キリバス語の長鼻音の音声学
Phonetics of Geminate Nasals in Kiribati

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ABSTRACT

ミクロネシア語族の一言語であるキリバス語には，短鼻音と長鼻音がある。本論文では男女4人ずつ8名のキリバス語話者から録音した鼻音のデータに基づく音響分析結果を報告する。8人の話者が8個のアイテムを5回繰り返した320トークンのデータを分析した。その結果は，佐藤（2009，2011）の報告結果を支持するもので，長鼻音は短鼻音の2倍以上の長さであった。さらに本研究では，単音節語には，最小語効果（オンセットの鼻音の種類に関わらず，単音節の長さが同じ）が見られることを示す。すなわち，短鼻音のオンセットの後ろに来る短母音は長めであった。一方，複数音節語では，短鼻音の後ろに来る短母音が長くなることはなかった。また，長鼻音の後ろに長母音が来るという唇鼻音のオンセットについても報告する。その結果，予測通りに，長鼻音のオンセットと長母音の長さには，有意な相関関係があることがわかった。

Kiribati is a Micronesian language with singleton and geminate nasals. This paper reports results of an acoustic study of Kiribati nasals based on data from 8 speakers (4 males and 4 females). Analyses were performed on 320 tokens (8 items * 8 speakers * 5 repetitions). Results show that geminate nasals are longer than singleton nasals, echoing findings reported in Sato (2009, 2011). We further report that monosyllabic words display a word-minimality effect based on the finding that syllables with singleton or geminate onsets have the same duration, that is, short vowels are longer after a singleton onset. However, in multisyllabic words, we do not see such a vowel lengthening after a singleton consonant. We also report the duration of labial onsets when geminates are followed by a long vowel. As expected, a positive correlation is found between the duration of geminate onsets and that of long vowels.

1. Introduction

This paper reports on the phonetics and phonology of nasals in Kiribati, a Micronesian language spoken in the Republic of Kiribati by around 110,000 people (National Statistics Office, 2016). Kiribati speakers also reside in Fiji, the Solomon Islands, and Tuvalu. The Republic of Kiribati is located in the South Pacific over a vast area that is mostly covered by ocean; the landmass constitutes only 0.02 % of the country.

Cowell (1951) as well as Blevins and Harrison (1999) describe Kiribati with a sound system that has 13 consonants and 10 vowels. The consonants include three plosives [p, t, k], three nasals [m, n, ŋ], and a rhotic [r]. The labials can be velarized [mˠ, pˠ, βˠ] and non-velarized nasals have geminate counterparts [mː, nː, ŋː]. The five vowels are [i, e, u, o, a] with a short and long counterpart.

In Lee and Timee (2019), three more qualitative vowels are reported [ɛ, æ, ɔ] in addition to the five vowels. The velarized labials were not observed in their work, but the [ɛ] vowel was observed after labials that are orthographically encoded with a *w* or an apostrophe: *mw*, *bw* or *m', b'*. In Lee and Timee (2020), the variable nature of the Kiribati labial plosive is acoustically examined, where labial plosives are realized both as voiced as well as voiceless.

Kiribati nasals show a three-way place contrast as labials, coronals, and dorsals. The nasals also have a length contrast between singletons and geminates. In the examples in (1), the length contrast in Kiribati nasals shows that the contrast appears in both word-initial (1a) and word-medial position (1b).

(1) Length contrast in Kiribati nasals

a.	mane	'money'
	mːaːne	'man, boy'
b.	karina	'suddenly'
	karinːa	'to put something inside'

In a survey of 44 languages based on grammar sketches in Lynch et al. (2002), Oceanic languages are found to have between two and six contrastive nasals: [m, n] to [mʷ, m, n, ɲ, ŋ, ŋʷ]. Most grammar sketches do not provide detailed information about the place of articulation of the nasals, but the coronal nasal is realized as a dental in three languages: Sobei (Sterner & Ross, 2002), Tobati (Donohue, 2002), and Iaai (Lynch, 2002). Descriptions about the presence of geminate consonants in these sketches turn up in three languages: *mata* 'eye', *mmata* 'wake up' in Ulithian (Lynch, 2002), [na] 'I', [nna] 'he, she' in Banoni (Lynch & Ross, 2002), and /kai/ 'eat', /kkai/ 'fester' in Ifira-Mele (Clark, 2002).

Kiribati nasals display the minimal place contrast with labial and coronal nasals. The coronal nasals in Kiribati are often produced as dental sounds like in Sobei, Tobati, or Iaai. Although Kiribati has three nasals based on the place contrast, similar to what is seen in Gapapaiwa (McGuckin, 2002), 'Al'ala (Ross, 2002), and Marquesan (Lynch, 2002), the length contrast is what makes Kiribati unique among the languages that have few nasal contrasts; none of the other languages are reported to have a geminate contrast.

Sato (2009, 2011) reports the duration of the length contrast in Kiribati nasals based on data, in which six male speakers (three in their 20's and three over 40 years old) recorded six pairs in isolation with five repetitions. The reported ratios between geminate and singleton durations demonstrate inter-item and inter-speaker variation. On average, geminates were between 0.98 to 5.91 times longer than singletons, while geminates are about 1.89 times longer in Sato (2009) and about 2.23 times longer in Sato (2011). Overall, in Sato's studies and the current study, the duration of geminates is more than twice as long as that of singletons, which has been reported in cross-linguistic studies (cf. Kawahara, 2015).

This paper offers a fresh observation of Kiribati nasals by reporting characteristics in addition to durational ratios. After reporting the durational differences in singletons and geminates, we report findings related to different place of articulation. When explaining phonetic duration in terms of phonology, the moraic theory proposed in Hyman (1985) offers an insight. For example, lengthening a vowel when a coda consonant is deleted can elegantly be explained with moras; the coda is deleted, but a mora remains. Some languages prefer to have monosyllabic words to have a long vowel; this preference is called word-minimality effect, which is formalized as a requirement for a word to have at least two moras.

In the next section, a new set of nasal data collected from eight Kiribati speakers will be presented and analyzed. As expected, geminates are longer than singletons. In section 3, Kiribati nasals are viewed in light of cross-linguistic geminate contrasts on nasals. Prosodic word-minimality is discussed as it relates to monosyllabic words that contrast in singleton and geminate onsets.

2. Acoustics of Kiribati nasals

2.1. Data collection and processing

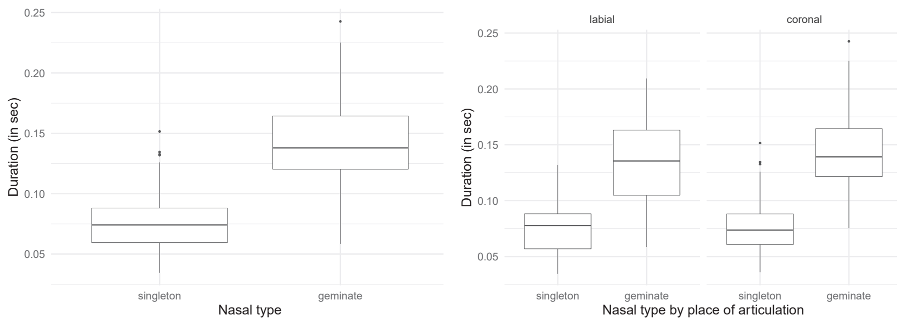
Kiribati data in this study comes from recordings made in August 2019 in Tarawa, Kiribati. The recordings were made in a quiet space. During the recording sessions, air conditioning was turned off to minimize the noise in the recordings. The stimuli set was constructed based on materials presented in Sato (2011). Four minimal pairs were recorded; one monosyllabic pair in (2a) and three multi-syllabic pairs in (2b-d). Note that the pair in (2d) is not strictly a minimal pair, since both consonant and vowel durations are lengthened in the first syllable. Although dorsal geminates are reported in Kiribati (cf. Blevins & Harrison, 1999), they were not included due to the absence of minimal pairs. The labial minimal pairs in (2d) have an additional variable where the vowels following the labial nasals differ in length; the singleton nasal is followed by a short vowel, whereas the geminate nasal precedes a long vowel.

(2) Stimuli set for Kiribati nasals

a.	na	‘will (future)’
	nːa	‘to give the slack’
b.	newe	‘tongue’
	nːewe	‘lobster’
c.	karina	‘suddenly’
	karinːa	‘to put something inside’
d.	mane	‘money’
	mːaːne	‘old man’

The recordings were made using a Tascam recorder with a head-worn Shure WH-30 XLR microphone. After signing a consent form and filling a demographic questionnaire, participants sat in front of a computer screen while wearing a microphone. Stimuli were presented using PowerPoint slides that were advanced manually by the experimenter. The order of the stimuli was randomized with a larger list of items constructed to elicit various aspects of the Kiribati language. Target items in the Roman script analyzed in this study were read in isolation. Participants read a set of a randomized list five times, resulting in five recordings of each item. The elicitation method differs from Sato (2011), in which participants read each word 5 times consecutively, and only read the 12 target items. Before the main part of the study, participants had an opportunity to practice how to read from the slides. After practice, they had an opportunity to ask questions if anything was unclear about the experimental procedure.

We recruited four female and four male participants in their 20’s and 30’s (mean 27 years old). Seven participants were born and raised in the outer islands: four from Tabiteuea, two from Butaritari, and one from Abaiang. One participant was from Northern Tarawa. The pronunciation of



(a) Collapsed by all data point

(b) By place of articulation

Figure 1. Duration of nasal intervals by geminates and singleton (n = 320)

speakers from the outer islands may be conservative compared to speakers in Tarawa, the capital of Kiribati. All participants use Kiribati in their everyday life in all social situations. At the time of the recording, the participants were pursuing an advance diploma to become a teacher in the Kiribati school system.

Data processing was facilitated by a series of Praat scripts that automatized the process by adding margins and labels with basic information to text grids (Boersma, 2006). Individual files for each token were created for further annotation. Intervals for nasals and vowels following the nasals were manually annotated by adding boundaries at the nearest zero crossing. Extracted duration data were further analyzed using R (R Core Team, 2020), and its tidyverse package (Wickham et al., 2019) and broom package (Robinson et al., 2020).

2.2. Results

Durational differences between singleton and geminate nasals across all speakers, items, and repetitions are shown in figure 1a. The duration of singletons (M = 76.3 ms, SD = 22 ms) is shorter than the duration of geminates (M = 140.1 ms, SD = 33 ms). Thus, geminates are 1.84 times longer than singletons. We refer to this as the duration ratio. This ratio is similar to what was reported by Sato (2009). We will see that the ratio is higher when we separate out place of articulation, as shown in figure 1b.

In Figure 2, the durational distribution is shown for individual speakers. As in Sato (2011), individual variation is found between mean durational ratios, but geminates are always longer than singleton nasals. Unlike Sato (2011), however, no speaker shows a durational ratio of 1 or less, which would mean that geminates have similar lengths as singletons.

The spectrograms in figure 3 visually demonstrate the durational difference between singletons and geminates in Kiribati (77 ms versus 188 ms; duration ratio is 2.44). The nasal portions have a weaker amplitude and anti-resonant formants are observable.

The durational difference between singleton and geminate nasals confirms what previous studies (Sato, 2009, 2011) have reported. Individual variation is observed, but the difference in the acoustic signals consistently displays a longer duration in geminates.

We hypothesized that geminates in a phonological system need to be understood in a relationship with the following vowel, that is, the absolute duration of a nasal itself may not be sufficient to provide enough cues to Kiribati speakers to discern geminates from

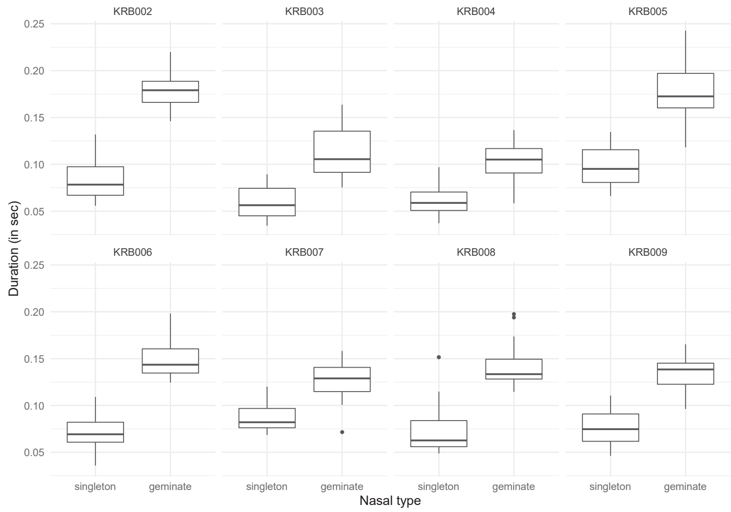
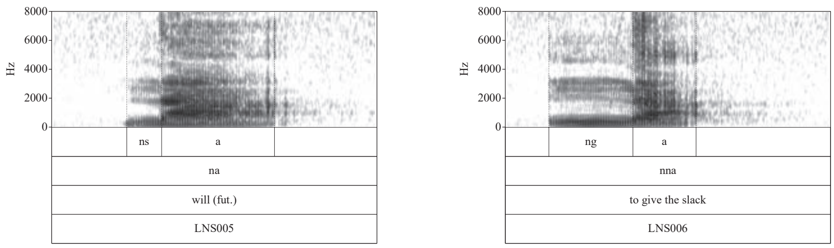


Figure 2. Durational difference by nasal type plotted by speakers



(a) **n**asal **s**ingleton ('ns', 77 ms)

(b) **n**asal **g**eminate ('ng', 188 ms)

Figure 3. Spectrogram of singleton and geminate nasals in Kiribati

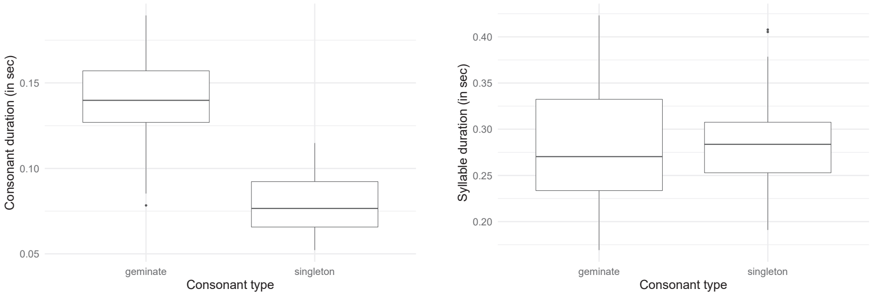
singletons. In the next section, three observations from the Kiribati data will be discussed with regard to this hypothesis: (a) the word-minimality effect (section 3.1), (b) the absence of the word-minimality effect (section 3.2), and (c) the effect of long vowel following geminates (section 3.3).

3. Discussion

3.1. Monosyllabic words with nasal length contrast

One of the minimal pairs in the stimuli is monosyllabic: [na] 'will (future)' versus [nːa] 'to give the slack'. We hypothesized that Kiribati speakers may not differentiate the overall duration of these two words if Kiribati has a word minimality effect that disfavors CV syllables with a short vowel. As shown in Figure 4a, geminates are significantly longer than singletons ($t(72) = 12.36$, $p < 0.0001$). However, no significant difference was observed in syllable durations shown in Figure 4b ($t(73) = -0.06$, $p = 0.95$).

When the duration of vowels in the monosyllabic words is considered, the vowel in [na] is significantly



a. Consonant duration by onset types

b. Syllable duration by onset types

Figure 4. Durational difference in the minimal pairs [na] and [n:a]

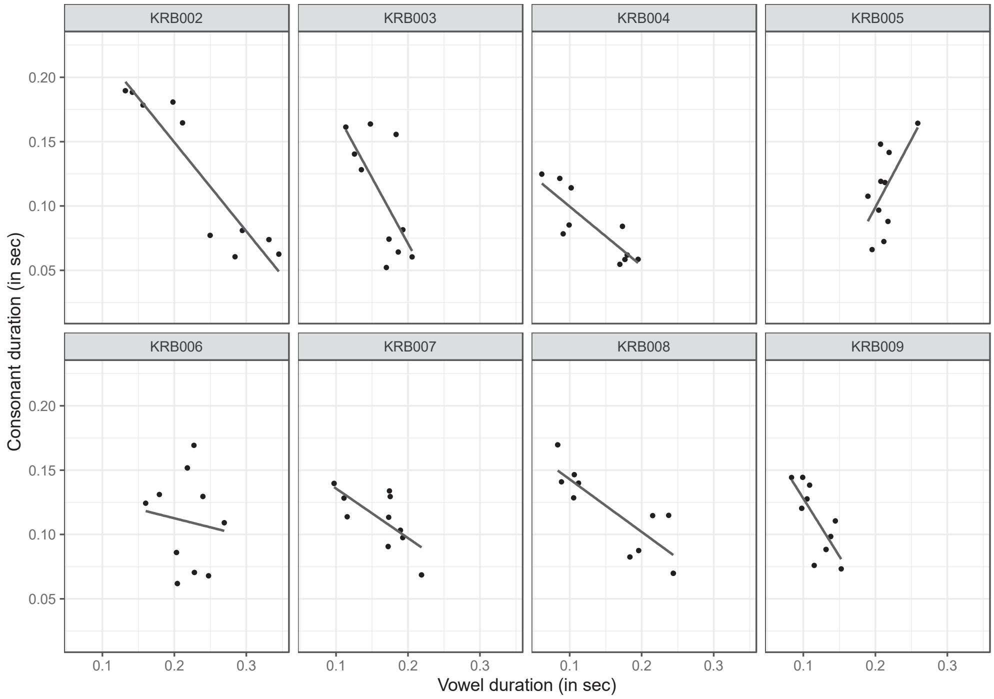
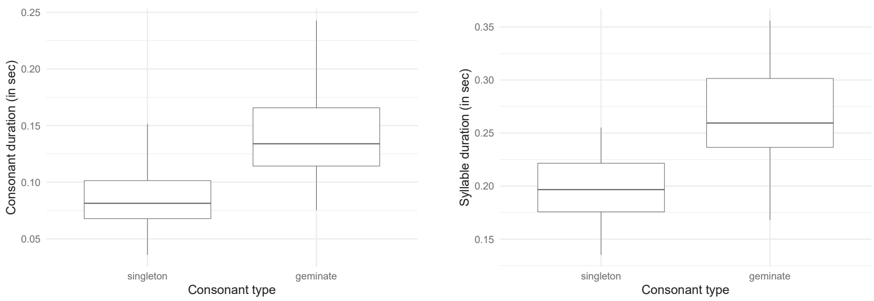


Figure 5. Consonant duration plotted against vowel duration in [na] and [n:a] tokens

longer than the vowel in [n:a] ($t(77.6) = -5.29$, $p <$ 0.0001). This result suggests a negative correlation between vowel and consonant durations; that is, if the consonant is longer, as in a geminate, then the vowel is shorter; and vice versa, if the consonant is shorter, as in a singleton, the vowel is longer. In Figure 5, data points are taken from all the [na] and [n:a] tokens are plotted.

For the most part, speakers show a negative relation between consonant and vowel durations. However, there are interspeaker differences. For instance, positive correlation is found in speaker KRB005 who produces longer consonants when vowels are longer. Note, however, this speaker also



a. Consonant duration b. Syllable duration

Figure 6. Consonant and syllable duration in geminate contrast in the word-initial position

shows a tendency of producing all vowels as long. Speaker KRB006 also shows a different pattern, i.e., no relation between consonant and vowel lengths.

While individual variation is observed, the findings in this section suggest the phonology of Kiribati speakers shows word-minimality, that is, in order to keep the word the same length, a short vowel in a CV syllable is lengthened. Word-minimality can also be satisfied by increasing the consonant duration, with a geminate consonant. If geminates did not contribute to the word-minimality, vowels after geminates would not be lengthened. But that is not the case. Our data show that the syllable duration of [na] and [nːa] is constant, which implies that geminates in Kiribati may serve as a phonologically weight-bearing unit, akin to moraic onsets proposed in Topintzi (2008).

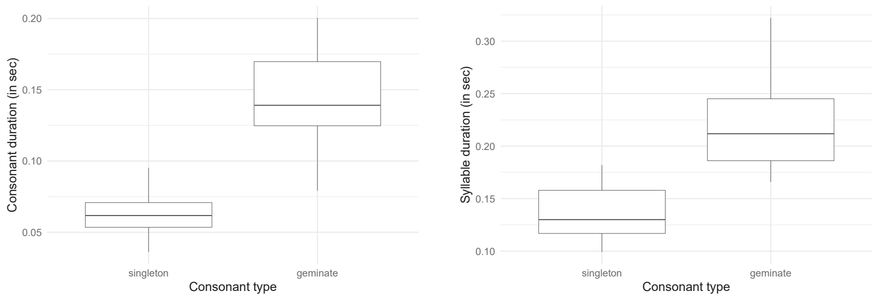
3.2. Multisyllabic words and nasal length contrast

Kiribati has multisyllabic words that show geminate contrast in an initial syllable ([newe] 'tongue' versus [nːewe] 'lobster') or in a non-initial syllable ([karina] 'suddenly' versus [karinːa] 'to put something inside'). Does the word minimality effect observed in section 3.1 hold for multisyllabic words? We hypothesize that short vowels after a singleton consonant will not be lengthened because multisyllabic words do not need to observe the word-minimality effect.

Data that display the geminate contrast in the initial syllable ([newe] vs [nːewe]) is examined first. As shown in figure 6a, geminates are longer than singletons ($t(67) = -7.44$, $p < 0.0001$). However, the initial syllable has a longer duration when onsets are geminates than when onsets are singletons in figure 6b ($t(68) = -7.76$, $p < 0.0001$).

The pattern in figure 6b is expected if the difference between syllables with a singleton onset and those with a geminate onset lies in the duration of the onset consonant, suggesting that the vowel duration in both types of syllables is relatively constant.

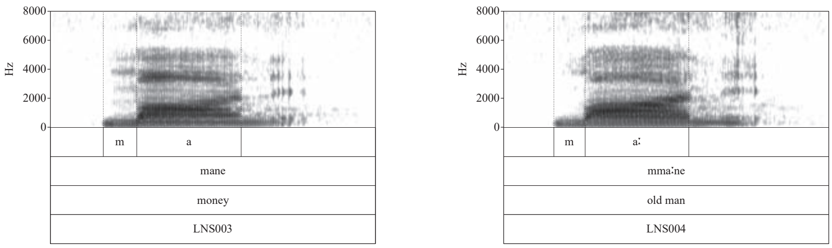
In non-initial syllables, ([karina] 'suddenly' versus [karinːa] 'to put something inside'), the durational distribution between singletons and geminates pattern akin to the distribution found in initial syllables of multisyllabic words. Geminate contrast is reflected in the durational difference in the onset consonants (figure 7a, $t(54) = -14.89$, $p < 0.0001$) as well as in the entire syllable duration (figure 7b, $t(63) = -10.81$, $p < 0.0001$). Thus, the duration of vowels is not different after a singleton onset and a geminate onset ($t(77.1) = -0.84$, $p = 0.4$); this means that the durational difference between singleton and geminate is the main factor for the



a. Consonant duration

b. Syllable duration

Figure 7. Consonant and syllable duration in geminate contrast in the non-initial position



a. Singleton labial onset (77.4 ms)

b. Geminate labial onset (71.6 ms)

Figure 8. Production of labial nasals by a female speaker KRB007

durational difference found in the entire syllable.

This section has examined the duration of singletons and geminates in multisyllabic words. The data show that vowel duration does not vary as a function of the onset consonant types, suggesting that only the duration of a geminate onset makes the duration of a syllable longer. This pattern contrasts with the pattern reported for monosyllabic words in section 3.1, in which the vowel duration demonstrated a negative correlation with the consonant duration; singleton onsets are followed by a phonetically longer short vowel.

3.3. The effect of long vowels after a geminate

Here we look at the first syllable of the labial minimal pair ([mane] vs [mːaːne]; Not only was the geminate onset longer than the singleton on, but also the long vowel following the geminate [mː] was longer than the vowel following the singleton [m]. During the annotation, the impression was that the durational differences between the singleton and geminate labials were not large. Figure 8 shows that the durational ratio between the two labials is 0.92; the geminate nasal is actually shorter than the singleton nasal.

The mean durational ratio between singleton and geminate labial nasals across all speakers and tokens is 1.82, suggesting that not all speakers display such a short durational ratio. Figure 9 plots vowel duration on the x-axis and consonant duration on the y-axis; the short vowels preceded by a singleton nasal is marked with a triangle, the long vowel preceded by geminate nasal is marked with a circle. Thus, we expect that in the panels for each speaker, triangles should be on the lower left side, and circles

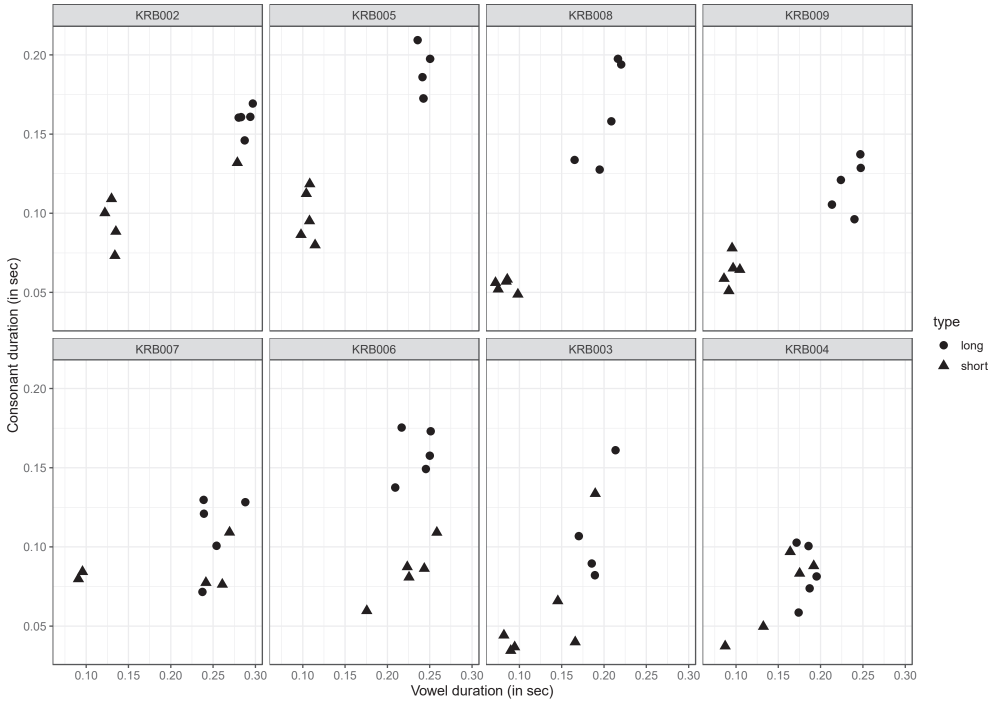


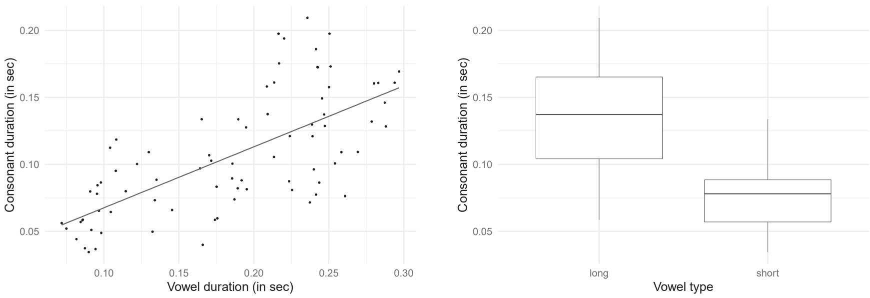
Figure 9. Vowel duration plotted against consonant duration by each speaker

in the upper right side. That is, short vowels preceded by singleton nasal should be shorter than long vowels preceded by geminate nasals.

Figure 9 shows the interspeaker variation. Half of the speakers (KRB002, KRB005, KRB008, KRB009, top row) display a bimodal distribution between vowel types and consonant duration: geminates before a long vowel are longer than singletons before a short vowel. Production by speakers in the bottom row shows that other speakers show a variable pattern. Speaker KRB006 produces most short vowels with a duration similar to that of long vowels while maintaining the durational difference between singletons and geminates. Speaker KRB007 produces some short vowels as long, while speaker KRB003 produces long vowels that are only slightly longer than short vowels (with a low durational ratio). The speaker KRB004 also displays the production of long vowels that are that converge with the duration of short vowels.

The overall patterns in the labial tokens confirm that the geminates have longer durations than singletons and that long vowels have longer durations than short vowels. Labials are found to have a positive correlation between vowel length and consonant duration ($R^2 = 0.46$ in Figure 10a); the longer the vowel is, the longer the consonant duration. Figure 10b demonstrates that the durational difference between singleton and geminate labials is significant ($t(65.8) = -8.45$, $p < 0.001$). This correlation is likely to have emerged due to the nature of the stimuli where a geminate followed by a long vowel and a singleton followed by a short vowel, respectively.

This section has reported how the duration of labial nasals correlates with the vowel duration, due



a. Correlation between duration of labial consonants and a following vowel

b. Duration of labial consonants by vowel types

Figure 10. Relationship between the duration of labial consonants and their following vowels

to the fact that the stimuli where geminate labials are followed by a long vowel and singleton labials are followed by a short vowel. A subjective impression was that the duration of geminate labial nasals was not as long as the duration of other geminates. However, the actual measurements reveal that the majority of Kiribati speakers produced a labial geminate longer than singletons when all data points were considered.

4. Conclusion

This paper has shown the nasal length contrast in two nasal places in Kiribati: coronal and labial. It also shows a contrast in the way intrasyllabic durations are handled for monosyllabic words on the one hand and multisyllabic words, on the other hand. Monosyllabic words show a word-minimality effect, where syllable duration is constant, regardless of whether the onset is a geminate or a singleton. However, for multisyllabic words, the initial syllable shows no such word-minimality effect: the syllable duration becomes longer with a geminate onset and shorter with a singleton onset. We also found interspeaker variability, especially in the way speakers handle long vowels after long consonants: some speakers show that long vowels are long, and short vowels are short, regardless of whether the syllable onset is a geminate or a singleton. Other speakers show a great deal of variation in segment durations.

Clearly more examples are needed to verify the tentative findings in this paper; but, we hope that this study has offered some new insights into durational relationships among geminate and singleton nasal consonants. Specifically, it will be interesting to see if word-minimality effects are found only for monosyllabic words. And, it will be interesting to see if these findings bear our cross-linguistically.

One further note: When words in Kiribati end in a vowel, speakers tend to add breathy or creaky phonation; as far as we know, the final phonation has not yet been reported in previous studies. Phonation types as well as overall intonation of Kiribati remain less studied areas; an area that needs further exploration.

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