón	Non-High	32.459701 84748428	prenasalized	50.395981 140091806	Prenasalized (voiced)	33.042217 671919616	7.8358686 06704821
<i>re_1_ver_b_1</i>	nd	alveolar	kendép	Non-High	630.77824 76694382	prenasalized	56.649911 816521126	Prenasalized (voiced)	19.995781 495822484	6.267
<i>toneCont_rast</i>	nd	alveolar	kondón	Non-High	24.989753 2964135	prenasalized	47.970049 17473302	Prenasalized (voiced)	41.882632 67263537	12.33
<i>toneCont_rast</i>	nd	alveolar	kondón	Non-High	27.576144 219483563	prenasalized	56.518857 9271414	Prenasalized (voiced)	29.866650 91286511	17.074824 145566936
<i>re_1_ver_b_1</i>	ng	velar	hoqpɔt- ɔnggón	Non-High	655.26645 42705971	prenasalized	129.10231 56737765	Prenasalized (voiced)	25.545803 40290613	8.7131122 84567615
<i>re_1_ver_b_1</i>	ng	velar	hoqpɔt- ɔnggón	Non-High	661.65652 42038845	prenasalized	93.458704 70178852	Prenasalized (voiced)	23.859294 96188055	16.036687 40210651
<i>re_1_ver_b_1</i>	ng	velar	hoqpɔt- nɔnggón	Non-High	802.32174 30623043	prenasalized	94.267486 84290942	Prenasalized (voiced)	19.108257 2406458	3.8138142 795105523
<i>re_1_ver_b_1</i>	ng	velar	hoqpɔt- nɔnggón	Non-High	806.21179 52806123	prenasalized	96.828398 13615374	Prenasalized (voiced)	22.692180 928856942	7.6891169 44675334
<i>re_1_ver_b_2</i>	ng	velar	#nggɛw ɛrí	Non-High	624.00041 29371047	prenasalized	83.313849 35763708	Prenasalized (voiced)	38.781911 55376953	2.9980554 099893197
<i>re_1_ver_b_2</i>	ng	velar	pinggɛn	Non-High	138.40347 46206175	prenasalized	90.436944 00835989	Prenasalized (voiced)	27.070828 331318353	19.419665 302024214
<i>toneCont_rast</i>	ng	velar	#nggɛin	Non-High	162.46316 198671497	prenasalized	66.037141 19202664	Prenasalized (voiced)	20.723688 3580606	11.042700 976332753
<i>toneCont_rastLong</i>	ng	velar	#nggɔr	Non-High	239.33923 701771462	prenasalized	135.31639 141822893	Prenasalized (voiced)	42.097453 96420317	15.624767 275198792
<i>toneCont_rastLong</i>	ng	velar	#nggɔr	Non-High	241.11464 00462963	prenasalized	93.586759 25923876	Prenasalized (voiced)	24.768427 495303058	8.1414856 99155737
<i>toneCont_rastLong</i>	ng	velar	#nggɛin	Non-High	580.62431 70295431	prenasalized	108.40391 702640773	Prenasalized (voiced)	41.824800 05408706	15.736968 08884506
<i>toneCont_rastLong</i>	ng	velar	#nggɛin	Non-High	596.90113 25496612	prenasalized	135.38270 002868558	Prenasalized (voiced)	28.045405 21697163	15.830345 310291705

<i>toneCont rastLong</i>	ng g	vela r	#nggɛin	Non- High	597.67934 84160382	prena salize d	84.849058 62906089	Prenasaliz ed (voiced)	27.593149 67431692	15.806648 632519682	
<i>re_1_ver b_1</i>	ng k	vela r	hoqpɔ- ja=ngke n	Non- High	814.10598 78679615	prena salize d	91.802621 9718513	Prenasaliz ed (voiced)	44.132160 608455706	9.0296247 98586156	ngg
<i>re_1_ver b_1</i>	ng k	vela r	hoqpɔ- ja=ngke n	Non- High	809.75928 40029093	prena salize d	57.642527 70291023	Prenasaliz ed (voiced)	38.937879 408763365	3.4975035 756588113	ngg
<i>re_1_ver b_3</i>	ng m b	vela r	nongmb ó	Non- High	354.13650 667674483	prena salize d	61.531872 00800403	Prenasaliz ed (voiced)	32.416225 74955727	5.9802757 08168392	
<i>toneCont rastLong</i>	ng m b	vela r	#ngmbr ɔk	Non- High	818.38695 72814125	prena salize d	40.523617 78008162	Prenasaliz ed (voiced)	39.712983 00587023	7.0600446 762227875	ngmb ɔɾk
<i>toneCont rastLong</i>	ng m b	vela r	o ngmbrɔ k	Non- High	820.22031 34889995	prena salize d	32.721863 87812326	Prenasaliz ed (voiced)	24.615637 2668338	6.0273330 68686858	o ngmb ɔɾk
<i>re_1_ver b_1</i>	nt	alve olar	nantéɛ n	Non- High	1074.5734 319727892	prena salize d	44.994583 01825143	Prenasaliz ed (voiced)	28.243890 1488149	17.950474 875760847	nand éɛn
<i>re_1_ver b_1</i>	nt	alve olar	nantéɛ n	Non- High	1077.7686 65582175	prena salize d	113.31854 480931725	Prenasaliz ed (voiced)	46.417233 560077875	7.2580143 16676054	nand éɛn
<i>re_1_ver b_1</i>	nt	alve olar	nantéɛ n	Non- High	1080.8503 113553113	prena salize d	60.831061 8545147	Prenasaliz ed (voiced)	21.919131 263075542	11.791656 010700535	nand éɛn
<i>re_1_ver b_1</i>	nt	alve olar	nantéɛ n	Non- High	1098.3503 577097506	prena salize d	76.306594 86017066	Prenasaliz ed (voiced)	25.475460 38613291	5.6191163 33491547	nand éɛn
<i>re_1_ver b_1</i>	p	bila bial	#pyemb ɔt	Non- High	381.77387 07482994	plain	0	Voiced	41.127004 55556251	2.2320279 463201587	b
<i>re_1_ver b_1</i>	p	bila bial	#pyemb ɔt	Non- High	259.60005 491085326	plain	0	Voiceless	20.471573 244662977	5.8920851 5629025	
<i>re_1_ver b_1</i>	p	bila bial	#pyemb ɔt	Non- High	420.80803 35097002	plain	0	Voiceless	25.594317 499098906	2.9281975 09504571	
<i>re_1_ver b_1</i>	p	bila bial	#pyemb ɔt	Non- High	461.10357 70975057	plain	0	Voiceless	16.690834 22842732	3.3825251 48310833	
<i>re_1_ver b_1</i>	p	bila bial	#pyemb ɔt	Non- High	629.54757 31562467	plain	0	Voiceless	16.288283 065932774	2.4310776 941547374	
<i>re_1_ver b_1</i>	p	bila bial	#pyemb ɔt	Non- High	634.30216 93121693	plain	0	Voiceless	18.623741 894430168	2.6088733 73901588	
<i>toneCont rastLong</i>	p	bila bial	#poun	Non- High	100.00415 43560606	plain	0	Voiceless	33.257273 43862184	9.5892385 56330315	
<i>toneCont rastLong</i>	p	bila bial	#poun	Non- High	102.48808 492867869	plain	0	Voiceless	19.197623 4046507	4.9843749 99992269	
<i>toneCont rastLong</i>	p	bila bial	#poun	Non- High	104.60894 791666666	plain	0	Voiceless	19.738945 578225753	1.8924201 625196702	
<i>toneCont rastLong</i>	p	bila bial	#poun	Non- High	109.37940 625	plain	0	Voiceless	31.841485 507243306	1.8118028 914386741	
<i>toneCont rastLong</i>	p	bila bial	#poun	Non- High	115.95262 736742424	plain	0	Voiceless	18.523882 57574944	5.6882682 29178561	
<i>toneCont rastLong</i>	p	bila bial	#poun	Non- High	121.40770 833333333	plain	0	Voiceless	21.553030 30302491	5.6972237 62012982	
<i>toneCont rastLong</i>	p	bila bial	#poun	Non- High	124.31576 041666666	plain	0	Voiceless	19.859913 79309837	2.6382902 298962563	
<i>toneCont rastLong</i>	p	bila bial	#poun	Non- High	127.59631 25	plain	0	Voiceless	19.283368 644067878	3.9968396 89264675	
<i>toneCont rastLong</i>	p	bila bial	#poun- ke	Non- High	119.18178 28525641	plain	0	Voiceless	21.519230 769229125	2.2200980 392170777	
<i>toneCont rastLong</i>	qp	vela r	#qpawó -da	Non- High	142.43430 87121212	plain	0	Voiced	40.948459 93256513	5.0524249 40771516	gbaw ó-da
<i>toneCont rastLong</i>	qp	vela r	#qpot	Non- High	164.08264 583333334	plain	0	Voiced	43.685882 39475457	4.2086343 33849659	gb
<i>re_1_ver b_1</i>	qp	vela r	hɔqpɔt- mbih	Non- High	264.34978 316326533	plain	0	Voiceless	67.767857 14282596	10.571165 664373439	
<i>re_1_ver b_1</i>	qp	vela r	hɔqpɔt- mbih	Non- High	266.90828 672209625	plain	0	Voiceless	89.571260 60306564	10.260095 449837081	
<i>re_1_ver b_1</i>	qp	vela r	hɔqpɔt- mbih	Non- High	270.26130 536659116	plain	0	Voiceless	87.124338 62427815	3.2342128 770892487	

<i>re_1_ver</i> <i>b_1</i>	qp	vela r	hoqpɔ- ja=ngke n	Non- High	809.36615 78798186	plain	0	Voiceless	92.092309 14586897	11.455190 772039714	
<i>re_1_ver</i> <i>b_1</i>	qp	vela r	hoqpɔ- ja=ngke n	Non- High	813.71167 80045352	plain	0	Voiceless	76.031746 03173102	9.2647828 36226004	
<i>re_1_ver</i> <i>b_1</i>	qp	vela r	hoqpɔt- ɔnggɔ́n	Non- High	654.98631 97278911	plain	0	Voiceless	70.959183 6736081	8.6205593 34758582	
<i>re_1_ver</i> <i>b_1</i>	qp	vela r	hoqpɔt- ɔnggɔ́n	Non- High	661.38792 51700681	plain	0	Voiceless	19.577259 47511335	8.1006033 3662932	
<i>re_1_ver</i> <i>b_1</i>	qp	vela r	hoqpɔt- mbɔ́n	Non- High	633.07944 44444444	plain	0	Voiceless	57.229024 94335358	21.988208 61678996	
<i>re_1_ver</i> <i>b_1</i>	qp	vela r	hoqpɔt- mbɔ́n	Non- High	636.17102 52672498	plain	0	Voiceless	50.450275 34822566	16.773415 900161126	
<i>re_1_ver</i> <i>b_1</i>	qp	vela r	hoqpɔt- mbih	Non- High	790.38534 92063492	plain	0	Voiceless	102.67517 006809612	14.488751 640897135	
<i>re_1_ver</i> <i>b_1</i>	qp	vela r	hoqpɔt- nɔ́nggɔ́n	Non- High	802.00185 56311414	plain	0	Voiceless	65.097203 32576308	8.4899391 33482949	
<i>re_1_ver</i> <i>b_1</i>	qp	vela r	hoqpɔt- nɔ́nggɔ́n	Non- High	805.64602 04081633	plain	0	Voiceless	143.66591 08087497	9.7035357 35297919	
<i>toneCont</i> <i>rastLong</i>	qp	vela r	#qpawó- -da	Non- High	138.80348 02631579	plain	0	Voiceless	23.608693 331766517	7.3475754 18634733	
<i>toneCont</i> <i>rastLong</i>	qp	vela r	#qpawó- -da	Non- High	146.34424 972587718	plain	0	Voiceless	25.481730 521192958	1.9344427 244334383	
<i>toneCont</i> <i>rastLong</i>	qp	vela r	#qpawó- -da	Non- High	150.28514 791666666	plain	0	Voiceless	24.664475 945030517	2.0424684 99411143	
<i>toneCont</i> <i>rastLong</i>	qp	vela r	#qpɔt	Non- High	167.61811 160714285	plain	0	Voiceless	30.666011 35867586	1.8617257 607616011	
<i>toneCont</i> <i>rastLong</i>	qp	vela r	#qpɔt	Non- High	173.91679 374999998	plain	0	Voiceless	35.391037 326405694	0.8754904 51363703	
<i>toneCont</i> <i>rastLong</i>	qp	vela r	#qpɔt o	Non- High	165.72065 162037035	plain	0	Voiceless	28.037352 693615958	5.6382129 91499358	
<i>toneCont</i> <i>rastLong</i>	qp	vela r	#qpɔt o	Non- High	170.06316 875	plain	0	Voiceless	32.340021 929826435	1.4546539 961202143	
<i>toneCont</i> <i>rastLong</i>	qp	vela r	#qpɔt-a	Non- High	171.86261 458333334	plain	0	Voiceless	24.693959 948308475	2.2970656 92715705	
<i>toneCont</i> <i>rastLong</i>	qp	vela r	hoqpoja	Non- High	18.114083 692528734	plain	0	Voiceless	97.797413 7931028	24.843420 989085985	
<i>toneCont</i> <i>rastLong</i>	qp	vela r	hoqpoja	Non- High	19.669411 732456137	plain	0	Voiceless	88.225767 54386091	26.878531 323877297	
<i>toneCont</i> <i>rastLong</i>	qp	vela r	hoqpoja	Non- High	21.167791 498960888	plain	0	Voiceless	144.08514 577595355	22.565807 44894876	
<i>toneCont</i> <i>rastLong</i>	qp	vela r	hoqpoja	Non- High	22.731246 820175436	plain	0	Voiceless	115.16305 414851402	17.607486 787159843	
<i>toneCont</i> <i>rastLong</i>	qp	vela r	hoqpoja	Non- High	168.19678 211805555	plain	0	Voiceless	118.79995 809388788	5.7965491 78626265	
<i>toneCont</i> <i>rastLong</i>	qp	vela r	hoqpoja	Non- High	172.40546 846064814	plain	0	Voiceless	111.22317 61142084	4.7310395 19697333	
<i>toneCont</i> <i>rastLong</i>	t	alve olar	qpɔt o	Non- High	165.94298 08006536	plain	0	Voiced	56.300997 59201812	2.4889125 386948763	d
<i>toneCont</i> <i>rastLong</i>	t	alve olar	qpɔt o	Non- High	170.22457 51312336	plain	0	Voiced	54.256153 633900794	4.4707433 51191686	d
<i>toneCont</i> <i>rastLong</i>	t	alve olar	qpɔt-a	Non- High	171.99183 741096866	plain	0	Voiced	45.794473 40273646	3.9947463 5278807	d
<i>re_1_ver</i> <i>b_1</i>	t	alve olar	#tɔ́mbɔ n	Non- High	536.70917 43970316	plain	0	Voiceless	18.762677 798349614	2.2245795 754542996	
<i>re_1_ver</i> <i>b_1</i>	t	alve olar	#tɔ́mbɔ n	Non- High	549.89289 79591838	plain	0	Voiceless	18.274961 59751263	3.5163376 381888156	
<i>toneCont</i> <i>rastLong</i>	t	alve olar	#tro	Non- High	60.463309 89583333	plain	0	Voiceless	58.822048 611105515	11.305555 555566116	
<i>toneCont</i> <i>rastLong</i>	t	alve olar	#tro	Non- High	70.077443 28703704	plain	0	Voiceless	28.401207 01058879	12.596227 601846977	
<i>toneCont</i> <i>rastLong</i>	t	alve olar	#troda	Non- High	73.219550 41666666	plain	0	Voiceless	27.375833 333337596	20.078888 888889423	
<i>toneCont</i> <i>rastLong</i>	t	alve olar	#tro-da	Non- High	71.340259 11458333	plain	0	Voiceless	24.500746 527778006	5.9779861 11105338	
<i>toneCont</i> <i>rastLong</i>	t	alve olar	#tro-da	Non- High	75.776021 875	plain	0	Voiceless	23.276157 40740896	18.095838 365539407	
<i>toneCont</i> <i>rastLong</i>	t	alve olar	#tro-da	Non- High	78.036682 29166666	plain	0	Voiceless	48.119295 63491901	13.426896 304977731	

<i>toneCont</i>	t	alve	#tro-da	Non-	81.691876	plain	0	Voiceless	22.167314	20.072318
<i>rastLong</i>		olar		High	1574074				814808492	840590242
<i>toneCont</i>	t	alve	#tro-ja	Non-	70.662562	plain	0	Voiceless	29.370330	7.9045923
<i>rastLong</i>		olar		High	5				45976989	79730957