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An acoustic study of Kope, Northeast Kiwai, Papua New Guinea, with preliminary tonal analysis

Julia Martin

AN ACOUSTIC STUDY OF KOPE, NORTHEAST KIWAI, PAPUA NEW GUINEA, WITH PRELIMINARY TONAL ANALYSIS

by

Julia Martin
B.A., Moody Bible Institute, Chicago, 2005

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This thesis, submitted by Julia Martin in partial fulfillment of the requirements for the Degree of Master of Arts from the University of North Dakota, has been read by the Faculty Advisory Committee under whom the work has been done and is hereby approved.

John M. Clifton, Chair

Adam Baker

Albert Bickford

This thesis meets the standards for appearance, conforms to the style and format requirements of the Graduate School of the University of North Dakota, and is hereby approved.

Grant McGimpsey
Dean of the Graduate School

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Julia Martin

25 August 2016

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[1] "Every New Day," from the album *Our Newest Album Ever*, by Five Iron Frenzy, Five Minute Walk Records, 1997, lyrics by Reese Roper

ABBREVIATIONS

Hz	Hertz
F_1	First Formant
F_2	Second Formant
F_0	Fundamental Frequency
ms	Millisecond(s)
HI	High tone
LO	Low tone
σ	Syllable
ρ	Correlation coefficient
PNG	Papua New Guinea

ABSTRACT

Kope is a dialect of Northeast Kiwai, a language of Papua New Guinea. It exhibits contrast for length on vowels, and a two-level tonal contrast. Measurements were taken from a recording of one speaker, and subjected to statistical tests to determine the relationship between variables of tone, phonemic length, duration, F_0, and the first and second formants.

The most consistent effect found is higher F_1 on HI-toned vowels, and indeed some measure of correlation between F_0 and F_1. Another effect, less consistent but still present, is the interaction of length with F_2. Duration is found to be heavily influenced by syllable position within the word. The intrinsic frequency effect is confirmed for Kope, including the exclusion of LO vowels from participation in the effect.

A preliminary tonal analysis is also included. Words were isolated by their number of syllables and their syllable profiles, and surface tone patterns in isolation and in frames are catalogued, with patterns discussed. HI tone spreading may be influenced by syllable weight, and downstep and spreading both occur across word boundaries.

CHAPTER 1
INTRODUCTION

Kope is a dialect of Northeast Kiwai (ISO 639-3: kiw), a language of Gulf Province, Papua New Guinea, with approximately 6,000 speakers (Lewis, Simons, & Fennig 2016). It has contrasts for long and short vowel length, and two phonemic tones. The purpose of this study is to focus on changes in the acoustics of vowels with relation to tone and length. Specifically, I look at whether length and phonemic tone affect vowel quality, that is, F_1 and F_2 measurements. To that end, the first and second formants of a large sample of vowels have been measured and subjected to statistical tests. Fundamental frequency and duration, as the phonetic correlates of tone and length, were measured. The effects of length and tone on formants and their interactions with each other are also examined. I show that in Kope, tone affects F_1 and duration affects F_2. There is also an interaction between F_0 and F_1. Finally, because of the nature of the data at hand, an effort is made toward a preliminary tonal analysis.

1.1 Language Community

The current 6,000 speaker population is up from the 4,000 indicated by Wurm in 1973 (Wurm 1973a). Northeast Kiwai is part of the Kiwaian language family. The box outlined in Figure 1 shows the region of Papua New Guinea in which the Kiwaian language family is located.

Figure 1. Language Region[2]

Figure 2 shows a detailed view of the region outlined in Figure 1.

[2] Used by permission

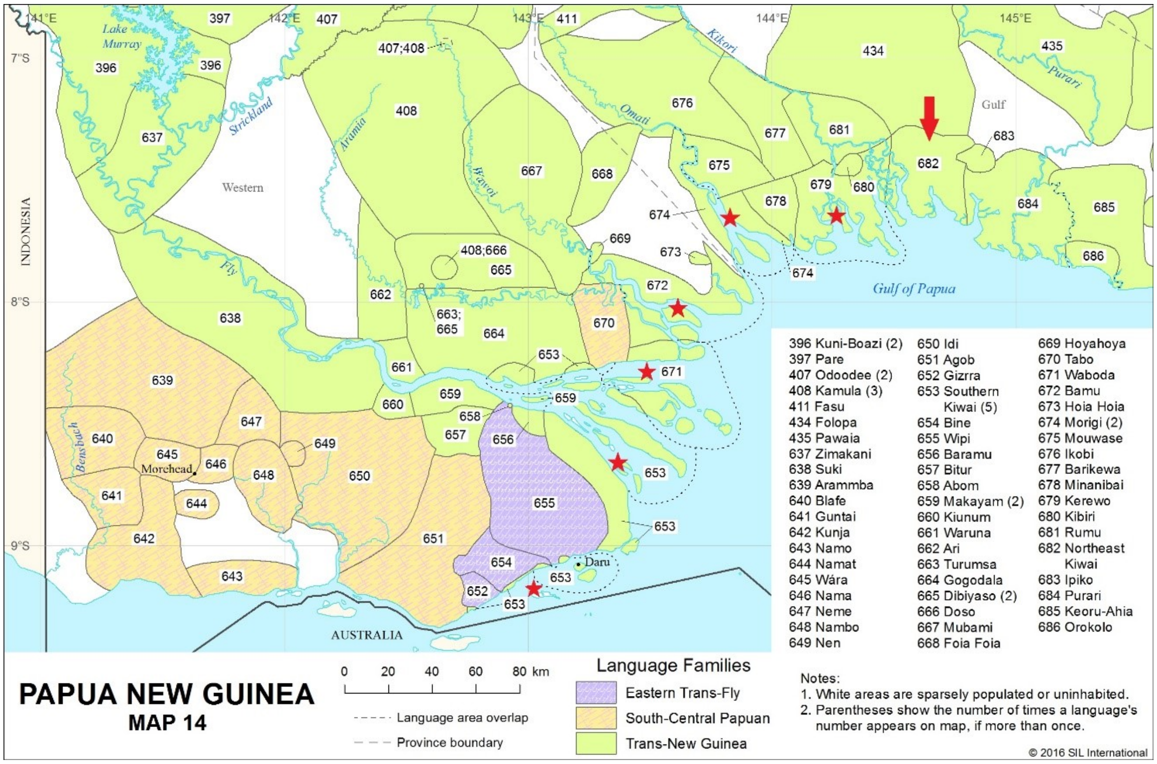


Figure 2. Language Location within Region[3]

The arrow points to the area occupied by the Northeast Kiwai speech community, of which Kope is a dialect. Kope is spoken in the northwestern corner of this area. Stars mark the locations of related languages within the Kiwaian family, listed below in section 1.2.

1.2 Classification

Lewis, Simons, & Fennig (2016) and Wurm (1973a) include this family in the Trans-New Guinea Phylum, but Foley (2000) does not positively identify it as a member. The Trans-New Guinea Phylum is one of the most prolific families listed in the Ethnologue, containing 482 listed languages, second only to Austronesian with

[3] Ethnologue: Languages of the World, Nineteenth Edition, 2016, Used by Permission.

1,254 (Lewis, Simons, & Fennig 2016). Other languages in the Kiwaian branch are marked with stars in Figure 2 above. They follow the coast and span the border from Western to Gulf Province. From southwest to northeast, they are: Southern Kiwai (653), Waboda (671), Bamu (672), Morigi (674), and Kerewo (679).[4] Northeast Kiwai dialects related to Kope include Gibaio, Urama, Anigibi, and Era Maipu'a (Clifton et. al. 2016). Sometimes, especially in older literature (e.g. Wurm 1973a&b) Kope is listed as Gope. Wurm (1973a) also lists Anigibi as "Arigibi" and as a separate language in the Kiwaian family, however ISO 639-3 and Lewis (2016) treat it as a dialect of Northeast Kiwai.

Languages in the Kiwaian family display some shared characteristics. The consonant inventory typical of Kiwaian languages includes /p, t, k, ʔ, b, d, g, m, n, r, l, s, h, w/. Wurm (1973a) states that the pairs /r, l/ and /s, h/ are mutually exclusive in most languages in the family; that is, either /r/ or /l/ is present but not both, for any one given language, and the same for /s, h/. None of the Kiwaian languages allow consonant clusters or codas. Some allow vowel sequences (Wurm 1973a).

1.3 Linguistic Description

1.3.1 Phonemic inventory

In this section I discuss Kope's phonemic constituents and their structure. Sections for consonants and vowels are included. The syllable structure is discussed as it is pertinent to questions of tonal analysis. The largely phonemic orthography is discussed in this section as well, and used throughout the thesis.

[4] Kibiri (680 in Figure 2 above) is included in the Kiwaian family by Lewis, Simons, & Fennig (2016), but not by Wurm (1973a) nor Foley (1986). Clifton (personal communication) confirms that its exclusion is correct.

1.3.1.1 Consonants

Stops occur at the bilabial, alveolar, and velar places of articulation, with voiced and voiceless versions of all these stops contrasted phonemically. Glottal stop also occurs. Nasals occur at bilabial and alveolar places of articulation, and nasals are always phonemically voiced. The only fricatives are /h, s/. Recall from section 1.2 that in Kiwaian languages, these two consonants do not co-occur in a given language. In Kope, this holds for "native" words, as /s/ is only found in loans. Table 1 shows the consonant inventory.

Table 1. Consonant Inventory

	Bilabial	**Alveolar**	**Velar**	**Glottal**
plosive	p b	t d	k g	ʔ
nasal	m	n		
fricative		(s)		h

[ɾ] is frequently present as a consistent intervocalic allophone of /n/. /m/ nearly always becomes [v] or [β] intervocalically. Consonant clusters do not occur (Clifton 1987).

1.3.1.2 Vowels

Five vowels occur in Kope, all of which contrast between long and short. Figure 3 shows the five vowels plotted according to their average (mean) formant values.

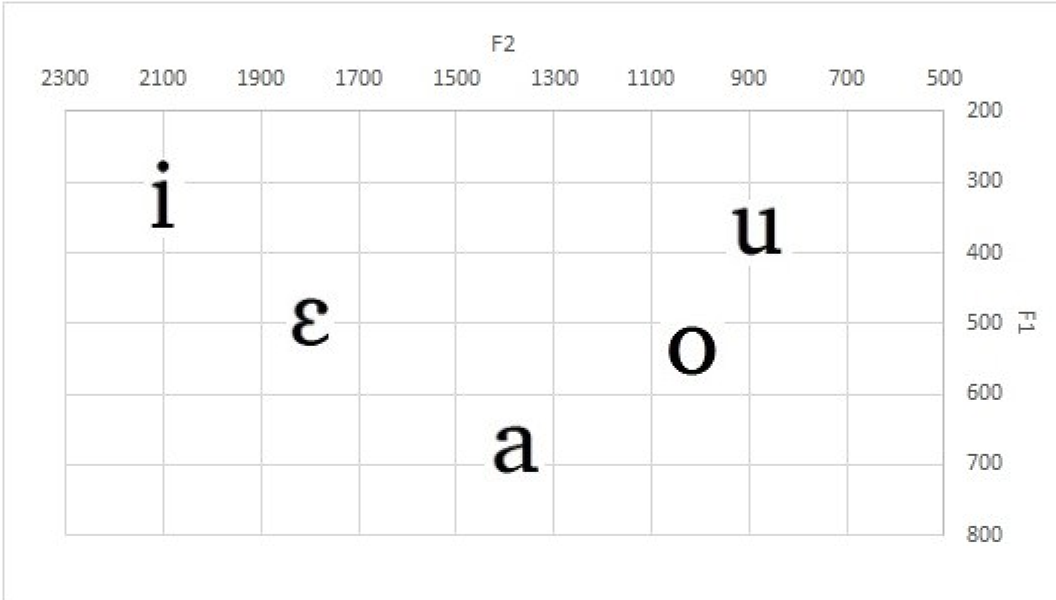


Figure 3. Vowel Inventory

In the figure above, note that the point of origin is in the upper-right corner of the graph. This is contrary to usual graphing convention but useful for displaying vowels, as it corresponds to the orientation of the IPA vowel chart. The leftmost and rightmost edges correspond to the front and back of the oral space, respectively. The top and bottom correspond to the top and bottom of the available articulatory space. High vowels have a lower F_1, front vowels have a higher F_2, etc. This graphing convention is used throughout the thesis.

The phonemic inventory is unspecified for length. Vowel length is contrastive in all positions: word-initially, word-medially, and word-finally. Example (1) shows contrastive length in all these positions. Orthographically, long vowels are written as double segments.

(1)	Initially		Medially		Finally	
	obo	*oobo*	*goro*	*gooro*	*mio*	*mioo*
	'water'	'woman'	'bandicoot'	'basket'	'sand'	'calling'

Long vowels are usually substantially longer than their short counterparts, all other things being equal.[5] Figure 4 illustrates.

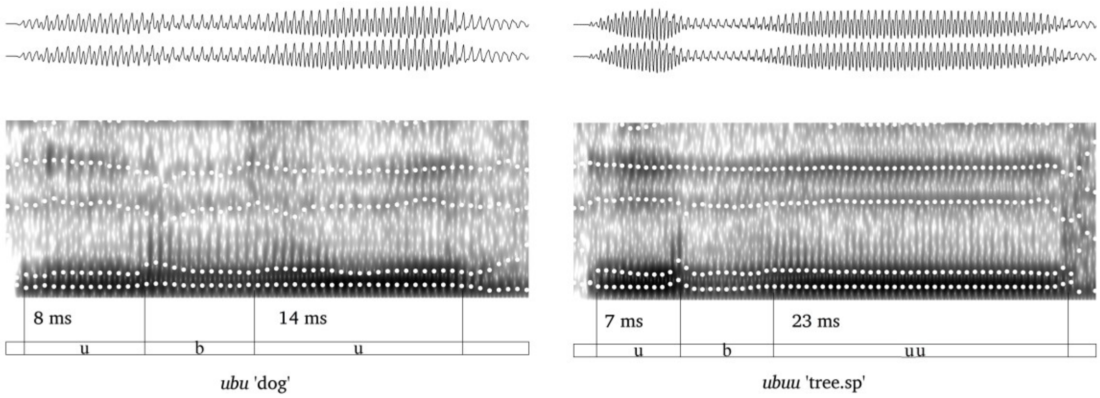


Figure 4. Short and Long Vowels

In the word on the left, we see lengths falling within the normal range for short vowels. In Kope, word-final vowels are uniformly longer. The word on the right shows a phonologically long vowel in word-final position. Vowel length must therefore always be considered in its immediate context and with reference to syllable position. Here, we compare initial syllable to initial syllable, and final to final. Section 6.5 examines this in greater detail and with more specificity.

Long vowels arose in Kope historically through elision of consonants still present in other dialects. Southern (Island) Kiwai's *orobo* 'woman' is *oobo* [o:bo] in Kope, while *obo* 'water' remains the same in both dialects (Wurm 1973a). This creates a minimal pair for length contrast in Kope, where the contrast remains segmental in Island Kiwai.

Vowels, in their capacity as the nuclei of syllables, also carry tone. Tone is discussed at greater length in section 1.4 and Chapter 7.

Kope has six diphthongs: /ai/, /ɛi/, /oi/, /aɛ/, /ou/, and /au/. Figure 5 illustrates.

[5] Variables include vowel quality, tone, and syllable position (initial, medial, final).

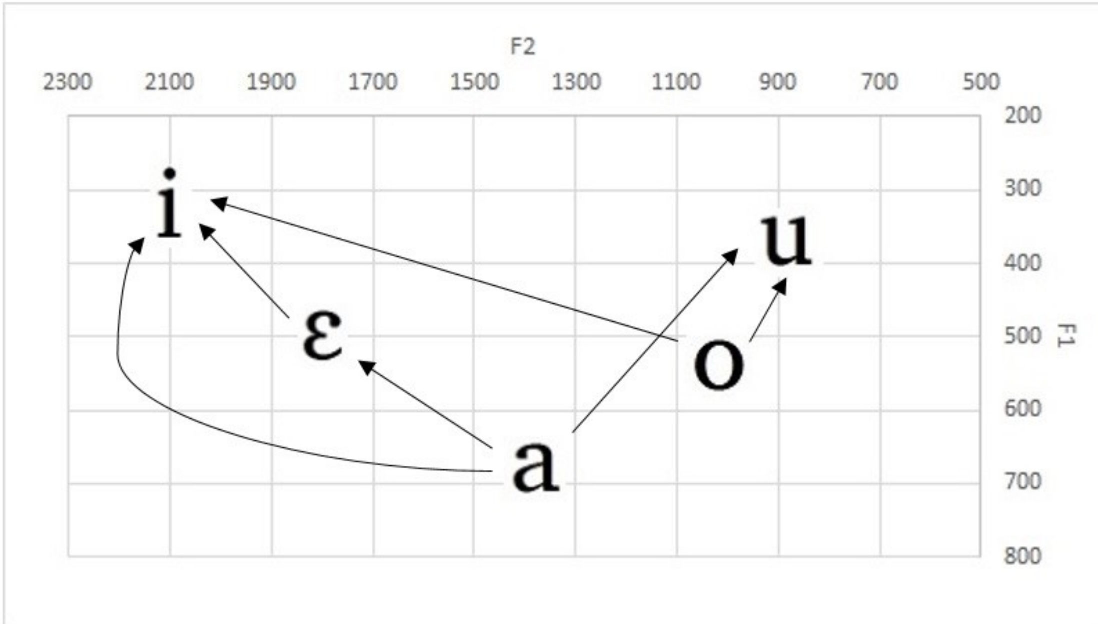


Figure 5. Diphthongs

Only vowel pairs moving from lower to higher in the vowel space pattern as single diphthong vowel units. I analyze these as diphthongs rather than glides in coda position, because Kope does not have codas.

Vowel sequences consisting of a high vowel followed by a lower vowel pattern in one of two ways. The first way is to pattern as semivowel [j] or [w] plus the second vowel. For example, /ai/ functions as a vowel unit, but /ia/ is pronounced more like [ja] and the first sound behaves consonantally in syllable patterning. An example of this consonantal realization of a high-low vowel sequence is /iamagauri/ [ja.ma.gau.ɾi] 'jump.' This option may be limited to verbs, based on discussion of careful speech included in the recordings. The other option for a high-low vowel pair is to realize them as two syllables, for example /iaha/ [i.a.ha] 'truly' (Clifton 1987).

1.3.2 Syllable structure

Codas are prohibited and onsets are optional. Given that diphthongs are analyzed as single vowel units, Kope only allows V and CV syllable profiles. Syllables appear to have weight which possibly affects tone assignment; for this purpose diphthongs and long vowels are analyzed as consisting of two moras. This is discussed further in Chapter 7.

1.3.3 Orthographic convention

Kope is written with the Roman alphabet and there are few differences between IPA and the orthography. These conventions are used throughout the thesis. Table 2 summarizes.

Table 2. Departures from IPA

IPA	ɾ	ʔ	ɛ	ɡ
Orthography	r	'	e	g

The orthographic conventions for vowel sequences and the alternations <n>/<r> and <m>/<v> have been and continue to be somewhat unsettled issues in the Kope language community. Various societal pressures come into play that are more relevant to the community than phonology. Two of the strongest pressures are the desire to differentiate the appearance of their orthography from that of nearby Kerewo, and to have their orthography correspond more closely to the language of wider communication in the area, Hiri Motu, in which many Kope speakers are literate. For example, although high-to-low vowel sequences such as <oa> and <ia> are frequently realized as consonantal glides [wa] and [ya], writers of Kope prefer to use vowel graphemes because Kerewo uses <w>, although in a different context, and Hiri Motu makes use of vowel sequences for the same contexts in which they occur in Kope (Clifton 2016). There are good phonological reasons for using vowel graphemes (Clifton 1987), but the reasons actually given by speaker-writers are sociolinguistic. This orthographic decision results in words spelled with vowel-only graphemes, but pronounced consonantally: *oaiaoaia* 'wild okari tree' is pronounced [wa.ya.wa.ya].

Writers remain inconsistent in their use of double vowels to indicate length. Petterson (2014) reported that Kope writers, not wishing to imply the presence of a glottal stop, often use a single vowel, going so far as to cross the second vowel out of others' work in an effort to correct it. Other speakers, although they understand and like the idea of using a double vowel to indicate length, cannot always identify which vowels are long in order to use this method. Yet others use the apostrophe to indicate length rather than glottal stop, or believe that its purpose "is for separating two vowels" whether or not the consonantal < ʔ > is present. Double vowels are used throughout this thesis to indicate length, and an apostrophe is used to represent glottal stop.

1.4 Tone

1.4.1 Tone in non-Austronesian languages of Papua New Guinea

It took a while for the linguistic community to realize the extent to which tone is used in the languages of PNG. Tone appears to have been recognized as an important element of some PNG languages by the early 1970s (Franklin 1971), and its study has accelerated rapidly since then. As late as 1986, Foley (1986) claimed that most Papuan systems appearing to be tonal may be better explained as only pitch-accent, not "genuinely" tonal. By 2000 he is ready to acknowledge that "Languages of the Trans New Guinea, Lakes Plain, Sko, and West Papuan families all tend to be tonal," putting forth the example of Iau as the "zenith of complexity" found in tonal systems of PNG. Today, there is widespread agreement that many languages of PNG are tonal.

Several summaries of tone in the non-Austronesian languages of Papua New Guinea have been undertaken. The two most notable are Donohue (1997) and Cahill (2011), both of whom independently classify tonal systems based on the "domain" of the tone. These works divide tone systems into three categories:

1. Systems that associate discrete tones to each syllable in a word; the syllable is the domain.

2. Systems that associate tone patterns to words; the word is the domain. The pattern may spread over the whole word, create contour tones, or result in floating tones off the edges of morpheme boundaries, depending on the number of tone-bearing units available for attachment.

3. Systems that associate tone only with one particular accented syllable per word; the accented syllable is the domain. Both works propose Fore (ISO 639-3: for), a language in the Kainantu-Gorokan branch of the Trans-New Guinea Phylum, as a prototypical example of this type.

Snider (2013) considers it more practical to speak not of discrete tones associated to tone-bearing units, but of tone patterns (sometimes called "melodies") with morphemes as their domain. Following that guideline, type (1) may be better understood as a very straightforward subset of type (2). Type (3) is usually termed pitch-accent. In most pitch-accent languages, the same level tone target (HI, LO) or contour tone (rise, fall) is always associated with the accented syllable, and the contrast is delineated according to which syllable is accented: babá vs. bába.

In some PNG languages, however, there is an additional contrast. Only one syllable per word is accented, but that syllable may carry one of several tones or tone patterns: babá, bába, babà, bàba. In this sequence of imaginary words with two syllables, the contrast is twofold, resulting in four words that are identical at the segmental level. Syllable 1 or syllable 2 may carry the accent, and the accent may be marked by either HI or LO tone. Tone is assigned to the unaccented syllables by predictable rules and is therefore not marked. If the tone pattern method of Snider is used here, the pattern of the first two words is H and that of the second two words is L – the patterns are identical but association rules must make reference to accent on a separate suprasegmental tier. HL and LH patterns in such a system might result in other strategies – for example, contour tones on the accented syllables: babâ and bâba for HL, and babǎ and bǎba for LH.

1.4.2 Tone in the Kiwaian family

Wurm (1973) indicates that a two-tone (HI-LO) system is prevalent in all Kiwaian languages, but carries the highest functional load in Northeast Kiwai. He speculates that this functional load became heavier as Northeast Kiwai elided consonants present in other languages of the family, and the resulting adjacent vowels coalesced, resulting in more segmentally identical morphemes than are found elsewhere in the Kiwaian family (as with length in section 1.3.1.2).

1.4.2.1 Gibaio

Petterson (2013) provides a preliminary analysis of tone in Gibaio, which like Kope is a dialect of Northeast Kiwai. Here I give a summary of his findings for Gibaio before I turn to Kope, because Gibaio has been more fully analyzed and provides a good foundation for understanding what Petterson has observed in Kope.

In Gibaio, he observes four patterns on two-syllable nouns and adjectives: Falling (HL), level, rising-spreadable (LH), and level-spreadable. At the time he made his notes, he was unsure whether to refer to the level patterns as HH or LL. Some words are eligible to receive spreading and others are not, for unknown reasons. Illustrations below are quoted from his work, pp 1-2.

(2) Falling

HL	HM L	HM L
titi	*titi ra*	*titi ka*[6]
'design'	'Is it a design?'	'It is a design.'

(3) Level

HH	H H L	H H L
moto	*moto ka*	*moto ra*
'house'	'Is it a house?'	'It is a house.'

(4) Rising spreading

L H	L H L	L L HL
umu	*umu ra*	*umu ka*
'dog'	'Is it a dog?'	'It is a dog.'

(5) Level spreading

HH	HH L	HH HL
mio	*mio ra*	*mio ka*
'peace'	'Is it peace?'	'It is peace.'

Note that in the spreading patterns, the H tone spreads right to *ka,* but not to *ra,* per the spreading-reception eligibility distinction referenced above. When it does spread, it creates a contour tone on the receiving syllable rather than replacing the native tone wholesale, or pushing it off to become a floating tone. M in the falling pattern is a notation for “Mid,” indicating that the tone is phonetically lower than the previous H, and higher than the following L. It may be a phonemic L with the following L downstepped.

Verbs use affixation for mood / tense / aspect. The tone patterns of stems are predictable based on the segmental affixation (Petterson 2013). This indicates that tone is intrinsic to affixes but not to verb stems, or perhaps overrides any tone on verb stems.

[6] Petterson has *titi-i ka* but that appears to be a typo; corrected here.

1.4.2.2 Kope

Petterson (2015) has also completed a preliminary tonal analysis of Kope. He finds that two of Gibaio's patterns have merged, resulting in three patterns for Kope: rising, HI-level (spreading), and falling (merged with Gibaio's level non-spreading). HI-level and rising both spread to *ka* but not to *ra,* as in Gibaio, and falling causes downstep on a following L – explicitly identified as downstep in the 2015 analysis. Examples below are taken from Petterson's notes. "↓L" indicates a downstepped LO.

(6) Falling

HL	HL ↓L	HL ↓L
pito	*pito ra*	*pito ka*
'cuscus'	'Is it a cuscus?'	'It is a cuscus.'

(7) Rising

L H	L H L	L L HL
umu	*umu ra*	*umu ka*
'dog'	'Is it a dog?'	'It is a dog.'

(8) Level

HH	HH L	HH HL
uma	*uma ra*	*uma ka*
'sore'	'Is it a sore?'	'It is a sore.'

The phonetic tone pattern in example (6) corresponds exactly to example (2), with (6) modified to reflect the acknowledgment of downstep. In (7), when H spreads right to *ka,* it apparently also detaches, and the previous L spreads over and occupies that tone-bearing unit.

CHAPTER 2
METHOD

In this section I discuss the materials and method used for this study. Materials include the audio recordings themselves, and information about the speaker. I then discuss how the materials were handled, how measurements were made, and the statistical tests performed on the measurements.

2.1 Materials

In the summer of 2015, recordings of word lists were taken from three male speakers of the Kope dialect. The core of the word list was a set of words designed to be used for research on the tone and length contrasts in the language. Sets of words that were segmentally identical, and differed only in vowel length or tone, were juxtaposed, for example *gòró* 'inside,' *górò* 'bandicoot,' and *góórò,* 'basket' (tone marked here for clarity). Since most of the segmentally identical words were two syllables, the list was supplemented with forty three-syllable words, eight four-syllable words, twenty-five compound words along with their monomorphemic, frequently two-syllable constituents, and eighteen reduplicated words. As each word was elicited via English trigger, the speaker produced the word twice in isolation. If it was grammatically possible, each word was also produced twice in each of the following frames: *ara* __ *ra* 'is this (a) _?' and *ara* __ *ka* 'this is (a) _.' The frame was not grammatical for all words, especially verbs and function words, e.g. *dódò* 'without / to forget.'

For formant measurements, words in isolation were used. Only vowels that could clearly be distinguished from their neighboring sounds were used — that is, vowels bordered on both sides by either word boundaries or consonants. Vowels occurring as part of diphthongs, vowels occurring in adjacent syllables but without a consonant to separate them, and vowels bordering phonetic semivowels were excluded. Words that only had one utterance in isolation were also excluded. Only 22 words were subject to exclusion on any one of their syllables; a total of 781 separate instances of vowels were included.

2.2 Subject

The speaker selected for the study is Samson Aumarie, a 31-year-old man from the village of Ubuo'o. He has completed grade 7 and speaks English well. He produced tokens of approximately 200 words from a word list, producing each word twice in isolation and twice in each of two frames, for a total of six utterances per elicited word. Samson was selected for this initial study because he produced the most utterances, providing the largest available dataset. His speech was recorded using an Edirol R-09HR recorder with an MMAudio MM-DPSM dual earset microphone.

2.3 Measurements

I decided to measure the following variables: first and second formants (F_1 and F_2), fundamental frequency (F_0), and duration. Each measurement was indexed for other variables including phonemic length, tone, vowel quality, and syllable position, and also indexed to each recording and utterance. Upon beginning the study I was primarily interested in the effect of phonemic tone and phonemic length upon F_1 and F_2, and began my measurements with those only, but it quickly became evident that F_0 and duration were relevant to the discussion. All of these measurements were necessary because many of these variables can interact in various ways (see Chapter 6), and it was desirable to have the ability to be able to control for any given variable, while also noting the effects of variables upon one another.

2.3.1 Measuring formants

There were several options as to how to measure vowel formants. Both measuring a point in the exact middle of a vowel, and averaging the formant measurements throughout each vowel are common practices and easily automated with Praat scripts. However for the purposes of this study, I believed both of them to be insufficient. I manually selected a point in each vowel and obtained formant data for that point. This was a relatively straightforward process. The measurement was generally made in the middle of the vowel (60%-70% of cases). However, in certain instances at that point the formants were perturbed or skewed by preceding or following consonants. In those cases (30-40%), I looked for the point in the vowel that appeared to be the steadiest, or most stable, for the longest period of time, and took my measurement there. Frequently this corresponded to the place where the formants appeared darkest on the spectrogram and amplitude was most pronounced, lending credence to my working hypothesis that I was measuring a slice of the most perceptively salient portion of the vowel. I submit that any errors resulting from having measured by hand are both fewer in quantity than errors resulting from measuring via blind automation, and also mitigated by the sheer size of the sample (1600 measurements.) Figure 6 shows an example of measuring methodology.

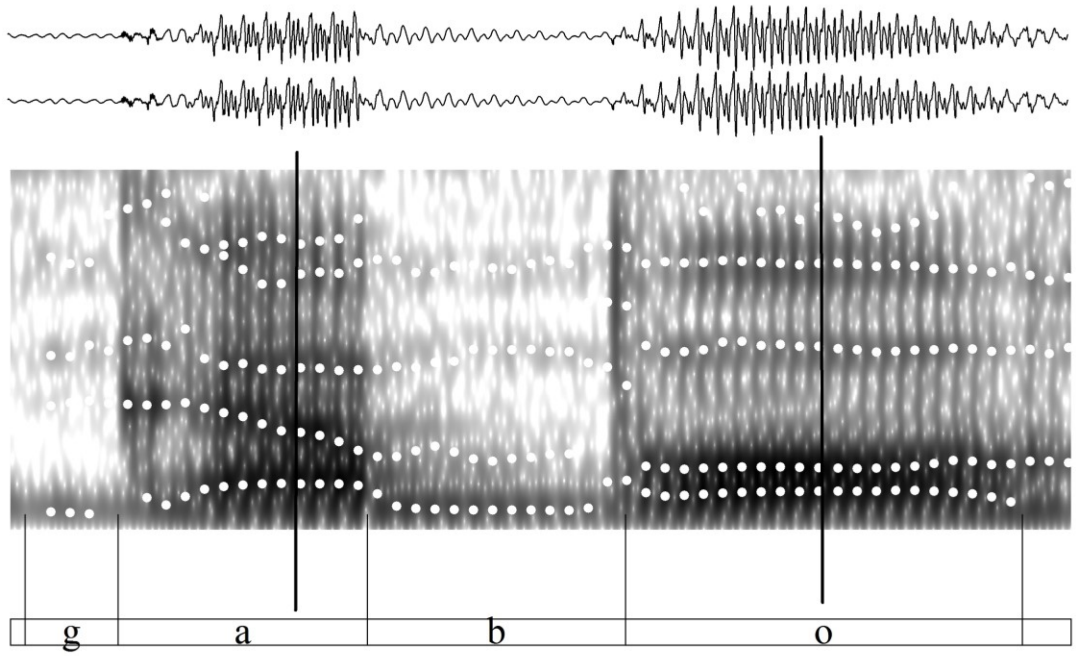


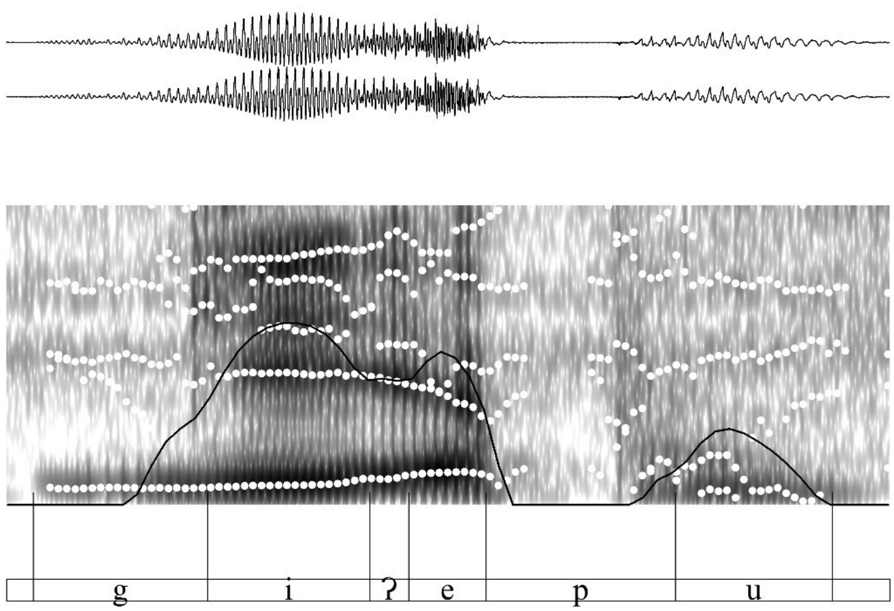
Figure 6. Measuring Formants

The word is *gàbó* 'path.' The white dots are formant tracks provided by Praat, and the dark vertical lines mark the locations selected for formant measurements. Segment /o/ provides a look at the default method I used where it was not necessary to take other factors into consideration: measure in the center of the vowel. The measurement for /a/ provides an example of a more nuanced case, and an illustration of one of the aforementioned “other factors:” the measurement is taken a bit right of center because the vowel doesn't really “get going” until a few milliseconds in, complicated by the release of /g/. Note that the location I have selected is in the center of where the waveform pattern is strongest and most regular.

2.3.2 Measuring duration

Duration was measured via Praat script in conjunction with a text grid. For each word in isolation, I annotated the boundaries of the vowels on a text grid. The script then instructed the program to return the duration of each bounded segment.

Vowel boundaries were determined by considering both the waveform and the spectrogram. At times, the intensity contour was also used to assist boundary visualization; this was especially helpful when /ʔ/ separated two vowels – a dip in intensity usually indicates that consonant's location when all other indicators are absent. Figure 7 shows an example.



giʔepu *'worry'*

Figure 7. Vowel Boundary Determination

In the figure above, the black line across the spectrogram shows intensity. Note that the formants run unbroken right through the glottal stop, but a dip in intensity in conjunction with the waveform gives a good idea of where to place the boundaries. In this case, the intensity contour dips down and stays level for a short time between /i/ and /ɛ/. Boundaries are placed at the beginning and end of that space. In other instances, the boundaries are less well-defined. In some cases, there is a very short and rounded dip in intensity between vowels, and in those cases /ʔ/ is placed in the center of the dip, as a point separating two vowels rather than an item with duration. As with measuring formants by hand, the nature of this process is vulnerable to human error, but I do not expect that this technique introduced a systematic bias into the measurements.

Vowels involved in off-glides and diphthongs were excluded from this study due to the lack of a reliable method for determining their boundaries.

2.3.3 Measuring fundamental frequency

Maddieson (1997) draws attention to an effect that was necessary to consider when making F_0 measurements. This is a two-way effect of consonants on vowels following them: voiceless consonants raise the F_0 of vowels that follow them, while voiced consonants lower the F_0. When F_0 is measured immediately at voice onset, and compared to F_0 later in the vowel, this effect becomes apparent. The F_0-raising effect of voiceless consonants is greater than the lowering effect of voiced consonants. Maddieson does not quantify the lowering effect but the raising effect is said to be about 7 Hz in one subject, a male speaker of a tonal language (Thai).

Both of these effects are presumed to be due to the physical structure of the larynx and the mechanics of voicing and air pressure:

> f_0 lowering with voicing may be a consequence of a lowered larynx position, or due to the aerodynamic effects of a supraglottal constriction. Aerodynamic effects may raise f_0 after voiceless consonants with an open glottis, and devoicing strategies that involve tensing the vocal folds will also be likely to raise f_0 after voiceless consonants (Maddieson 1997: 629).

In light of the phenomenon described above, care was exercised in the measurement of F_0. In particular, requesting Praat to return the highest frequency realized over the duration of the vowel was rejected since this strategy could cause the program to return artificially high F_0 values for any vowel following a voiceless consonant, and artificially low values for vowels following voiced consonants. For the same reason, averaging the F_0 over the duration of the vowel was rejected – the same vowels would have artificially high average F_0 values, pulled up by the portion of the vowel immediately following the consonant. Likewise, vowels following voiced consonants would have an artificially low average F_0.

Rather, F_0 measurements were collected automatically via a Praat script from the center of each vowel, with the center being determined according to the edge boundaries discussed in section 2.3.2.

2.4 Statistical Analysis

Appendix A contains the results of my measurements. ANOVA and linear regression tests were run, checking for F_1 and F_2 effects, F_0 effects, and duration effects, against the interaction of multiple variables: vowel quality, tone, length, and word position (initial, medial, final). Selected p-values of interest from the ANOVA are discussed in Chapter 3 and Chapter 4. The full ANOVA results are discussed in detail in Chapter 6. When I discuss levels of statistical significance, only a few target p-values are used. The threshold for significance is a p-value of 0.05 or less. In order to balance avoidance of tedium with value of information, I anchor my discussion of p-values to the following reference points: 0.05, the threshold of significance, 0.01, 0.001, and 0.0001. Any p-values smaller than 0.0001, no matter by how many decimal points, are uniformly expressed as simply < 0.0001.

I also ran a paired t-test between first and second utterances. This test compares pairs of the same vowel in the same word, so all other variables are automatically controlled for.

2.5 Conventions Regarding Feature Specifications

Measurements of formant frequency and fundamental frequency are in Hz, and rounded to the nearest 1 Hz. Measurements of duration are in milliseconds, and rounded to the nearest 1ms. In this thesis there is much discussion of vowel position in the articulatory space, as well as tone.[7] Standard linguistic terms for both of these qualities include the terms "high" and "low." To avoid confusion, I use the uncapitalized words to indicate articulatory position, and small-capital abbreviated terms when I intend to indicate tone (HI, LO). I also abbreviate tone, especially in the context of describing tone patterns, with H and L, but never do so with articulatory position. Table 3 summarizes.

Table 3. Feature Terms and Abbreviations.

Vowel quality	**Term to be used**	**Abbreviation**
Articulatorily high	high	(none)
Articulatorily low	low	(none)
High tone	HI	H
Low tone	LO	L

[7] "Tone" in this context and throughout the thesis refers to surface tone, rather than fully-analyzed underlying tone.

CHAPTER 3
HI VS LO TONE: FORMANT COMPARISONS

3.1 Distribution of Vowels.

Figure 8 shows the distribution of vowels in acoustic space, showing five clusters of tokens corresponding to the five phonemic vowels.

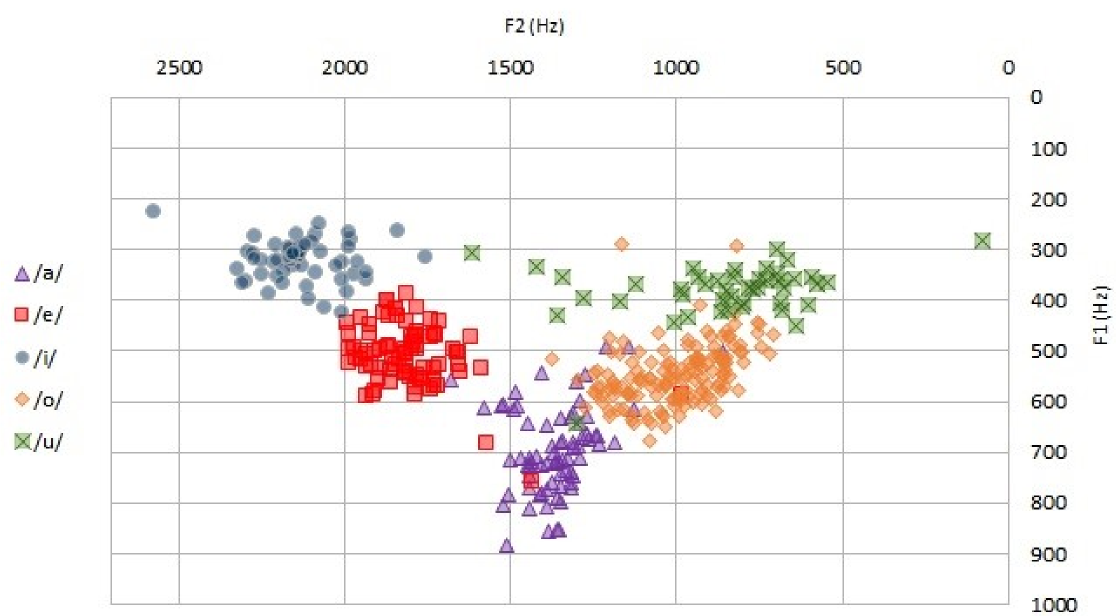


Figure 8. All Vowels

In the figure above, /o/ encroaches the most on the space of other vowels, especially its neighbors /u/ and /a/. It is also the vowel with the most available samples, so I examine whether this large sample is perhaps responsible for the widespread area covered by /o/, or whether its wide spread is conditioned by variables. This is discussed in sections 3.2.4 and 4.1.3. This section examines how HI and LO tone affect F_1 and F_2.

3.2 First Formant

An ANOVA was performed with F_1 as the dependent variable and the following four factors as independent variables: vowel quality, tone, position, and length. Broadly, I found that HI vowels have a higher F_1. ANOVA results are discussed in detail in Chapter 6 below and include several interactions of variables, for which reason I take this section vowel-by-vowel as I discuss F_1 effects.

3.2.1 /a/

There are 147 tokens of /a/, 73 HI and 74 LO. Figure 9 provides a close-up of the vowel space occupied by /a/, and includes all instances.

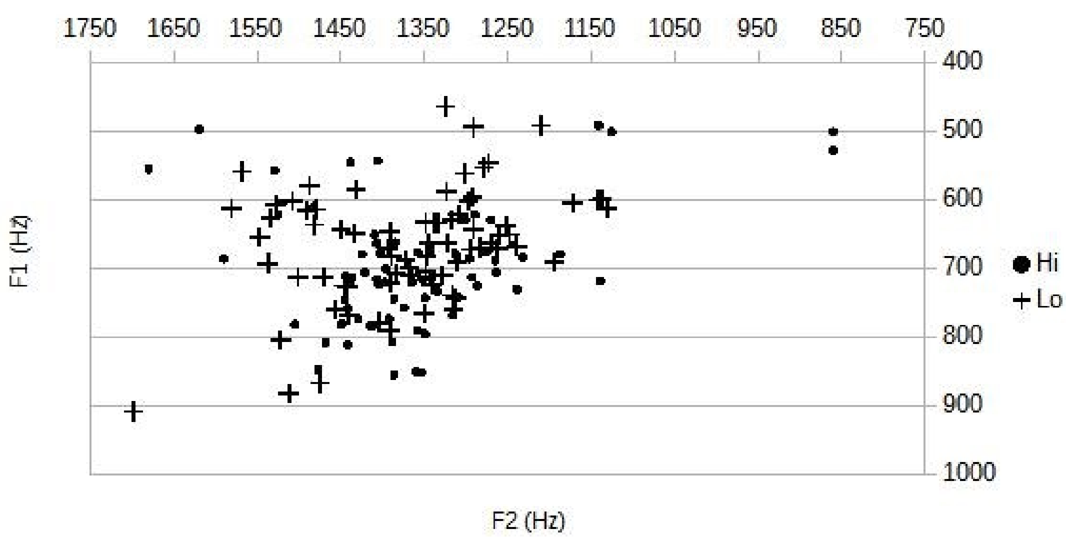


Figure 9. HI vs. LO Instances of /a/

HI instances of /a/ have a higher F_1 than LO instances in initial and final syllables ($p < 0.0001$ for both positions). Medial instances are excluded from the effect, but included in the figure above. It is possible that this is due to the small sample size for medial instances, as most words in the corpus have two syllables. Uncontrolled for other variables, 696 Hz is the average F_1 measurement for HI, and 665 Hz for LO. With F_1 measurements for /a/ ranging from 465-909 Hz, this 31 Hz increase represents an almost 7% jump in F_1, on average, for HI vowels.

3.2.2 /ɛ/

There are 160 instances of /ɛ/, 70 HI and 90 LO. Figure 10 shows all instances of /ɛ/, although like /a/, medial instances do not participate in the F_1 effect in a statistically significant manner.

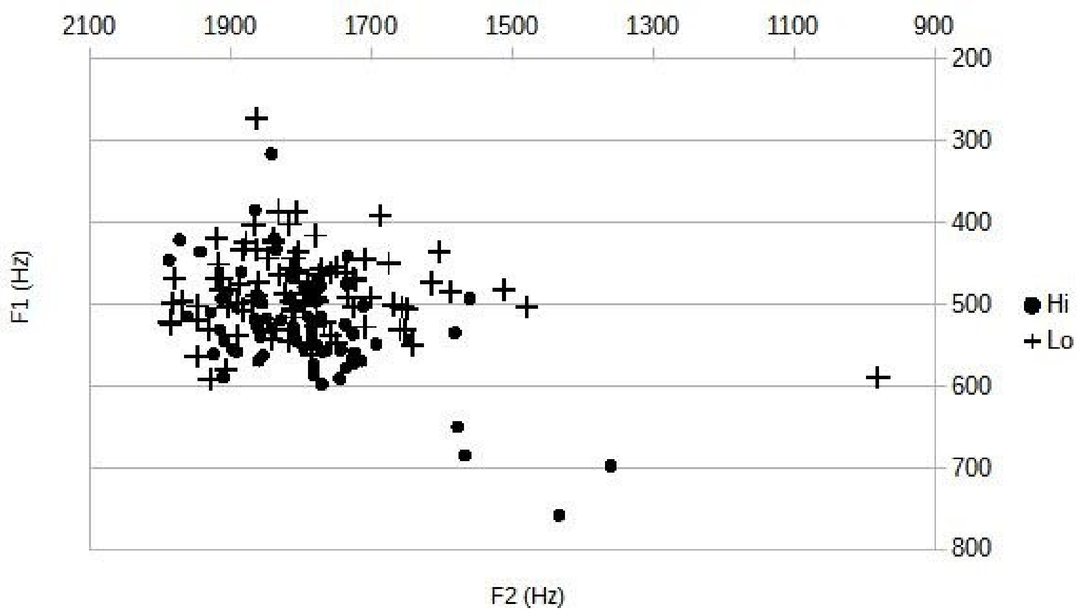


Figure 10. HI vs. LO Instances of /ɛ/

Just as with /a/, initial and final HI instances of /ɛ/ have a higher F_1 ($p < 0.0001$) than LO instances. The average F_1 measurements are 528 Hz for HI, and 482 Hz for LO, a difference of 46 Hz. With F_1 measurements for /ɛ/ ranging from 272-758 Hz, this represents a 9.4% increase in F_1 for vowels carrying HI tone.

3.2.3 /i/

There are 110 instances of /i/, 64 HI and 46 LO. Figure 11 shows the vowel space occupied by /i/. Medial instances are included in the figure, but once again did not participate to a statistically significant degree in the effect being examined in this section.

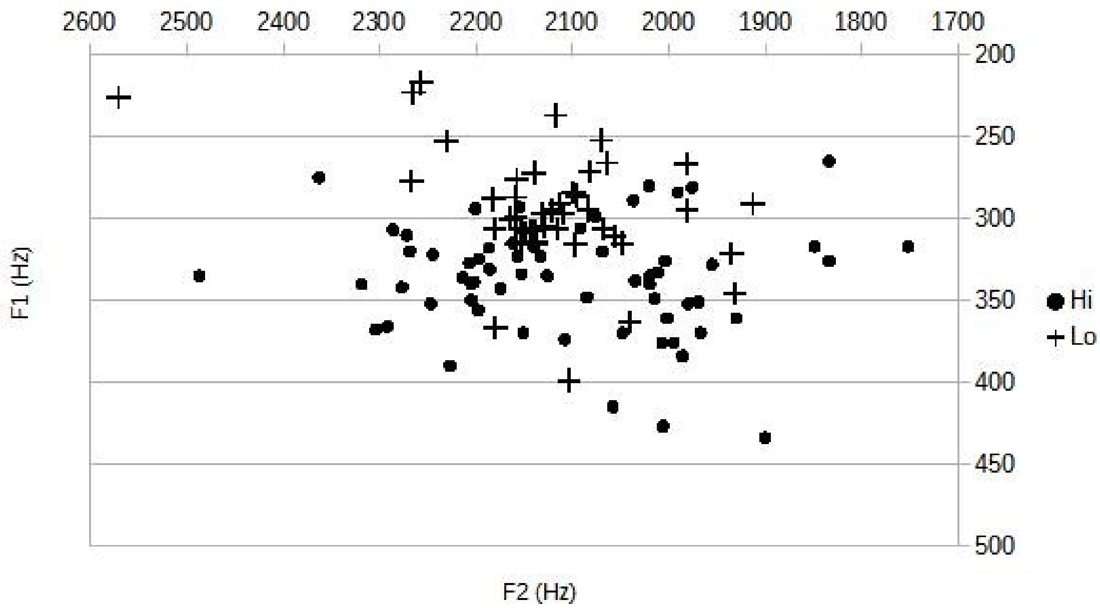


Figure 11. HI vs. LO Instances of /i/

Initial and final HI instances of /i/ have a higher F_1 than LO instances ($p < 0.0001$). The average F_1 measurements are 337 Hz for HI, and 295 Hz for LO. F_1 measurements for /i/ range from 217-434 Hz, so the average jump in F_1 from LO to HI covers 19% of the vowel's total F_1 range.

3.2.4 /o/

Instances of /o/ are by far more numerous than the other four vowels. There are 292 instances of /o/, 166 HI and 126 LO. Figure 12 shows the vowel space occupied by /o/. Due to the relatively large space occupied by /o/, five outliers ($F_1 < 300$ Hz,

$F_2 > 1450$ Hz) are excluded from the graph's scope (but not from the statistical analysis) in order give a better view of the core vowel space and the effect being illustrated.

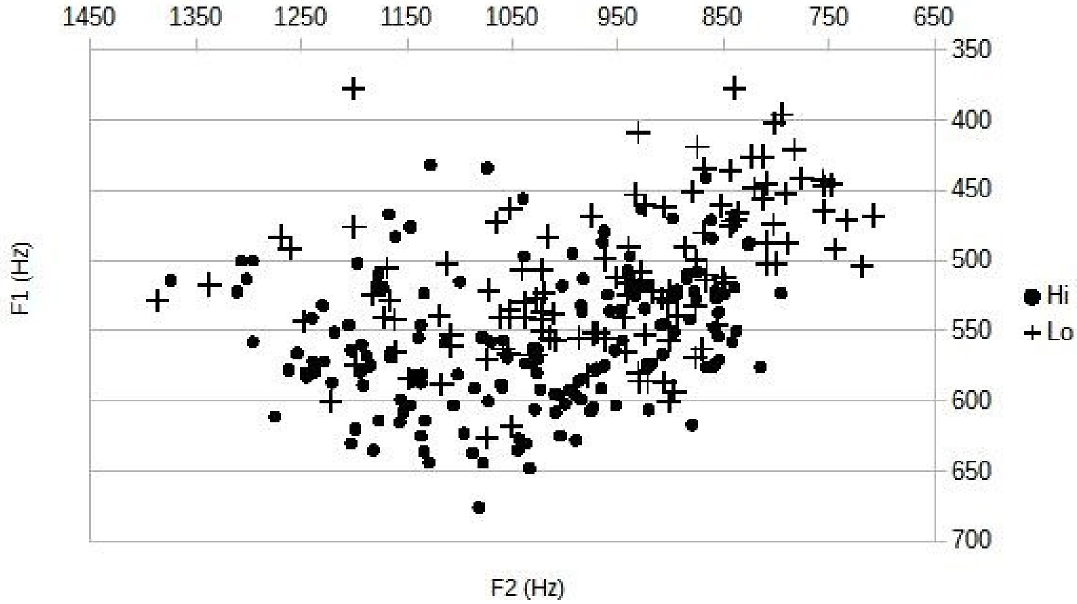


Figure 12. HI vs. LO Instances of /o/

In the figure above, the pattern we have heretofore observed holds true: HI vowels have a higher F_1 than LO vowels ($p < 0.0001$ for initial and final, < 0.05 for medial).

The average F_1 measurements for HI and LO are 556 Hz and 508 Hz, respectively. The vowel height range is 386 Hz, with a low of 290 Hz and a high of 676 Hz. The 48 Hz jump in F_1 between LO and HI vowels represents 12% of the total F_1 range.

The simple paired t-test mentioned in section 2.4 yielded a significant result for this vowel; there are systematic differences between the speaker's first and second utterances. Figure 13 compares measurements of /o/ formants taken from utterance token 1 vs. utterance token 2.

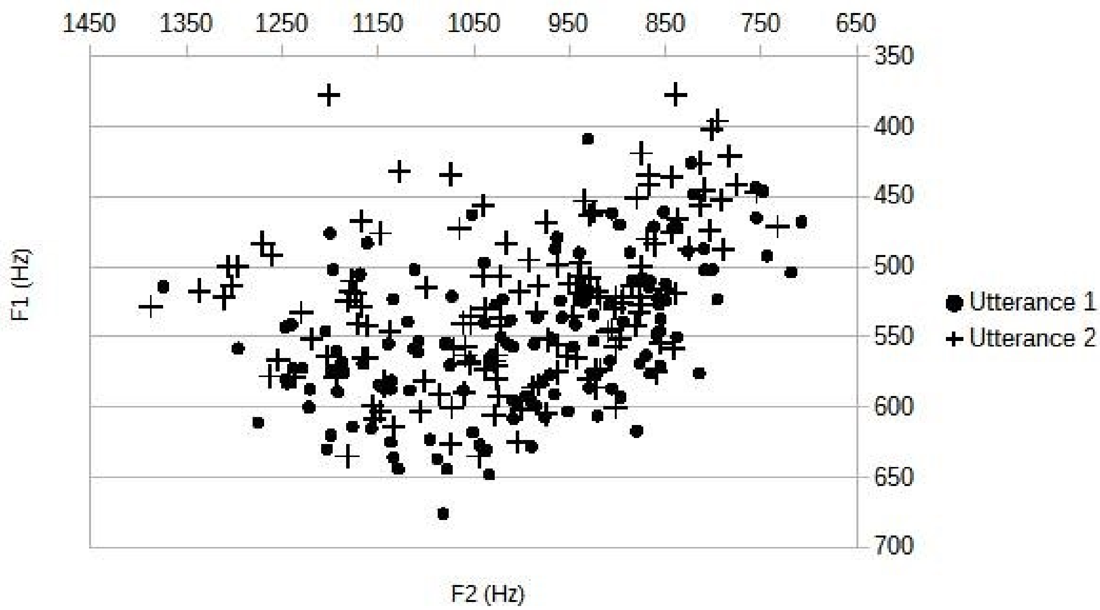


Figure 13. First vs. Second Utterance Tokens of /o/

Tokens of /o/ taken from the first utterance have a slightly higher F_1 than tokens from the second utterance, $p < 0.05$. The F_1 range for both sets of utterances is 290-676 Hz, a span of 386 Hz. The average utterance 1 F_1 is 546 Hz, vs. 525 Hz for utterance 2. This difference of 21 Hz represents only 5% of the F_1 range. Because the t-test is paired, all other variables are automatically controlled for since the same vowel in the same word, with the same tone, syllable position, and length, is being compared between utterances. F_0 also dropped ($p < 0.0001$) in the second utterance for /o/, lending weight to the case that F_0 and F_1 are tied together phonetically.

Recall that in section 3.1, I noted that /o/ appears to encroach more on the vowel space of other vowels than the other vowels encroach on one another. Two possible explanations were hypothesized; either the high volume of samples could be responsible, or the formants of /o/ could genuinely have a wider distribution than other vowels. The answer is a more complicated version of the latter. This vowel does indeed have a wider distribution of formant values, but this variation is conditioned, not entirely random. Not only does HI vs. LO tone affect high vs. low F_1, as in other vowels, but /o/ is also affected by tone with regard to F_2, as shown in sections 4.1.3 and 6.3 below. When we add to this the variation between first vs. second utterances, it begins to appear that /o/ is a bit of a moving target, conditioned by at least three variables.

3.2.5 /u/

There are very few samples of /u/ in the data, only 90: 52 HI and 38 LO. Many instances of /u/ occur in the context of diphthongs or vowel clusters, which rendered them ineligible for measurement due to parsing concerns (see section 2.3). Figure 14 shows all instances of /u/.

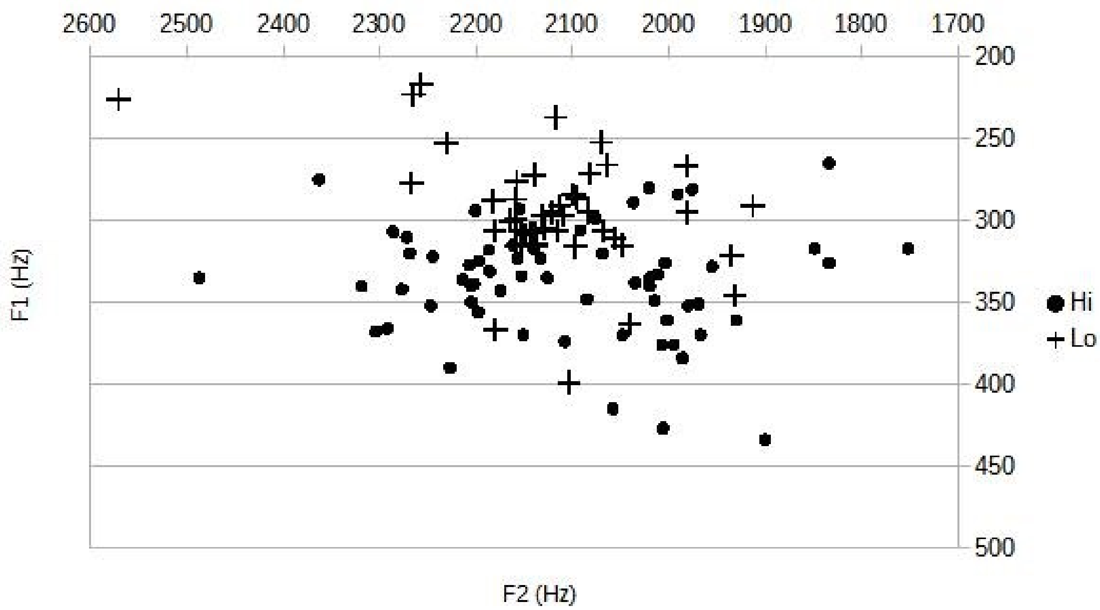


Figure 14. HI vs. LO Instances of /u/

Once again, HI vowels have a higher F_1 ($p < 0.0001$ for initial and final, < 0.05 for medial). The average F_1 measurements for HI and LO are 388 Hz and 344 Hz respectively, a difference of 44 Hz. The range of F_1 measurements is 192-642 Hz, a space of 450 Hz. The difference between the average HI and LO F_1 measurements represents a jump of 10% of the range for HI vowels.

Like /o/, /u/ also has statistically significant ($p < 0.05$) difference in first vs. second utterances for F_1. First utterances average 381 Hz and second utterances average 358 Hz for F_1. This difference of 23 Hz, with a range of 359 Hz, has first utterances with a 6.8% jump in F_1 over second utterances. Also like /o/, F_1 appears tied to F_0, as F_0 drops significantly ($p < 0.0001$) from the first to the second utterance.

3.2.6 Summary: F_0 and F_1

There is a tendency, for all vowels, for the vowel to have a higher F_1 when the F_0 is higher. This tendency was statistically significant across all vowels. Table 4 summarizes the results.

Table 4. F_0 and Formant Comparison Results

Vowel	**p-value (uncontrolled for position)**	**Average F_1 movement as percentage of total range**
a	< 0.05	7%
e	< 0.0001	9.4%
i	< 0.0001	19%
o	< 0.0001	12%
u	< 0.0001	10%

/a/ had both the highest p-value (lowest degree of confidence) and the smallest percentage of movement. This could be because /a/ is already close to its maximal F_1 value; more research is necessary.

It is likely that part of the physical process of creating HI tone also raises the F_1 in some way. The other possibility is that raising the F_1 creates HI tone; I reject this hypothesis on the grounds that raising F_0 to produce HI tone appears to be the more intentional gesture in this language, carrying phonemic functional load.

High F_1 is most often associated with articulatory low-ness. What might be causing HI vowels to be articulated lower in the oral space? Could something other than articulatory height affect F_1? Larynx height is the likely factor. Lindblom and Sundberg (1971) found that lowering the larynx, by virtue of increasing the volume of the pharyngeal cavity, lowers F_1. Raising of the larynx is often observed to accompany the production of high tone (Yip 2002). This would reduce the volume of the pharynx and raise F_1. This would also explain the drop in F_1 between the first and second utterances found for /o/ and /u/. With the second utterance, the muscles and tendons maintaining the raised larynx are perhaps beginning to tire or relax, diminishing the effect. The reason for the exclusion of non-back (or possibly non-round) vowels from that effect is a topic for further research. Section 6.4 narrows the focus on F_0, examining the interaction of other variables.

3.3 Second Formant

An ANOVA was performed with F_2 as the dependent variable and tone, length, vowel quality, and word position as independent variables. For certain vowels in certain positions, F_2 was higher for HI vowels. The effect is statistically significant only in /a/ ($p < 0.05$) and /o/ ($p < 0.0001$) in initial position. However, all vowels in medial position display the effect, with a p-value just on the wrong side of the significance threshold: $p = 0.062$. It is possible that with more data we would achieve significance; there are not many medial vowels in the data set.

3.3.1 Initial /a/

Figure 15 shows HI vs. LO instances of initial /a/.

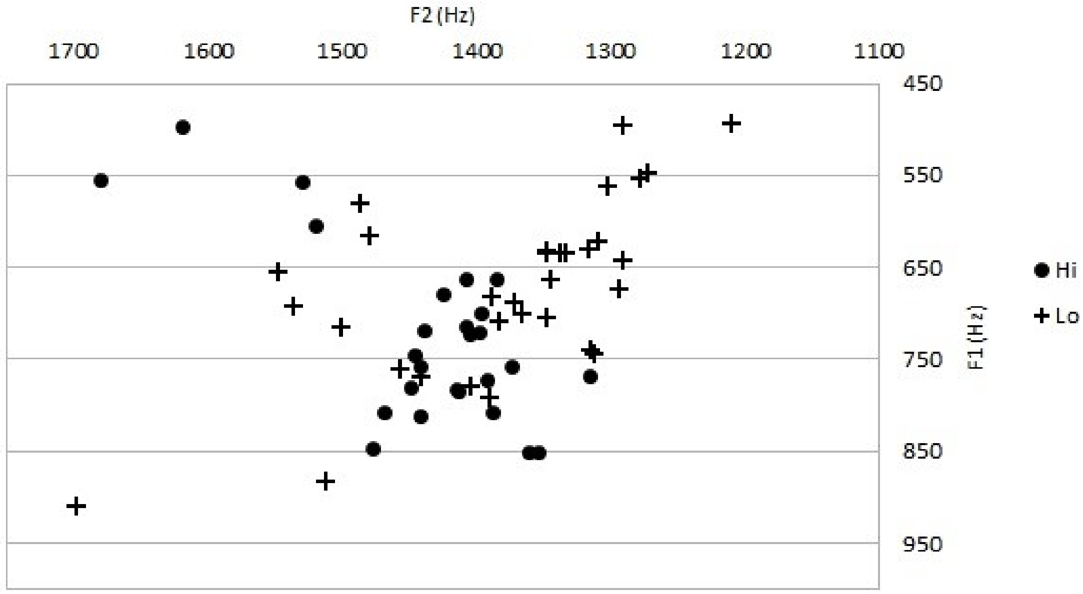


Figure 15. HI vs. LO Initial /a/

There are 58 instances of initial /a/ in the data, 26 HI and 32 LO. The average F_2 for HI is 1436 Hz and for LO it is 1382 Hz. The F_2 range for initial instances of /a/ is 488 Hz, so the jump of 54 Hz from LO to HI accounts for 11% of the total F_2 range for /a/ in initial position.

3.3.2 Initial /o/

Figure shows HI vs. LO instances of initial /o/.

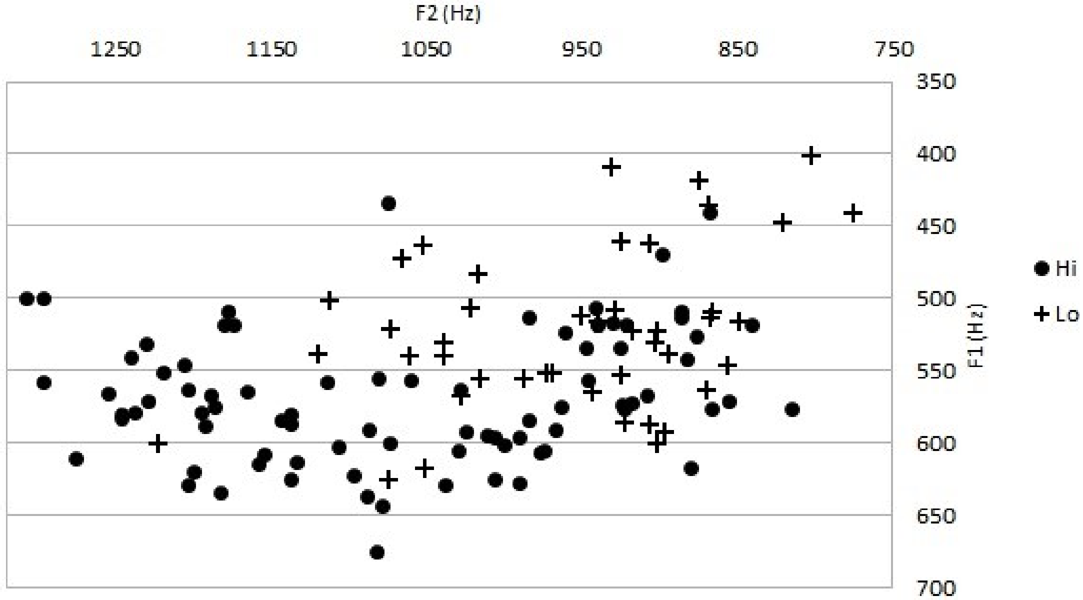


Figure 16. HI vs. LO Initial /o/

There are 128 instances of initial /o/ in the data, 84 HI and 44 LO. The average F_2 for HI is 1070 Hz and for LO it is 956 Hz. The F_2 range for initial instances of /o/ is 989 Hz, so the jump of 114 Hz from LO to HI accounts for 12% of the total F_2 range for /o/ in initial position.

3.4 Summary

HI vs. LO tone appears to affect F_1 for all vowels and F_2 for particular instances of certain vowels. F_1 is raised with HI tone. This effect was not found on medial vowels, but the small sample size of medial vowels in the data may be responsible for this exclusion. F_2 is raised with HI tone on initial /a/ and /o/ only.

CHAPTER 4

SHORT VS LONG VOWELS: FORMANT COMPARISONS

Kope employs lexically contrastive vowel length. Refer to section 1.3.1.2 for minimal pairs. Figure 4 from that section is repeated here as Figure 17 to illustrate the degree of durational difference being discussed.

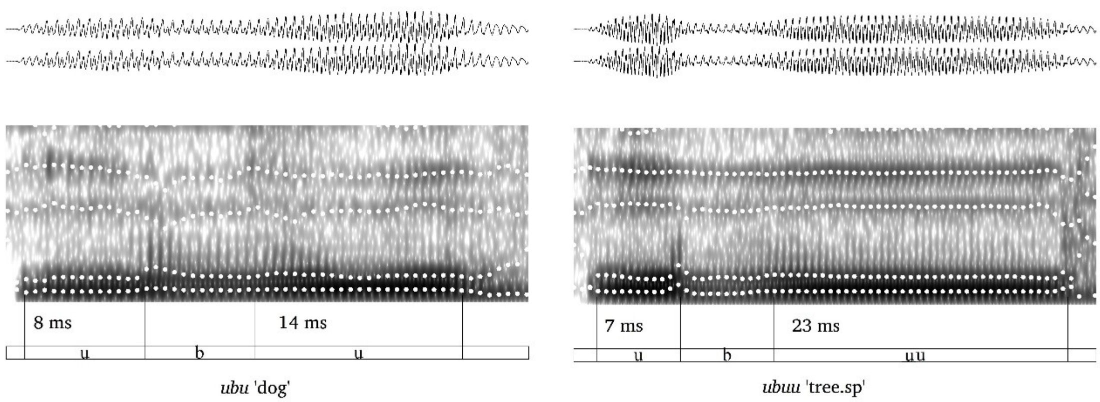


Figure 17. Long vs. Short Vowels

In the word on the left, both vowels are short. In the word on the right, the second vowel is long. This chapter examines whether phonemic length affects formant measurements.

4.1 Individual Measurements

4.1.1 Method

A combination of listening and observing spectrograms in Praat was used to identify phonemically long vowels. Vowels were identified binarily as either short or long, and the aggregated data was subjected to ANOVA tests, as described in section 2.4 and in detail in Chapter 6, searching for effects of long vs. short vowels on F_1 and F_2.

Unfortunately, there are no instances of long /i/ in the data, and only two instances of long /a/, so this analysis is limited to /ɛ/, /o/, and /u/.

There are no statistically significant effects of length on F_1. There is a simple effect of length ($p < 0.05$) on F_2, but the particular effect varies by vowel. Length does not participate in any statistically significant interactions among the other variables. When broken down by vowel position, the significance disappears for final vowels but increases ($p < 0.001$) for initial vowels. There are no long vowels from medial syllables in the data. When the corpus of all vowels is broken up by vowel quality, this effect fluctuates.

4.1.2 /ɛ/

There are 10 long and 144 short instances of /ɛ/. They are distinguished long vs. short in Figure 16 below.

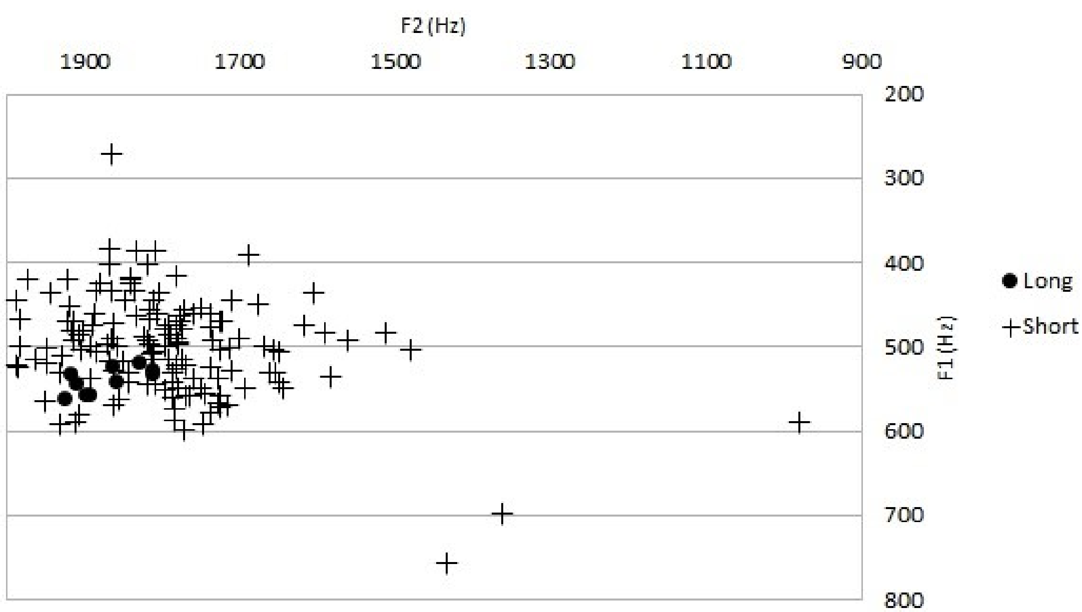


Figure 18. Long vs. Short /ɛ/

The few instances of long /ɛ/ cluster toward the higher end of the F_2 range. The average F_2 values are 1792 for short and 1872 for long. This difference of 80 Hz accounts for 8% of the total F_2 range for /ɛ/. This effect was not significant, with $p = 0.09$, but as there are only eight instances of long initial /ɛ/ in the data, more data may yield a significant effect.

4.1.3 /o/

Like /ɛ/, long instances of /o/ are mostly HI. There are 24 instances of long /o/, with 6 LO and 18 HI. That is, 75% of long instances of /o/ are HI, as opposed to only 57% of all instances of /o/. Figure 19 shows all instances of /o/.

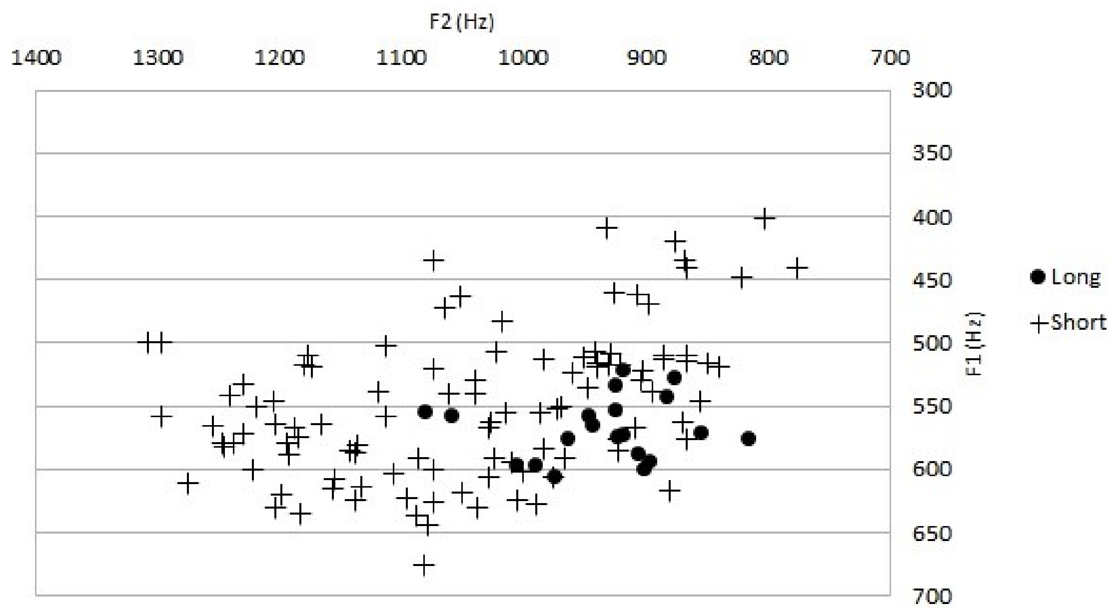


Figure 19. Long vs. Short /o/

Long instances of /o/ are clustered near the lower end of the F_2 range. The average F_2 for long /o/ is 935 Hz and for short it is 1048 Hz. This difference of 113 Hz represents 11% of the total F_2 range. This effect was significant, $p < 0.001$.

4.1.4 /u/

There are only four instances of long / u/ in the data. 100% of long /u/ samples are HI, as opposed to only 58% of all /u/ samples.

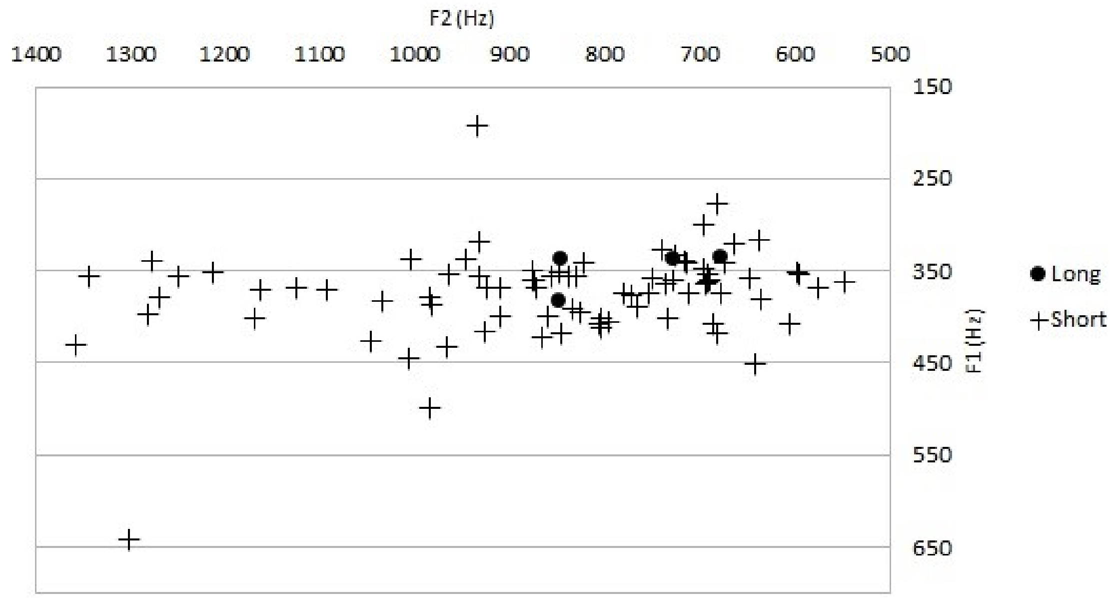


Figure 20. Long vs. Short /u/

As with /o/, long instances of /u/ appear to cluster toward the low end of the F_2 range. The average F_2 measurements are 776 Hz for long and 883 Hz for short. This difference of 107 Hz represents 10% of the total F_2 range for /u/. However, this difference is not statistically significant. For all instances of /u/, $p > 0.05$. The only long instances of /u/ are also HI, but if we restrict the comparison to HI only, still $p > 0.05$. We cannot restrict the comparison to initial position only, because all instances of long /u/ occur in final position. Despite the absence of a statistically significant finding, this section was included because the pattern for /u/ corresponds to the wider pattern.

4.1.5 Summary and discussion

F_2 was observed to move up for long /ɛ/, down for long /o/, and down for long /u/ ($F = (10.03, 301)$, $p < 0.01$). There are no long instances of /i/ in the data, and no F_2 effect on /a/. This effect was significant only for initial /o/. Figure 21 shows the effect on a vowel plot. The single statistically significant effect is circled.

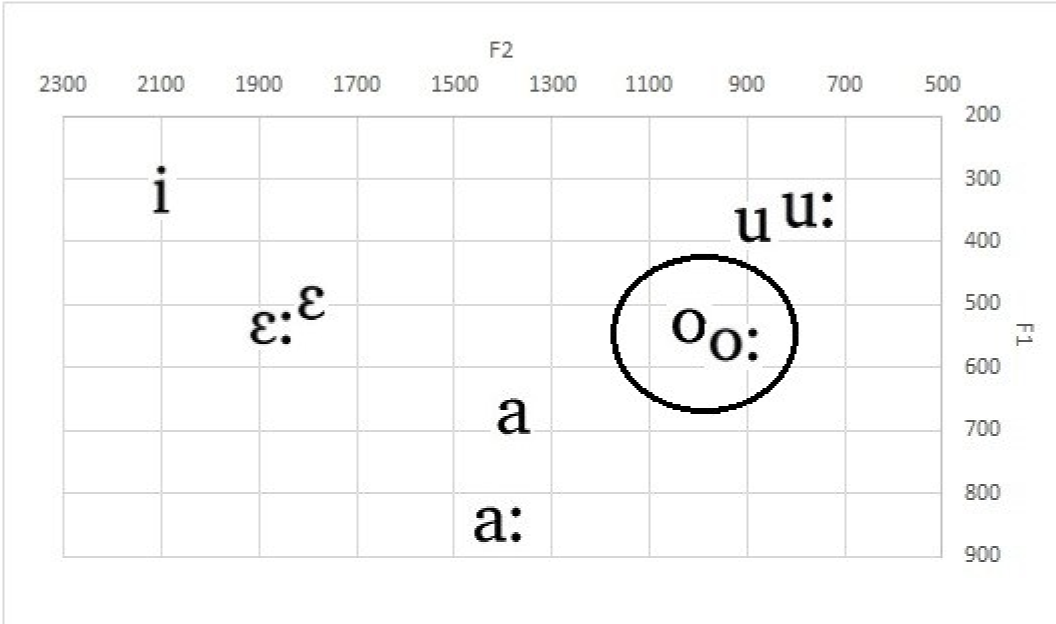


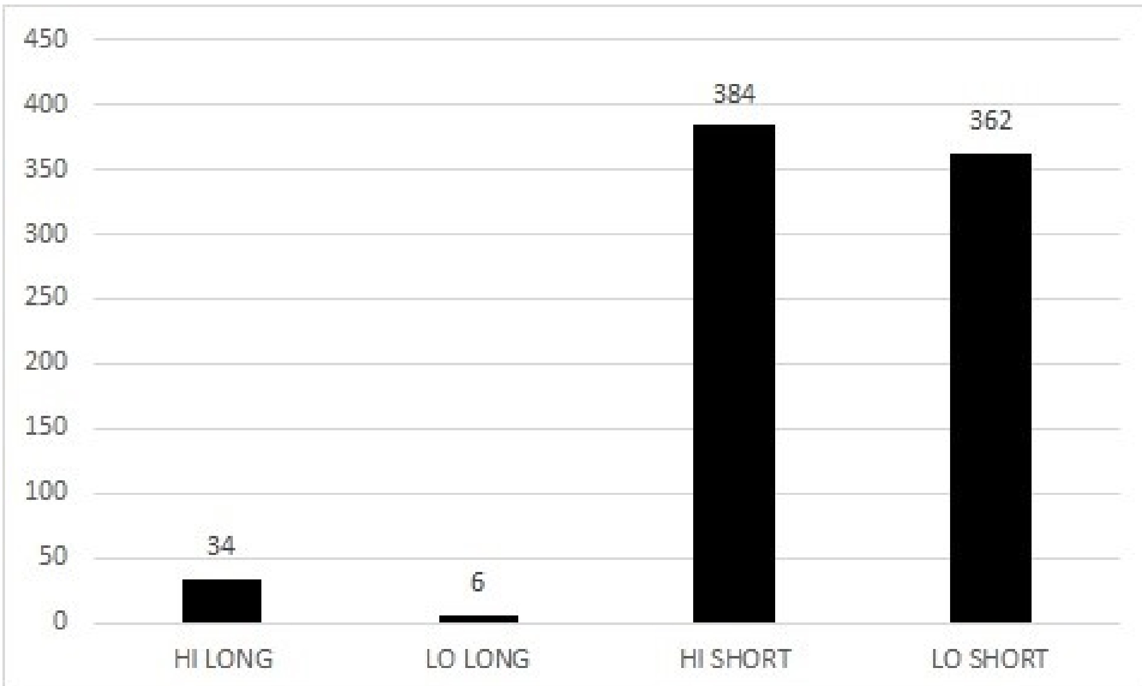
Figure 21. Long Vowel Effect on F_2

Physiologically, this is likely to correspond to fronting /ɛ/ and backing /o/ and /u/. This effect is not surprising when we consider that long instances of vowels are more likely to hit the extremes of their articulatory targets. That is, /ɛ/, as a front vowel, is articulated more fully frontally, and /o/ more fully toward the back, than their short counterparts would have the opportunity to reach given the time available for their articulation. Muehlbauer (2012) found a similar process in Plains Cree, in which long vowels moved toward the periphery of the vowel space relative to short vowels. More research is needed, especially for /a i u/, which had two, zero, and four long instances in the data, respectively.

4.2 Correlation of Length and Tone

In this section I examine the relationship between length and tone, and show that in Kope length and tone seem to be partially associated. It is clear from sections 4.1.2 through 4.1.4 that length and tone are interrelated. Figure 22 illustrates.

Figure 22. Relationship of HI Tone to Long Vowel Length



By far most examples of long vowels present in the data are also HI — 92% of them. This is in contrast to all vowels, of which only 54% are HI. Only 7.4% of all HI vowels are also long, in contrast to all vowels, of which 4.75% are long.

This strong relationship, combined with the paucity of length-only minimal pairs (that is, controlled for tone), suggests some connection between tone and length. Clifton (personal communication) says that not all long vowels may be marked as such, as some Kope speakers have difficulty identifying them. This difficulty is also mentioned in Petterson (2014). What we are left with, even considering that caveat, is that most vowels that are known to be long, identified by speakers as such, are also HI.

This in itself is a point in favor of the suspected relationship: speakers have an easier time unambiguously identifying long vowels when they are also HI. In this section I examine whether the relationship is attributable to a consistent phonetic process.

4.2.1 Methodology

All vowels were measured for both duration and F_0 using Praat scripts; refer to the method discussed in 2.3.2 and 2.3.3. ANOVAs were also completed for these variables; see Chapter 6 for a detailed discussion. The purpose of this section is limited to looking at the question of whether there is a broad positive correlation between F_0 and duration that could explain the relationship between HI tone and long length.

4.2.2 Results

In the data taken as a whole, there is a moderate negative correlation between duration and length ($\rho = 0.30$). However, many variables come into play when discussing F_0 and duration, such as tone and length, their respective phonemic counterparts. Controlling for those variables, we find the following coefficients of correlation between duration and F_0: HI short: $\rho = -0.17$, HI long: $\rho = 0.17$, LO short: $\rho = -0.60$, and LO long: $\rho = -0.09$. These correlations are quite low, near zero.

The last variable for which it is necessary to control is syllable position, alluded to above. When we do so, the correlations between F_0 and duration approach $\rho = 0$. In initial syllables, $\rho = .04$, in medial syllables, $\rho = -0.02$, and in final syllables, $\rho = 0.05$.

The only correlations between F_0 and duration found in the ANOVA discussed in Chapter 6 are negative. That is, as duration increases, F_0 decreases. For non-initial LO /ɛ/, $\rho = -0.65$. All other non-initial LO vowels also showed a negative correlation, $\rho = 0.29$.

The lack of a consistent strong positive correlation between length and F_0 argues for a phonological connection between the two relative factors. That is, length does not make F_0 higher, and high F_0 does not make duration longer. The relationship noted at the beginning of section 4.2 is not attributable to any mechanistic automatic phonetic process, and must therefore be built into the lexicon or an accident of the particular words chosen for this set of data. It may arise from the historical factors discussed in sections 1.3.1.2 and 1.4.2 that gave rise to tone and length contrasts.

The moderate negative correlation shown in the data as a whole is likely due to vowels in final syllables. F_0 has a tendency to decline over the course of an utterance, so vowels toward the end of an utterance naturally have a lower F_0 than vowels at the beginning or in the middle. Recall that the syllable structure of Kope (section 1.4) does not allow for codas, so all vowels occurring in the final syllable of a word are also word-final vowels. Word-final vowels tend to be longer in duration (see section 6.5). When we compare final syllables to one another, the F_0-to-length correlation is not there, because they are all both long and low, but when final vowels are compared to non-final vowels, final vowels are (on average) 27 Hz lower ($p < 0.0001$) and 1.88 times longer ($p < 0.0001$), giving the appearance of a broad negative correlation between F_0 and duration where there is none.

CHAPTER 5
THE INTRINSIC FREQUENCY EFFECT

5.1 Introduction

Whalen and Leavitt (1995) in a study of 32 languages from 11 families, added empirical verification to something linguists had asserted for some time: that higher vowels exhibit a higher fundamental frequency. This intrinsic frequency effect is abbreviated IF_0. According to their findings, this tendency is indeed cross-linguistic and is due not to a deliberate enhancement of vowel differentiation for the benefit of the listener, but more likely due to constraints on the physical apparatus of articulation common to all humans. They compared [u] and [i] as representative of high vowels, with [a] or sometimes [ɑ] as representative of low vowels. Their results were significant, with $p < 0.0001$. The average (mean) F_0 values they obtained are as follows: [u]: 177.4 Hz; [i]: 174.9 Hz; [a]: 160.9 Hz.

They found an average difference in F_0 of 15.3 Hz between high and low vowels. Controlling for sex, particular language, and size of vowel inventory did not yield significantly different results. When they narrowed down to particular languages, they found that languages with larger numbers of subjects in the available data set more closely approached the mean they had found across languages. They did find, however, that in tonal languages, the intrinsic frequency effect usually disappears on vowels with Lo tone. There were only ten tonal languages included in the study, and one of those languages showed the effect present but diminished with Lo tone. The others showed the intrinsic frequency effect fully neutralized with Lo tone.

The data at hand presents an opportunity to expand on their study and contribute some variety to the discussion. Fifteen of the 32 languages included in the original study were Indo-European. Only ten were tonal. One was Austronesian. None were from the Trans-New Guinea phylum, nor indeed from Papua New Guinea. In this section I examine what elements of the IF_0 effect hold true for Kope.

5.2 Method

Following the method from the Whalen and Leavitt study, the F_0 measurements for /u/ and /i/ were taken together and compared with the F_0 measurements for /a/. Because of the additional contrasts present in Kope, length and tone were also controlled for. The following comparisons were made: HI /i/ and /u/ vs. HI /a/, HI short /i/ and /u/ vs. HI short /a/, LO /i/ and /u/ vs. LO /a/, LO short /i/ and /u/ vs. LO /a/.

Because of the near-absence of long /a/ and total absence of long /i/ in the data, the following comparisons were not made: HI long high vs. low, LO long high vs. low, and all long high vs. low. The F_0 measurements from section 4.2 were used.

5.3 Results

The results of the comparisons are shown in Table 5.

Table 5. Intrinsic Frequency Comparisons

Domain of Comparison	Average F_0 high vowels	Average F_0 /a/	Difference low-to-high	p-value
All HI	180 Hz	161 Hz	+19 Hz	<0.0001*
HI short	179 Hz	161 Hz	+18 Hz	<0.0001*
All LO	131 Hz	137 Hz	-6 Hz	>0.05
LO short	131 Hz	137 Hz	-6 Hz	>0.05
All short	159 Hz	149 Hz	+10 Hz	<0.01*

*Statistically significant

The expectations set by the Whalen and Leavitt study are borne out. There is a significant difference in F_0 between high and low vowels that is neutralized in the presence of Lo tone, and only in that environment. High vowels range from 10 to 19 Hz higher than low vowels, depending on the specific population. The population "all short" comes closest to including "all vowels," since only /u/ in this portion of the study has long vowels and there are only four of those.

To conclude, the IF_0 effect holds for Kope. That is, articulatorily high vowels are likely to have a significantly higher F_0 than articulatorily low vowels, even when controlling for duration. This distinction, for some reason, disappears with Lo tone. Further IF_0 research focused on tonal languages is needed to provide an explanation for the neutralization of the effect with Lo tone.

This IF_0 effect does not have anything to do with the F_1 effect observed in Chapter 3. It is simultaneously true that producing Hi tone raises F_1, and high vowels (with a low F_1) have a higher F_0 than low vowels (with a higher F_1). The effect of phonological tone is exactly opposite to the effect of phonetic F_1 on F_0.

CHAPTER 6
STATISTICAL ANALYSIS

6.1 Purpose

Analysis of Variance (ANOVA) tests were used to determine which variables interact with one another, to what degree, and which interactions and effects are statistically significant. For these ANOVA tests, each instance of each vowel was marked for F_1, F_2, Vowel Quality (a, e, i, o, u), Tone (HI, LO), Syllable Position within the word (initial, medial, final), Length (short, long), F_0 (in Hz), and Duration (in ms). Linear regressions were conducted when the dependent variables were scalar. Key aspects of these results were presented in Chapter 3 and Chapter 4; this chapter will discuss the results in a more comprehensive manner.

6.2 First Formant

An ANOVA was performed with F_1 (in Hz) as the dependent variable and the following four factors as independent variables: Vowel Quality (a, e, i, o, u), Tone (HI, LO), Position (initial, medial, final), and Length (long, short). A significant interaction was found between Vowel Quality, Tone, and Position ($F(8, 738) = 3.02$, $p < 0.002$). The data were therefore divided by Position for further analysis.

In the initial syllable, there were significant simple effects of Vowel and Tone. There were no significant interactions of dependent variables. F_1 was found to be affected by Vowel ($F(4,301) = 330.52$, $p < 0.001$). This result is of course expected and unremarkable, as F_1 correlates with vowel height. More interesting was the significant effect of Tone on F_1. Figure 23 shows a box plot of the data.

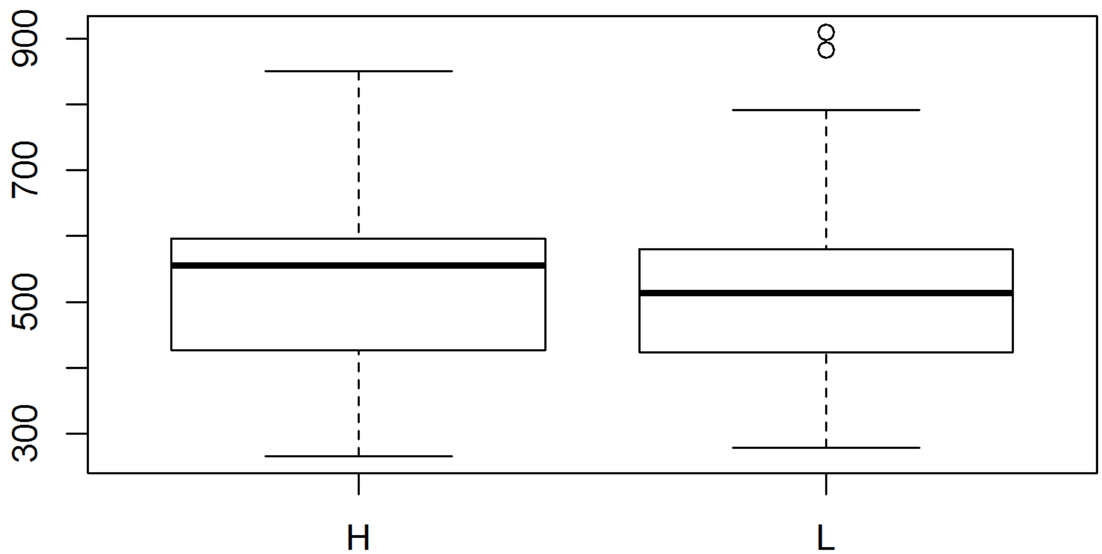


Figure 23. HI vs. LO F_1 in Initial Position.

For vowels in initial syllables, HI vowels have a higher F_1 than LO vowels. $F(1, 301) = 48.42$, $p < 0.0001$.

In the final syllable the same two variables (Vowel and Tone) yielded significant results, with no significant interactions among independent variables. Figure 24 shows the result of Tone.

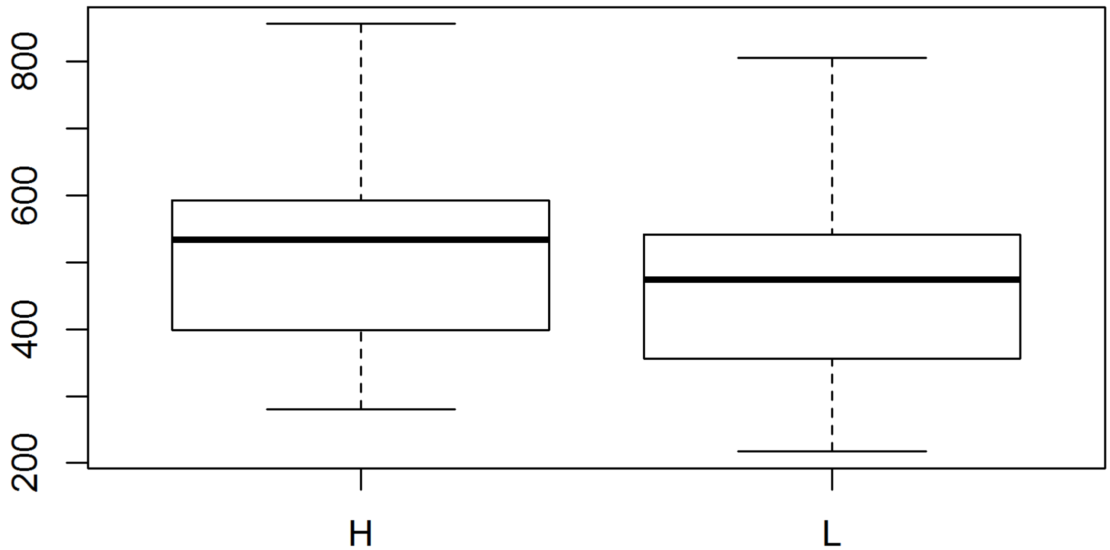


Figure 24. HI vs. LO F_1 in Final Position

In the final syllable, as in the initial syllable above, HI vowels have a higher F_1 than LO vowels: $F(1, 275) = 68.27$, $p < 0.0001$.

In the medial syllables, a significant interaction was found between Vowel and Tone ($F(4, 152) = 3.72$, $p < 0.001$). The data were therefore divided by Vowel for further analysis. Significant results were obtained for only /o/ and /u/. Figure 25 shows the effect.

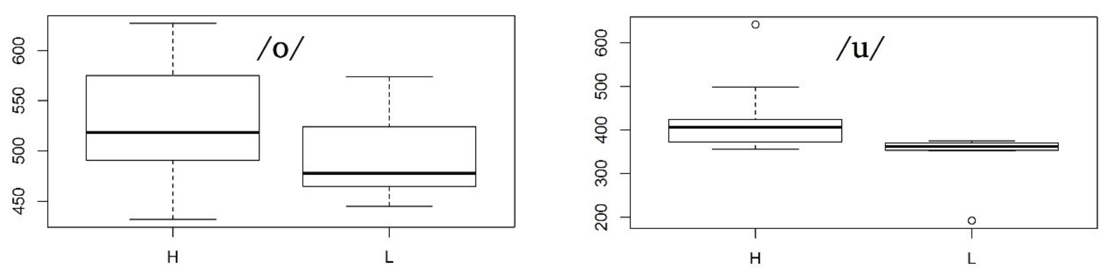


Figure 25. HI vs. LO F_1 in medial /o/ and /u/

For /o/, $F(1, 44) = 6.72$, $p < 0.05$. For /u/, $F(1, 18) = 5.92$, $p < 0.05$. For both of these vowels, HI vowels have a higher F_1 than LO vowels. Table 6 summarizes the findings for F_1. 'X' indicates that for the given vowel, HI vowels have a higher F_1 than LO vowels.

Table 6. Significant F_1 Effects

	Initial	**Medial**	**Final**
/a/	X		X
/ɛ/	X		X
/i/	X		X
/o/	X	X	X
/u/	X	X	X

Refer to Chapter 3 for a discussion of each vowel in detail, with formant plots. This confirms the findings from that chapter, but excludes non-round vowels in medial position. The reason for their exclusion is a topic for further research. /a/ and /ɛ/ show a reverse effect in medial vowels; HI vowels have a lower F_1 than LO vowels. /i/ shows the expected effect in medial vowels, HI vowels have a higher F_1 than LO vowels. However, none of these effects are statistically significant.

6.3 Second Formant

An ANOVA was performed with F_2 as the dependent variable and Tone (HI, LO), Length (long, short), Vowel Quality (a, e, i, o, u), and Position (initial, medial, final) as independent variables. A significant interaction was found between Vowel and Position ($F(8, 738) = 3.15$, $p < 0.01$). The data were divided by Position for further analysis.

In initial syllables, a significant interaction was found between Vowel and Tone ($F(4, 301) = 6.39$, $p < 0.0001$). The data were once again divided by Vowel for further analysis. Significant results were obtained for /a/ and /o/. Figure 26 illustrates.

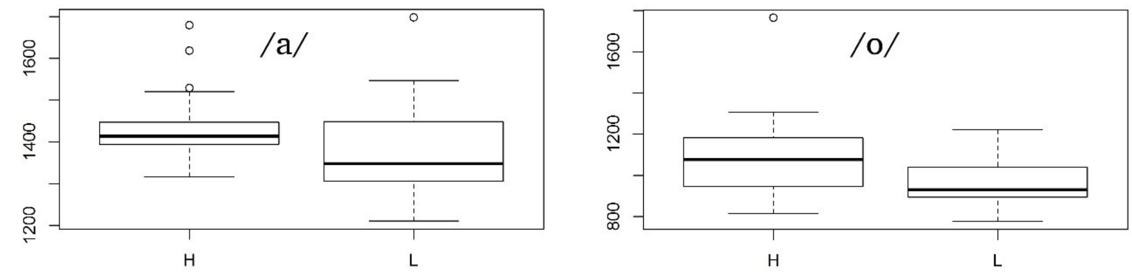


Figure 26. HI vs. LO F_2 in Initial /a/ and /o/

For /a/, $F(1, 54) = 5.02$, $p < 0.05$. For /o/, $F(1, 126) = 20.45$, $p < 0.0001$. For both /a/ and /o/, in initial syllables, HI vowels have a higher F_2 than LO vowels.

For vowels in medial syllables, an ANOVA was performed with F_2 as the dependent variable, and Tone and Vowel Quality as independent variables. There were no long medial vowels in the data. The only significant effect was for Vowel Quality, which is expected and unremarkable. There was an effect for Tone that did not quite meet the significance threshold, but as it is relevant to the pattern we have been observing, I list it here: For vowels in medial syllables, HI F_2 is higher than LO F_2 ($F(1, 162) = 3.54$, $p = 0.062$). There were few medial syllables in the data, so with more instances a significant effect might be reached.

For F_2 in final syllables, no significant effects were observed. Table 7 summarizes the findings for F_2. 'X' indicates that for the given vowel, HI tokens have a higher F_2 than LO tokens. '(X)' in parentheses indicates the effect described above that was not statistically significant but conforms to a pattern.

Table 7. F_2 Effects of Tone

	Initial	**Medial**	**Final**
/a/	X	(X)	
/ɛ/		(X)	
/i/		(X)	
/o/	X	(X)	
/u/		(X)	

HI /a/ and /o/ have a reliably higher F_2 in both initial and medial syllables. All vowels in medial syllables have a higher F_2 on HI vowels, but not quite to the degree of significance. With more available data, it is possible that the effect might have risen to the level of significance for medial vowels.

There was a significant simple effect of Length found on F_2 in initial syllables. Because there was a nearly-significant ($p = 0.084$) interaction between Length and Vowel Quality, the data were divided by Vowel for further analysis. Only /o/ and /ɛ/ are present in initial syllables. For /ɛ/ the effect was found not to be significant ($F(1, 51) = 3.03$, $p = 0.09$). For /o/, the effect was significant ($F(1, 124) = 14.9$, $p < 0.001$). Figure 27 shows the effect of Length on the F_2 measurement of initial /o/.

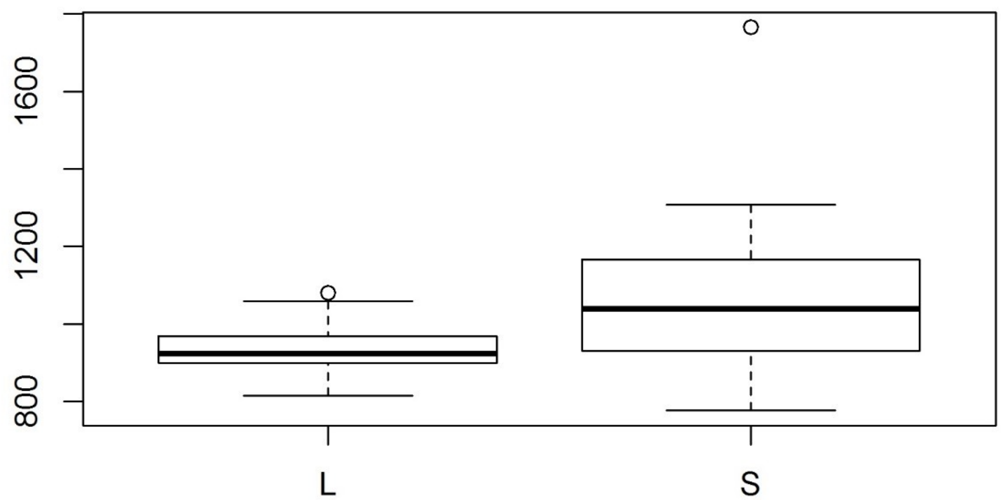


Figure 27. Long and Short Initial /o/ F_2

Long initial instances of /o/ have a significantly lower F_2 than short instances; that is, the vowel is backed.

6.4 Fundamental Frequency

A linear regression was performed with F_0 (in Hz) as the dependent variable and F_1, Vowel Quality (a, e, i, o, u), Tone (HI, LO), Duration (in ms), and Syllable Position (initial, medial, final) as the independent variables. Dummy coding was used to represent the multiple levels of the factors Vowel and Position. There was a significant five-way interaction between F_1, the /u/ level of Vowel, Tone, Duration, and the initial level of Position ($\beta = -0.286$, $p < 0.05$, with an R^2 value of 0.67). The data were therefore divided by Position, initial vs. non-initial, for further analysis. There were no significant effects in initial syllables, but this could be due to the small data set.

For vowels in non-initial syllables, there was a significant interaction between Vowel /ɛ/, F_1, and Duration ($\beta = 0.003$, $p < 0.01$, with an R^2 value of 0.65). The data were therefore divided /ɛ/ and non-/ɛ/ for further analysis. For /ɛ/, a significant interaction was found between F_1, Tone, and Duration ($\beta = 0.002$, $p < 0.05$, with an R^2

value of 0.69). The data were further divided by Tone. For non-initial /ɛ/ with Lo tone, Duration and F_0 were found to be correlated ($\beta = -0.545$, $p < 0.0001$ with an R^2 value of 0.53). Figure 28 shows the correlation.

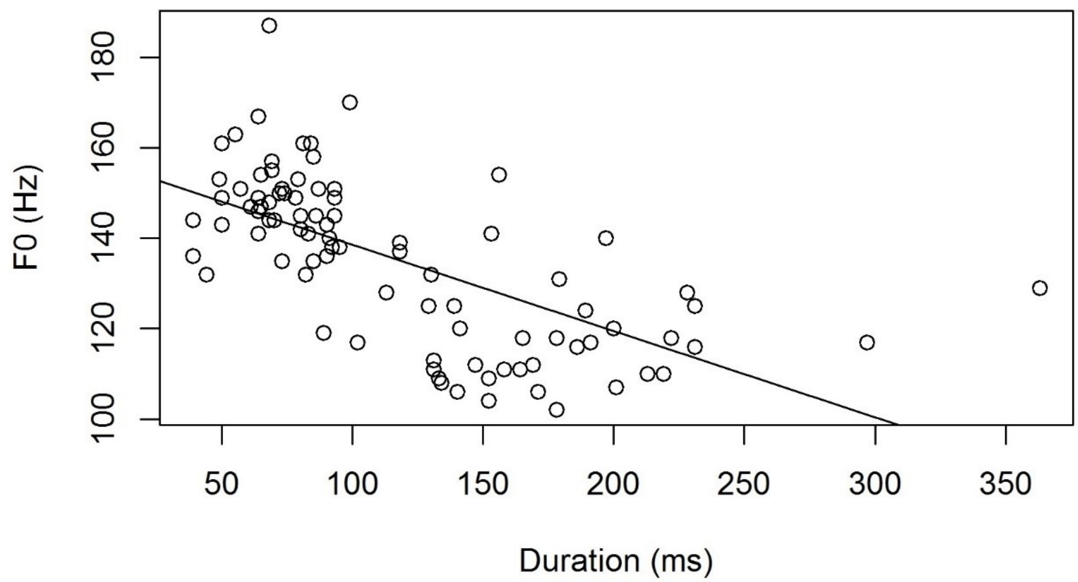


Figure 28. F_0 vs. Duration, Lo non-Initial /ɛ/

In the figure above, we see that as Duration increases, F_0 decreases. The correlation coefficient is -0.65, on the strong side of moderate.

For non-initial /ɛ/ with Hi tone, F_1 and F_0 were found to be correlated ($\beta = 0.273$, $p < 0.01$, with an R^2 value of 0.22). Figure 29 shows the correlation.

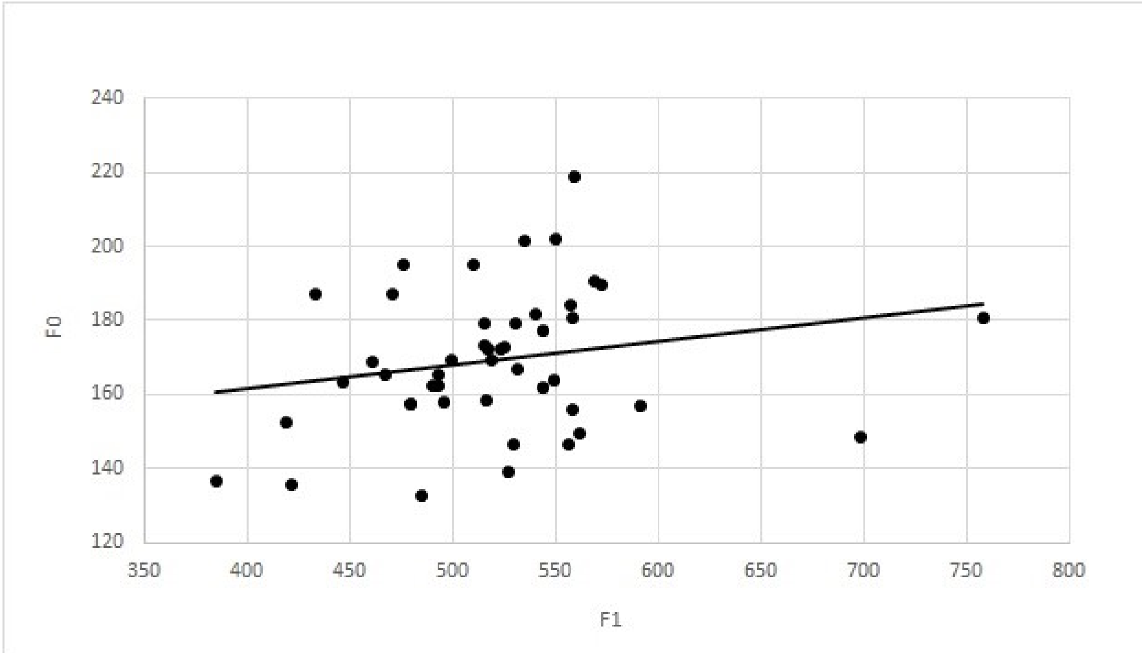


Figure 29. F_0 vs. F_1, HI non-Initial /ɛ/

The higher the F_0, the higher the F_1 is apt to be. This is in line with findings from section 3.2.

Moving on to other (non-/ɛ/) vowels in non-initial syllables, a significant interaction was found between Tone and Duration ($\beta = -0.299$, $p < 0.01$, with an R^2 value of 0.49). This is in line with observations from section 4.2. The data were divided by Tone for further analysis. No significant effects were found for HI vowels. For LO vowels, there was a simple effect between Duration and F_0 ($\beta = 0.005$, $p < 0.0001$, with an R^2 value of 0.34), with the pattern we have seen before: the longer the Duration, the lower the F_0. A two-way interaction of F_1 and Duration was also found to affect F_0 ($\beta = 0.0003$, $p < 0.05$, with an R^2 value of 0.34). Figure 30 shows this three-dimensional interaction of variables.

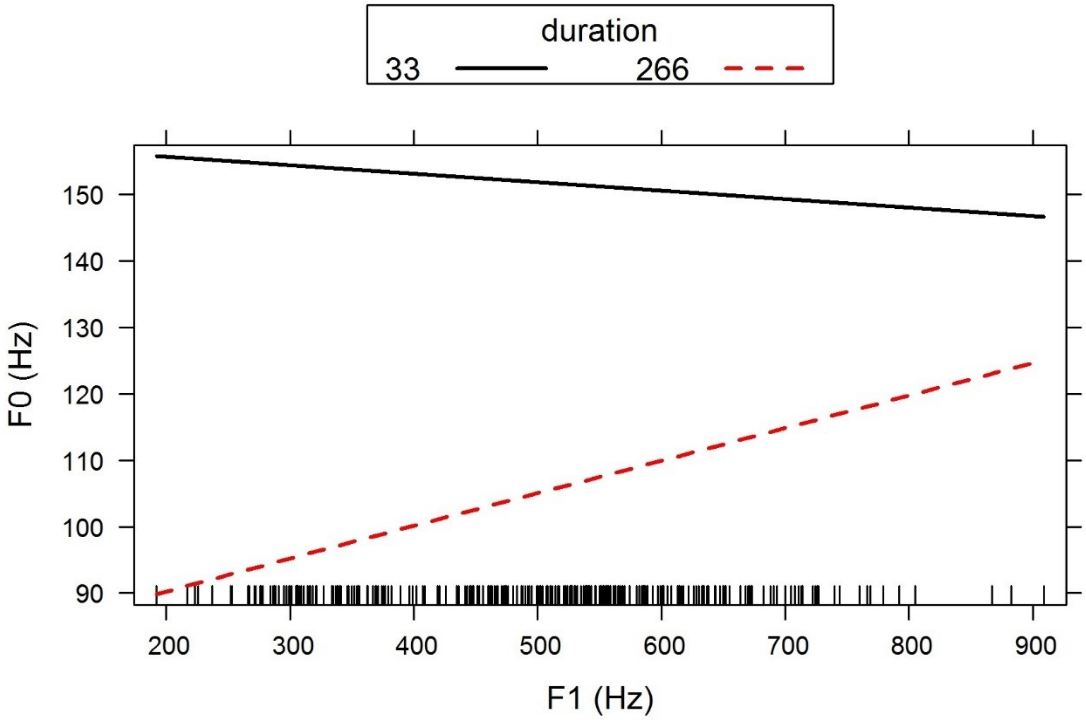


Figure 30. Interaction of F_0, F_1, and Duration

In the figure above, the unbroken black line represents the trend-line for shorter vowels. The dotted red line represents the trend-line for longer vowels. Here we see that for longer vowels, F_0 and F_1 are positively correlated – the higher the F_0, the higher the F_1. For shorter vowels, they are negatively correlated – higher F_1 comes with lower F_0. The small vertical lines at the bottom of the graph show the distribution of F_1 values.

6.5 Duration

An ANOVA was performed with Duration (in ms) as the dependent variable and Vowel Quality (a, e, i, o, u), Tone (HI, LO), Position (initial, medial, final) and Length (long, short) as independent variables. There was a significant interaction of Vowel Quality with both Length and Position, so the data were divided by Vowel for further analysis.

Phonemic Length was found to significantly influence Duration, as expected. For /a/, $F(1, 138) = 18.46$, $p < 0.0001$. For /ɛ/, $F(1, 146) = 8.67$, $p < 0.01$. For /o/, $F(1, 274) = 280.02$, $p < 0.0001$. For /u/, $F(1, 81) = 30.81$, $p < 0.0001$. There were no long instances of /i/ in the data. Figure 31 Shows the average durational differences.

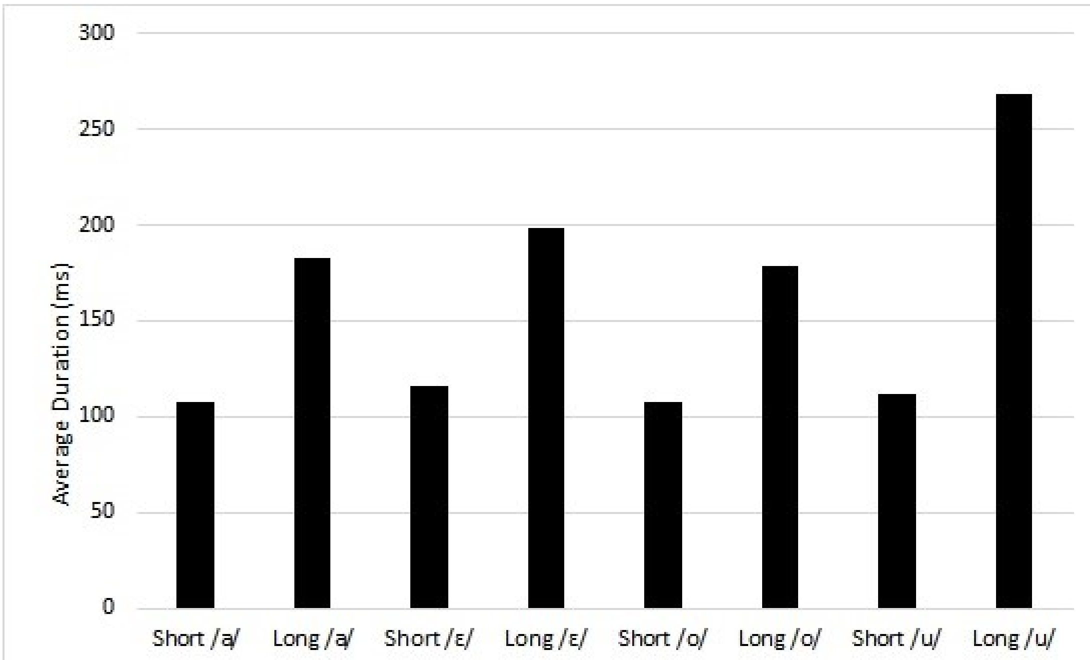


Figure 31. Average Durations for Short and Long Vowels

The only other variable found to significantly affect Duration was Syllable Position. This significant effect of Syllable Position was present for all vowels. For /a/, $F(3, 138) = 63.9$, $p < 0.0001$. For /ɛ/, $F(2, 146) = 120.2$, $p < 0.0001$. For /i/, $F(2, 102) = 131.3$, $p < 0.0001$. For /o/, $F(2, 274) = 254.5$, $p < 0.0001$. For /u/, $F(2, 81) = 25.9$, $p < 0.0001$. Figure 32 shows the average duration of each vowel in each syllable position.

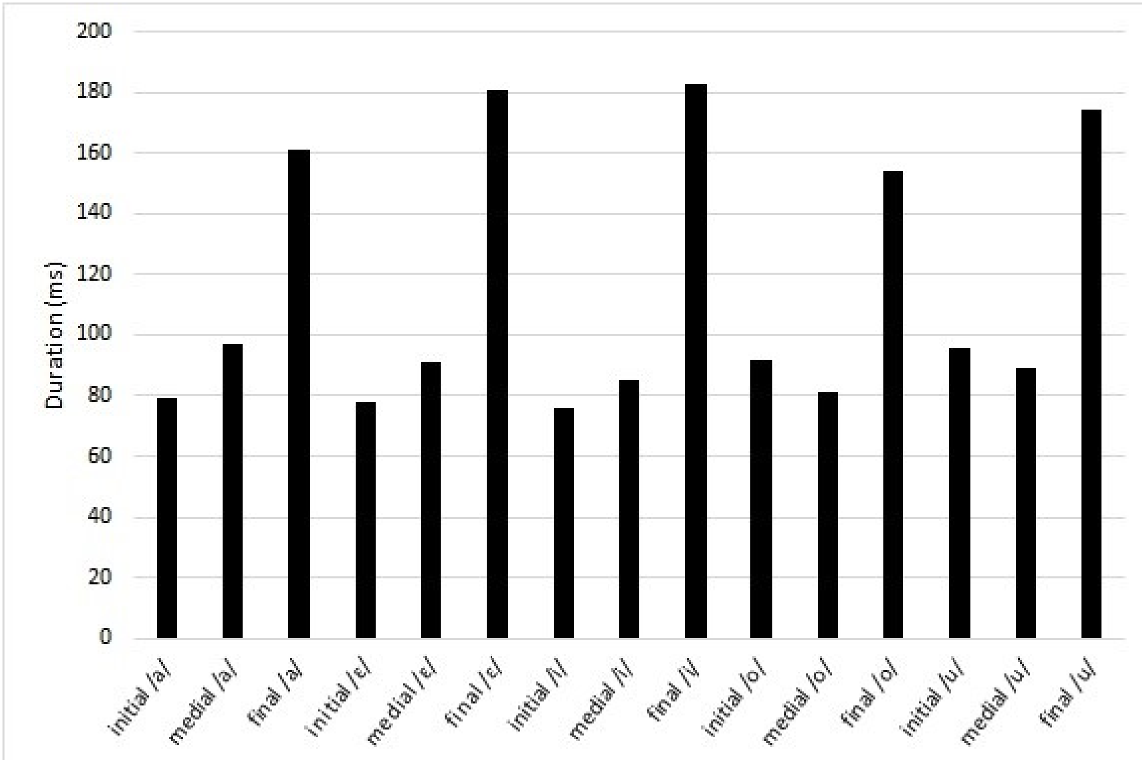


Figure 32. Duration by Syllable Position for all Vowels

Vowels in final syllables (which are also word-final due to absence of codas) have a much longer duration. This effect was briefly discussed in section 4.2. This highlights the importance of taking syllable position into account when attempting to make long vs. short comparisons in a language with phonemic vowel length.

CHAPTER 7
TONE

7.1 Introduction

The data made available to me for this study was optimized for tonal analysis. The linguists collecting the data deliberately targeted (among other things) minimal tonal pairs, and elicited environments of isolation and frame. In addition to the above acoustic study, I used this data to complete a preliminary tonal analysis, building on the work of Petterson (2013, 2015) and using the method described by Snider (2013). The transcription of tone is my own. In this section, I separate words by the number of syllables they have, and catalog patterns of surface tones in isolation and in frames.

7.2 Surface Tone Patterns

Two words may seem to have the same tone pattern in isolation, but if they behave differently in the same frame, they have different underlying tone patterns (Snider 2013). To determine underlying patterns, surface patterns are examined in various contexts. Any two words with the same underlying pattern will behave the same both in isolation and in any given frame. Kope has robust affixation on verbs, with wholesale tonal effects (Petterson 2015), so the preponderance of nouns in the data is ideal for my purposes. Words selected for pattern-hunting must also be monomorphemic and non-loans (Snider 2013).

7.2.1 Two syllables in isolation

On two-syllable words in isolation, the following surface patterns are present: HH, LH, and HL. LL, the only remaining logical possibility for a two-level system, is absent.

According to the syllable structure constraints discussed in section 1.4, the minimal possible two-syllable word has a V.V syllable profile. We are fortunate to have a minimal pair in the data answering to this description. These are the only examples of V.V in the data, and LH is not attested for this syllable profile. Likewise CV.V words in the data display only HL and HH surface patterns in isolation.

(9)

HL	HH
[¯ _]	[¯ ¯]
ue	*ue*
'sugarcane'	'arrow.flat.blade'

Example 10 shows V.CV words – the minimal syllable profile for which all three patterns are present in isolation.

(10)

LH	HL	HH
[_ ¯]	[¯ _]	[¯ ¯]
obe	*obe*	*oto*
'moon'	'shark'	'foot'

Example 11 shows the same three patterns in the maximal syllable profile for a two syllable word, CV.CV

(11)

LH	HL	HH
[_ ¯]	[¯ _]	[¯ ¯]
gabo	*goro*	*gara*
'step'	'bandicoot'	'fence'

Table 8 gives a summary of the word-level patterns found in isolation, and how many are found for each syllable profile.

Table 8. Surface Patterns on Two Syllables in Isolation

Syllable Profile	**HH**	**LH**	**HL**
V.V	1		1
CV.V	1	1	4
V.CV	7	10	16
CV.CV	14	19	33
TOTALS	**23**	**30**	**54**

HL is by far the most common pattern, and CV.CV the most common syllable profile. HH and HL are the only patterns attested for all syllable profiles, but given that there are only two V.V words in the data, this could be accidental.

7.2.2 Two syllables in frames

Two frames were used. Frame 1 is *ara* ___ *ra* 'Is it __?' *ara* and *ra* both carry low tone. Frame 2 is *ara* __ *ka* 'It is __.' *ka* also carries low tone. As described in section 1.3.1.2, *ka* is eligible to receive spreading tones, and *ra* is not.

Words that have HH surface patterns in isolation, for the most part, continue to have HH in both frame 1 and frame 2. In frame 2 the H spreads onto *ka* and causes it to have HL pattern, which appears as a falling contour tone when it is squeezed onto one syllable (12, 13).

(12) [¯ ¯] [–– ¯¯ –] [–– ¯ ¯ ˋ]

gama *ara gama ra* *ara gama ka*

'drum' 'is it a drum?' 'it is a drum'

(13) [¯¯] [–– ¯¯ –] [–– ¯¯ ˋ]

tutu *ara tutu ra* *ara tutu ka*

handle 'is it a handle?' 'it is a handle.'

Some words that are HH in isolation become H(HL) in the second frame. This appears to be limited to words that have two moras on the second syllable (14, 15)

(14) [¯ ¯] [––¯ ¯ –] [––¯ ˋ –]

ubuu *ara ubuu ra* *ara ubuu ka*

'tree.by.river' 'is it a tree?' 'it is a tree'

(15) [¯ ¯] [–– ¯¯ –] [–– ¯ˋ –]

mioo *ara mioo ra* *ara mioo ka*

calling 'is it a calling?' 'it is a calling.'

Two-syllable words that have LH pattern in isolation display a similar pattern. After words with monomoraic final syllables (16), *ka* takes on falling tone, but after words with a bimoraic final syllable (long vowels and diphthongs) (17), *ka* is low and it is the final syllable of the target word that falls.

(16) [– ¯] [–– – ¯ –] [–– – ¯ ˋ]

gabo *ara gabo ra* *ara gabo ka*

'path' 'is it a path?' 'it is a path.'

(17) [– ¯] [–– – ¯ –] [–– – ˋ –]

meree *ara meree ra* *ara meree ka*

child 'is it a child?' 'it is a child.'

Two-syllable words that have HL surface pattern in isolation do not spread their tones to either word in the frame, but they do cause downstep on the following *ra* and *ka* (18, 19).

(18) [¯ –] [–– ¯ – _] [–– ¯ – _]

bobo *ara bobo ra* *ara bobo ka*

'well' 'is it a well?' 'it is a well.'

(19) [‾–] [–– ‾– _] [–– ‾– _]

obe *ara obe ra* *ara obe ka*

'shark' 'is it a shark?' 'it is a shark.'

However, words that begin with a heavy syllable with no onset (20) are phonetically (LH) on that first syllable.

(20) [‾ –] [–– ⁄ – _] [–– ⁄ – _]

oobo *ara oobo ra* *ara oobo ka*

'adze' 'is it an adze?' 'it is an adze.'

Heavy syllables with an onset (21) do not appear to participate in this effect, nor do monomoraic onset-free syllables (19).

(21) [‾ –] [–– ‾ – _] [–– ‾ – _]

goobo *ara goobo ra* *ara goobo ka*

'chest' 'is it a chest?' 'it is a chest.'

Table 9 summarizes the surface patterns displayed by two-syllable words. Tones paired in parentheses indicate that they both attach to the same tone-bearing unit, creating a falling (HL) or rising (LH) contour tone.

Table 9. Two-Syllable Surface Patterns

Pattern	Isolation	Frame 1	Frame 2	Notes
A	HH	LL HH L	LL HH (HL)	
B	HH	LL HH L	LL H(HL) L	σ2 bimoraic
C	LH	LL LH L	LL LH (HL)	
D	LH	LL LH L	LL L(HL) L	σ2 bimoraic
E	HL	LL HL ↓L	LL HL ↓L	
F	HL	LL (LH)L ↓L	LL (LH)L ↓L	σ1 bimoraic no onset

Patterns B and D seem to involve heavy (bimoraic) syllables attracting the leftward spread of L from *ka*. Pattern F, which occurs only on vowel-initial words, is possibly due to the smooth transition, uninterrupted by a consonant, from Lo on a preceding morpheme to Hi on a long vowel in the next morpheme. Given more time to realize the phonemic HI, the vocal apparatus takes its time to hit the target. Or, alternatively, the L from *ara* is invited to spread right by the following heavy syllable, but consonants block spreading. If this effect is present, it is neutralized in B and D since there are no codas in Kope, hence no consonants in a position to do block the leftward spread. If this is the case, an explanation would be required for the fact that it does not affect words with HH pattern; many participants in pattern A have no onset.

7.2.3 Three syllables in isolation

When known compounds and non-nouns are excluded, there are 43 three-syllable words available for analysis. The patterns in isolation are as follows: HHH, LHH, LLH, HLL, HHL, LHL. As with two-syllable words, there are no all-LO three-syllable words. There are no HLH words. It is possible that this is an accidental gap, though I do not think this is the case (see section 7.3).

Table 10. Surface Patterns on Three Syllables in Isolation

Syllable Profile	**HHH**	**LLH**	**LHH**	**LHL**	**HHL**	**HLL**
CV.CV.CV	3	1		9	2	8
CV.CV.V	1	2	1	3		1
CV.V.CV						1
V.CV.CV	1		1	5		
V.CV.V		1		1		2
TOTALS	**5**	**4**	**2**	**18**	**2**	**12**

The most robustly attested patterns in isolation are LHL and HLL. HHH comes in third, with only five instances total. LLH, LHH, and HHL are less frequently attested.

7.2.4 Three syllables in frames

For HHH, we see similar behavior to HH in frame. (22) shows how the pattern remains HHH in frame 1, but the final H falls in frame 2 before *ka*.

(22)	[¯ ¯ ¯]	[‒‒ ¯ ¯ ¯ ‒]	[‒ ‒ ¯ ¯ ╲ ‒]
	kakapi	*ara kakapi ra*	*ara kakapi ka*
	‘finger’	‘is it a finger?’	‘it is a finger.’

Some words that are HLL in isolation remain HLL in both frames (23), and others become HHL (24). Following L is always downstepped.

(23)	[¯‒‒]	[‒‒ ¯‒‒ _]	[‒‒ ¯‒‒ _]
	gi‘epu	*ara gi’epu ra*	*ara gi’epu ka*
	‘throat’	‘is it a throat?’	‘it is a throat.’
(24)	[¯‒‒]	[‒‒ ¯ ¯‒ _]	[‒‒ ¯ ¯‒ _]
	dodoro	*ara dodoro ra*	*ara dodoro ka*
	‘river bank’	‘is it a river bank?’	‘it is a river bank.’

Most words that are LHL in isolation remain LHL in both frames (25). When that is the case, they generate downstep on a following L. Some become LHH in frame with concurrent falling tone on *ka* (26).

(25)	[‒ ¯ ‒]	[‒‒ ‒ ¯ ‒ _]	[‒‒ ‒ ¯ ‒ _]
	gidobu	*ara gidobu ra*	*ara gidobu ka*
	‘barrimundi’	‘is it a barrimundi?’	‘it is a barrimundi.’
(26)	[‒ ¯ ‒]	[‒‒ ‒ ¯ ¯ ‒]	[‒‒ ‒ ¯ ¯ ╲]
	korobo	*ara korobo ra*	*ara korobo ka*
	‘wind’	‘is it a wind?’	‘it is a wind.’

The single instance of consistent HHL in isolation (*hu'ure* 'fly') matches the surface pattern of (25) in both frames. The word for ‘rainbow,’ *huhuia / hi’uia,* is pronounced differently (both tonally and segmentally) across speakers and therefore excluded from the tonal study, but one person does pronounce it HHL in isolation. It is possible that the nature of the first two segments involved, a voiceless consonant and a high vowel, make the first syllable sound like it has HI tone, and these words actually belong to the

LHL category. HHL as an independent pattern cannot be ruled out, but with only one reliable instance to examine, neither can it be definitively included.

LLH and LHH also have their contrast neutralized to match (25) in both frames (27), (28).

(27)	[– – ¯]	[–– – ¯ – _]	[–– – ¯ –_]
	kebari	*ara kebari ra*	*ara kebari ka*
	'tusk'	'is it a tusk?'	'it is a tusk.'
(28)	[–¯¯]	[–– –¯ – _]	[–– –¯ –_]
	eburu	*ara eburu ra*	*ara eburu ka*
	'tree'	'is it a tree?'	'it is a tree.'

Both become LHL in the first and second frames, and downstep occurs on *ra* and *ka*. Table 11 summarizes the surface patterns in all environments for three-syllable words.

Table 11. Three-Syllable Surface Patterns

Pattern	Isolation	Frame 1	Frame 2
G	HHH	LL HHH L	LL HH(HL) L
H	HLL	LL HLL ↓L	LL HLL ↓L
I	HLL	LL HHL ↓L	LL HHL ↓L
J	LHL	LL LHL ↓L	LL LHL ↓L
K	LHL	LL LHH L	LL LHH (HL)
L	LLH	LL LHL ↓L	LL LHL ↓L
M	LHH	LL LHL ↓L	LL LHL ↓L

G has a clear similarity to A from Table 9. H and I are probably variations of E, but there is no mechanism to explain why one patterns in frame as HHL and the other remains HLL. Beyond that, attempts to tie three-syllable patterns to two-syllable patterns become muddled by context. For example, compare patterns K and M, which completely transpose their patterns in the context of isolation vs. frame. More research in this area is needed, especially pertaining to stress.

7.2.5 Four syllables in isolation

When known compounds and non-nouns are excluded, there are 13 four-syllable words available for analysis. Seven of these are reduplicated. Table 13 shows the distribution of isolation surface patterns. Reduplicated words are noted with asterisks on their syllable profile and situated at the bottom of the table.

Table 12. Surface Patterns on Four Syllables in Isolation

Syllable Profile	**HHHH**	**HHHL**	**HHLL**	**HLHL**	**LLHL**	**LLLH**
V.CV.CV.CV	1	1				
CV.CV.CV.CV					1	1
CV.V.CV.V					1	
CV.CV.CV.V					1	
V.CV.V.CV*		1				
CV.CV.CV.CV*		2	2			1
CV.V.CV.V*				1		
TOTALS	**1**	**4**	**2**	**4**	**3**	**1**

Due to the small pool of data, no conclusions may be drawn. Simple observations may, however, be made. First, there are only four patterns present on non-reduplicates: HHHH, HHHL, LLHL, and LLLH. As with two- and three-syllable words, there are no all-L patterns. These four surface patterns may well correspond to underlying H, HL, LHL, and LH patterns. There is simply not enough data to conclude anything – much more data is needed. Second, tone patterns on reduplicated words are limited to HHHL, HHLL, HLHL, and LLLH. Of these, HHLL and HLHL are not found in non-reduplicates. Given the complicated nature of the HLHL pattern, I predict that it is likely only to be found in reduplicates. Apart from that pattern, no H's are ever separated from each other by a L word-internally.

7.2.6 Four syllables in frames

Combinations of isolation and frame patterns are listed below in Table 13. Patterns restricted to reduplicates are flagged with an asterisk on the letter designating the pattern.

Table 13. Four-Syllable Surface Patterns

Pattern	Isolation	Frame 1	Frame 2
N	HHHH	LL LLLH ↓L	LL LLLH ↓L
O	HHHL	LL LLLH ↓L	LL LLLL (HL)
P*	HHHL	LL HHHL ↓L	LL HHHL ↓L
Q*	HHHL	LL HHLL ↓L	LL HHLL ↓L
R*	HHHL	LL HHHH ↓L	LL HHHH ↓L
S*	HHLL	LL HHLL L	LL HHLL L
T*	HHLL	LL LHHL ↓L	LL LHHL ↓L
U	LLHL	LL LLHL ↓L	LL LLHL ↓L
V	LLHL	LL HHHL ↓L	LL HHHL ↓L
X*	HLHL	LL HHHH ↓L	LL HHHH ↓L
Y	LLLH	LL LLHH ↓L	LL LLHH ↓L

There are eleven patterns listed here for thirteen words. Clearly, more data is needed to find patterns, to say nothing of drawing conclusions. Notably, pattern U occurs in two words, as does pattern Y, although for Y one of the words is a reduplicate.

7.3 Summary

Each word has at least one HI syllable – this is a feature typical of pitch-accent systems, although not sufficient in and of itself to identify Kope as such. HI tone spreads across word boundaries. Also operating across word boundaries, LO tone causes downstep on a following Lo tone. The data at hand was not sufficient to discover what happens when Lo precedes Hi across a word boundary, but Petterson (2015) indicates that downstep occurs in that environment as well. Data from section 7.2.2 suggests that syllable weight may be a factor in determining which syllables attract spreading. More data is needed to make patterns clear: more instances of three and four-syllable words, in frames other than Lo_Lo would go a long way toward expanding the inventory of surface patterns. A study of stress will also be necessary, as it is highly plausible that Kope is a pitch-accent language and makes reference to stress when assigning tone patterns to tone-bearing units.

APPENDIX A

VOWEL MEASUREMENTS

The data in this appendix is organized first by vowel, then by tone, then by length. Syllable position notations (initial, medial, final) are abbreviated I, M, F respectively.

gloss	transcription	vowel	tone	which utterance	which σ	length	F_1 (Hz)	F_2 (Hz)	F F_0 (Hz)	Duration (ms)	σ Position
thing	naara	a	H	1	1	L	852	1353	162	184	I
thing	naara	a	H	2	1	L	848	1477	141	181	I
mosquito larva	gama	a	H	1	2	S	796	1349	166	135	F
mosquito larva	gama	a	H	2	2	S	677	1358	134	137	F
drum	gama	a	H	1	2	S	684	1232	139	148	F
drum	gama	a	H	2	2	S	706	1264	139	113	F
large	geema	a	H	1	2	S	791	1358	147	112	F
large	geema	a	H	2	2	S	774	1429	141	127	F
skin	tama	a	H	1	2	S	734	1334	163	119	F
skin	tama	a	H	2	2	S	719	1139	141	138	F
tame	tama	a	H	1	2	S	680	1187	131	118	F
tame	tama	a	H	2	2	S	783	1409	140	105	F
blood	ora	a	H	1	2	S	679	1313	163	203	F
blood	ora	a	H	2	2	S	689	1265	142	201	F
leaf	paha	a	H	1	2	S	856	1386	211	193	F
leaf	paha	a	H	2	2	S	745	1386	153	164	F
fence	gara	a	H	1	2	S	722	1365	168	203	F
fence	gara	a	H	2	2	S	679	1403	153	167	F
lizard	tu'a	a	H	1	2	S	713	1293	214	150	F

lizard	tu'a	a	H	2	2	S	726	1287	183	169	F
sandal	ototama	a	H	1	4	S	630	1270	154	173	F
sandal	ototama	a	H	2	4	S	630	1301	126	210	F
clothes	tamarara	a	H	1	4	S	715	1341	170	248	F
clothes	tamarara	a	H	2	4	S	677	1277	149	242	F
father	abea	a	H	1	1	S	851	1360	165	78	I
father	abea	a	H	2	1	S	782	1449	145	73	I
mosquito larva	gama	a	H	1	1	S	724	1405	167	103	I
mosquito larva	gama	a	H	2	1	S	663	1385	135	72	I
drum	gama	a	H	1	1	S	747	1445	144	92	I
drum	gama	a	H	2	1	S	721	1397	143	98	I
croton	hamera	a	H	1	1	S	758	1374	196	66	I
croton	hamera	a	H	2	1	S	716	1407	181	68	I
talon	kakahi	a	H	1	1	S	605	1520	171	63	I
talon	kakahi	a	H	2	1	S	558	1529	161	54	I
finger	kakapi	a	H	1	1	S	556	1680	161	51	I
finger	kakapi	a	H	2	1	S	498	1619	145	53	I
one	ga'ubuo	a	H	1	1	S	808	1388	163	109	I
one	ga'ubuo	a	H	2	1	S	701	1396	144	119	I
word	made	a	H	1	1	S	812	1442	165	77	I
word	made	a	H	2	1	S	680	1424	141	82	I
neck	maru	a	H	1	1	S	774	1392	200	94	I
neck	maru	a	H	2	1	S	759	1441	157	105	I
tail	mapo	a	H	1	1	S	769	1316	199	79	I
tail	mapo	a	H	2	1	S	783	1414	155	84	I
fence	gara	a	H	1	1	S	719	1438	171	101	I
fence	gara	a	H	2	1	S	664	1407	160	104	I

price	ta'i	a	H	1	1	S	785	1413	195	112	I
price	ta'i	a	H	2	1	S	809	1468	170	96	I
heat	erara	a	H	1	2	S	782	1505	157	173	M
heat	erara	a	H	2	2	S	713	1437	154	140	M
sago beetle	gogabe	a	H	1	2	S	707	1421	180	96	M
sago beetle	gogabe	a	H	2	2	S	651	1409	146	98	M
ear	hepato	a	H	1	2	S	666	1244	190	67	M
ear	hepato	a	H	2	2	S	622	1289	153	79	M
talon	kakahi	a	H	1	2	S	610	1482	173	84	M
talon	kakahi	a	H	2	2	S	622	1525	161	68	M
finger	kakapi	a	H	1	2	S	544	1406	179	71	M
finger	kakapi	a	H	2	2	S	546	1438	149	51	M
red	oratoti	a	H	1	2	S	686	1296	184	72	M
red	oratoti	a	H	2	2	S	676	1275	163	93	M
jump	iamagauri	a	H	1	2	S	492	1141	209	93	M
jump	iamagauri	a	H	2	2	S	502	1125	173	96	M
thorny vine	orotabi	a	H	1	3	S	677	1343	165	110	M
thorny vine	orotabi	a	H	2	3	S	683	1311	148	116	M
sandal	ototama	a	H	1	3	S	717	1352	168	78	M
sandal	ototama	a	H	2	3	S	731	1239	140	87	M
hamstring	otoga'ibi	a	H	1	3	S	711	1444	179	120	M
hamstring	otoga'ibi	a	H	2	3	S	686	1590	143	96	M
toes	otoikakahi	a	H	1	3	S	441	1734	155	56	M
toes	otoikakahi	a	H	2	3	S	316	1843	146	47	M
narrow part above ankle	otoimarui	a	H	1	3	S	717	1365	190	100	M
narrow part above ankle	otoimarui	a	H	2	3	S	671	1343	170	103	M

clothes	tamarara	a	H	1	3	S	743	1349	175	139	M
clothes	tamarara	a	H	2	3	S	743	1310	152	163	M
toes	otoikakahi	a	H	1	4	S	685	1568	156	107	M
toes	otoikakahi	a	H	2	4	S	650	1578	136	89	M
hip	gema	a	L	1	2	S	614	1130	133	89	F
hip	gema	a	L	2	2	S	599	1137	136	82	F
exchange	miha	a	L	1	2	S	805	1522	124	119	F
exchange	miha	a	L	2	2	S	559	1568	121	123	F
thing	naara	a	L	1	2	S	766	1350	125	254	F
thing	naara	a	L	2	2	S	724	1341	113	243	F
tree	nu'a	a	L	1	2	S	760	1315	147	194	F
tree	nu'a	a	L	2	2	S	691	1194	119	226	F
coconut	go'ota	a	L	1	3	S	726	1446	117	151	F
coconut	go'ota	a	L	2	3	S	671	1393	119	152	F
heat	erara	a	L	1	3	S	647	1391	109	169	F
heat	erara	a	L	2	3	S	652	1260	121	86	F
ladle	ga'iba	a	L	1	3	S	597	1292	127	198	F
ladle	ga'iba	a	L	2	3	S	589	1323	122	150	F
croton	hamera	a	L	1	3	S	608	1528	113	131	F
croton	hamera	a	L	2	3	S	637	1482	115	147	F
tree	tapau'a	a	L	1	3	S	672	1262	124	166	F
tree	tapau'a	a	L	2	3	S	651	1248	127	162	F
all	turiaha	a	L	1	4	S	616	1491	105	181	F
all	turiaha	a	L	2	4	S	628	1534	107	163	F
sago bag	abea	a	L	1	1	S	622	1309	123	66	I
sago bag	abea	a	L	2	1	S	792	1391	129	64	I
path	gabo	a	L	1	1	S	633	1348	137	52	I
path	gabo	a	L	2	1	S	634	1338	125	67	I

step	gabo	a	L	1	1	S	688	1372	121	79	I
step	gabo	a	L	2	1	S	634	1334	125	66	I
skin	tama	a	L	1	1	S	740	1316	142	73	I
skin	tama	a	L	2	1	S	705	1348	127	89	I
tame	tama	a	L	1	1	S	700	1367	121	70	I
tame	tama	a	L	2	1	S	760	1457	122	68	I
idol	agibe	a	L	1	1	S	883	1512	162	58	I
idol	agibe	a	L	2	1	S	909	1698	148	58	I
stud	atiho	a	L	1	1	S	769	1441	154	63	I
stud	atiho	a	L	2	1	S	655	1547	138	64	I
ladle	ga'iba	a	L	1	1	S	714	1501	166	95	I
ladle	ga'iba	a	L	2	1	S	693	1537	151	80	I
side	hapuo	a	L	1	1	S	547	1273	150	48	I
side	hapuo	a	L	2	1	S	554	1278	142	51	I
feast	mahua	a	L	1	1	S	562	1302	139	83	I
feast	mahua	a	L	2	1	S	495	1291	134	72	I
butterfly	badare'e	a	L	1	1	S	580	1487	142	50	I
butterfly	badare'e	a	L	2	1	S	615	1479	138	49	I
spider	marakaki	a	L	1	1	S	493	1210	137	47	I
spider	marakaki	a	L	2	1	S	708	1383	139	63	I
tree	tapau'a	a	L	1	1	S	643	1291	146	60	I
tree	tapau'a	a	L	2	1	S	682	1389	141	69	I
clothes	tamarara	a	L	1	1	S	630	1317	153	62	I
clothes	tamarara	a	L	2	1	S	634	1348	146	65	I
bushfowl	mabo	a	L	1	1	S	744	1312	159	85	I
bushfowl	mabo	a	L	2	1	S	673	1294	142	101	I
leaf	paha	a	L	1	1	S	779	1404	162	83	I
leaf	paha	a	L	2	1	S	664	1345	146	88	I

tusk	kebari	a	L	1	2	S	691	1311	147	110	M
tusk	kebari	a	L	2	2	S	601	1141	134	100	M
butterfly	badare'e	a	L	1	2	S	613	1581	153	66	M
butterfly	badare'e	a	L	2	2	S	602	1508	142	59	M
wasp	gu'ario	a	L	1	2	S	722	1390	164	126	M
wasp	gu'ario	a	L	2	2	S	664	1322	160	91	M
spider	marakaki	a	L	1	2	S	644	1450	133	63	M
spider	marakaki	a	L	2	2	S	585	1431	140	60	M
clothes	tamarara	a	L	1	2	S	668	1239	157	83	M
clothes	tamarara	a	L	2	2	S	638	1252	144	87	M
spider	marakaki	a	L	1	3	S	713	1471	140	123	M
spider	marakaki	a	L	2	3	S	650	1433	133	120	M
joke	oriobade	a	L	1	4	S	670	1283	156	114	M
joke	oriobade	a	L	2	4	S	605	1172	132	112	M
flash	eremabe	a	L	1	3	S	711	1328	166	92	M
flash	eremabe	a	L	2	3	S	711	1366	143	99	M
respect	eremabee	a	L	1	3	S	727	1442	150	139	M
respect	eremabee	a	L	2	3	S	867	1475	132	139	M
child	meree	e	H	1	2	L	531	1916	167	279	F
child	meree	e	H	2	2	L	556	1898	147	276	F
longhouse	mere	e	H	1	2	L	540	1859	182	148	F
longhouse	mere	e	H	2	2	L	544	1910	162	156	F
child	meree	e	H	1	2	L	558	1892	156	227	F
child	meree	e	H	2	2	L	561	1925	150	257	F
respect	eremabee	e	H	1	4	L	519	1829	169	179	F
respect	eremabee	e	H	2	4	L	527	1812	139	171	F
large	geema	e	H	1	1	L	532	1811	151	141	I
large	geema	e	H	2	1	L	524	1864	143	145	I

light	hehe	e	H	1	2	S	558	1770	181	174	F
light	hehe	e	H	2	2	S	591	1746	157	155	F
moon	obe	e	H	1	2	S	544	1808	177	157	F
moon	obe	e	H	2	2	S	529	1862	147	167	F
fire	era	e	H	1	2	S	758	1434	181	193	F
fire	era	e	H	2	2	S	698	1361	149	206	F
word	made	e	H	1	2	S	490	1861	163	234	F
word	made	e	H	2	2	S	485	1906	133	222	F
piece	kere	e	H	1	2	S	569	1715	191	200	F
piece	kere	e	H	2	2	S	479	1797	158	214	F
eel	debe	e	H	1	2	S	559	1725	219	184	F
eel	debe	e	H	2	2	S	515	1773	173	157	F
lightning	berebere	e	H	1	4	S	517	1850	172	117	F
lightning	berebere	e	H	2	4	S	479	1774	158	157	F
hip	gema	e	H	1	1	S	436	1944	183	85	I
hip	gema	e	H	2	1	S	530	1786	176	79	I
hard tree	hehe	e	H	1	1	S	578	1737	202	69	I
hard tree	hehe	e	H	2	1	S	556	1744	184	76	I
woven wall	sero	e	H	1	1	S	543	1648	179	102	I
woven wall	sero	e	H	2	1	S	569	1861	155	109	I
heat	erara	e	H	1	1	S	552	1797	179	72	I
heat	erara	e	H	2	1	S	598	1771	169	62	I
ear	hepato	e	H	1	1	S	537	1727	194	31	I
ear	hepato	e	H	2	1	S	502	1713	155	54	I
vein	he'ube	e	H	1	1	S	587	1783	205	116	I
vein	he'ube	e	H	2	1	S	567	1728	173	96	I
twigs	eke'eke	e	H	1	1	S	589	1911	205	69	I
twigs	eke'eke	e	H	2	1	S	518	1867	174	54	I

twig	eke	e	H	1	1	S	563	1855	186	63	I
twig	eke	e	H	2	1	S	543	1786	158	46	I
piece	kere	e	H	1	1	S	574	1783	208	88	I
piece	kere	e	H	2	1	S	493	1817	166	76	I
flash	eremabe	e	H	1	2	S	476	1736	195	89	M
flash	eremabe	e	H	2	2	S	525	1738	173	82	M
tears	idebi	e	H	1	2	S	433	1836	187	81	M
tears	idebi	e	H	2	2	S	461	1886	169	87	M
twigs	eke'eke	e	H	1	2	S	515	1963	180	80	M
twigs	eke'eke	e	H	2	2	S	499	1856	170	65	M
flexible	mihemihe	e	H	1	2	S	419	1839	153	76	M
flexible	mihemihe	e	H	2	2	S	385	1866	137	75	M
pain	tebetebe	e	H	1	2	S	535	1582	202	67	M
pain	tebetebe	e	H	2	2	S	493	1561	165	58	M
girl	merebehe	e	H	1	2	S	557	1765	184	98	M
girl	merebehe	e	H	2	2	S	549	1694	164	104	M
boy	merehio	e	H	1	2	S	572	1725	190	150	M
boy	merehio	e	H	2	2	S	523	1782	172	167	M
baby	mere'upi	e	H	1	2	S	470	1776	187	83	M
baby	mere'upi	e	H	2	2	S	467	1815	165	110	M
baby	merekehi	e	H	1	2	S	550	1778	202	100	M
baby	merekehi	e	H	2	2	S	495	1778	158	98	M
butterfly	badare'e	e	H	1	3	S	530	1842	180	176	M
butterfly	badare'e	e	H	2	3	S	516	1790	159	143	M
baby	merekehi	e	H	1	3	S	446	1988	163	109	M
baby	merekehi	e	H	2	3	S	421	1973	136	94	M
little toe	otoikere	e	H	1	3	S	510	1929	195	99	M
little toe	otoikere	e	H	2	3	S	493	1914	162	92	M

hard tree	hehe	e	L	1	2	S	545	1817	140	197	F
hard tree	hehe	e	L	2	2	S	561	1785	141	153	F
shark / tree w white bark	obe	e	L	1	2	S	589	981	132	130	F
shark / tree w white bark	obe	e	L	2	2	S	486	1789	120	141	F
twig	eke	e	L	1	2	S	509	1813	111	164	F
twig	eke	e	L	2	2	S	434	1884	108	134	F
jealousy	gi'e	e	L	1	2	S	499	1891	129	363	F
jealousy	gi'e	e	L	2	2	S	482	1902	117	297	F
cough	ure	e	L	1	2	S	491	1780	128	228	F
cough	ure	e	L	2	2	S	450	1676	116	231	F
sago grub	ore	e	L	1	2	S	531	1653	116	186	F
sago grub	ore	e	L	2	2	S	503	1479	111	158	F
idol	agibe	e	L	1	3	S	496	1869	128	113	F
idol	agibe	e	L	2	3	S	460	1806	111	131	F
mullet	auere	e	L	1	3	S	503	1904	131	179	F
mullet	auere	e	L	2	3	S	463	1832	110	213	F
sago beetle	gogabe	e	L	1	3	S	504	1657	125	139	F
sago beetle	gogabe	e	L	2	3	S	483	1512	107	201	F
vein	he'ube	e	L	1	3	S	416	1781	118	165	F
vein	he'ube	e	L	2	3	S	391	1688	118	178	F
fly	hu'ure	e	L	1	3	S	500	1796	125	231	F
fly	hu'ure	e	L	2	3	S	503	1725	120	200	F
flash	eremabe	e	L	1	4	S	425	1879	125	129	F
flash	eremabe	e	L	2	4	S	436	1804	117	102	F
butterfly	badare'e	e	L	1	4	S	532	1931	118	222	F
butterfly	badare'e	e	L	2	4	S	507	1883	124	189	F

twigs	eke'eke	e	L	1	4	S	434	1864	112	169	F
twigs	eke'eke	e	L	2	4	S	444	1848	104	152	F
flexible	mihemihe	e	L	1	4	S	403	1868	113	131	F
flexible	mihemihe	e	L	2	4	S	386	1833	106	140	F
pain	tebetebe	e	L	1	4	S	474	1616	119	89	F
pain	tebetebe	e	L	2	4	S	436	1605	112	147	F
girl	merebehe	e	L	1	4	S	474	1792	109	133	F
girl	merebehe	e	L	2	4	S	402	1817	109	152	F
little toe	otoikere	e	L	1	4	S	497	1816	117	191	F
little toe	otoikere	e	L	2	4	S	462	1805	110	219	F
joke	oriobade	e	L	1	5	S	403	1866	106	171	F
joke	oriobade	e	L	2	5	S	272	1865	102	178	F
child	meree	e	L	1	1	S	499	1982	141	83	I
child	meree	e	L	2	1	S	564	1949	140	91	I
longhouse	mere	e	L	1	1	S	520	1947	149	93	I
longhouse	mere	e	L	2	1	S	521	1987	139	118	I
flash	eremabe	e	L	1	1	S	538	1891	187	68	I
flash	eremabe	e	L	2	1	S	516	1811	163	55	I
respect	eremabee	e	L	1	1	S	528	1711	144	39	I
respect	eremabee	e	L	2	1	S	526	1780	136	39	I
light	hehe	e	L	1	1	S	581	1907	153	79	I
light	hehe	e	L	2	1	S	490	1864	135	85	I
tree	eburu	e	L	1	1	S	592	1930	154	65	I
tree	eburu	e	L	2	1	S	548	1750	148	68	I
fire	era	e	L	1	1	S	525	1985	145	93	I
fire	era	e	L	2	1	S	475	1888	136	90	I
rat	gero'o	e	L	1	1	S	486	1790	157	69	I
rat	gero'o	e	L	2	1	S	549	1643	145	80	I

tusk	kebari	e	L	1	1	S	445	1710	149	50	I
tusk	kebari	e	L	2	1	S	462	1738	143	50	I
lightning	berebere	e	L	1	1	S	469	1921	151	87	I
lightning	berebere	e	L	2	1	S	456	1816	150	74	I
pain	tebetebe	e	L	1	1	S	470	1723	161	50	I
pain	tebetebe	e	L	2	1	S	532	1660	144	70	I
child	meree	e	L	1	1	S	468	1981	138	95	I
child	meree	e	L	2	1	S	420	1921	132	82	I
girl	merebehe	e	L	1	1	S	444	1811	146	64	I
girl	merebehe	e	L	2	1	S	487	1824	144	68	I
boy	merehio	e	L	1	1	S	464	1776	147	65	I
boy	merehio	e	L	2	1	S	473	1862	141	64	I
baby	mere'upi	e	L	1	1	S	421	1839	150	72	I
baby	mere'upi	e	L	2	1	S	469	1913	142	80	I
baby	merekehi	e	L	1	1	S	387	1808	153	49	I
baby	merekehi	e	L	2	1	S	425	1840	135	73	I
small	kehi	e	L	1	1	S	451	1918	154	156	I
small	kehi	e	L	2	1	S	482	1915	137	118	I
eel	debe	e	L	1	1	S	475	1782	167	64	I
eel	debe	e	L	2	1	S	457	1771	151	73	I
respect	eremabee	e	L	1	2	S	538	1758	151	93	M
respect	eremabee	e	L	2	2	S	522	1768	138	92	M
croton	hamera	e	L	1	2	S	500	1669	170	99	M
croton	hamera	e	L	2	2	S	491	1701	158	85	M
lightning	berebere	e	L	1	2	S	469	1725	151	57	M
lightning	berebere	e	L	2	2	S	462	1758	149	64	M
lightning	berebere	e	L	1	3	S	505	1811	149	78	M
lightning	berebere	e	L	2	3	S	492	1735	143	90	M

twigs	eke'eke	e	L	1	3	S	502	1948	161	81	M
twigs	eke'eke	e	L	2	3	S	542	1843	145	86	M
pain	tebetebe	e	L	1	3	S	505	1650	161	84	M
pain	tebetebe	e	L	2	3	S	484	1589	155	69	M
girl	merebehe	e	L	1	3	S	497	1779	147	61	M
girl	merebehe	e	L	2	3	S	455	1750	132	44	M
small	kehi	i	H	1	2	S	356	2198	180	188	F
small	kehi	i	H	2	2	S	320	2069	146	145	F
price	ta'i	i	H	1	2	S	320	2269	199	191	F
price	ta'i	i	H	2	2	S	340	2205	174	175	F
tears	idebi	i	H	1	3	S	343	2175	183	161	F
tears	idebi	i	H	2	3	S	323	2133	162	164	F
talon	kakahi	i	H	1	3	S	348	2085	173	160	F
talon	kakahi	i	H	2	3	S	333	2011	157	198	F
tusk	kebari	i	H	1	3	S	351	1969	169	167	F
tusk	kebari	i	H	2	3	S	336	2021	132	154	F
finger	kakapi	i	H	1	3	S	317	2140	158	182	F
finger	kakapi	i	H	2	3	S	280	2021	137	147	F
spider	marakaki	i	H	1	4	S	323	2157	161	177	F
spider	marakaki	i	H	2	4	S	306	2092	146	154	F
thorny vine	orotabi	i	H	1	4	S	326	2004	161	194	F
thorny vine	orotabi	i	H	2	4	S	317	1849	148	164	F
hamstring	otoiga'ibi	i	H	1	5	S	328	1955	164	205	F
hamstring	otoiga'ibi	i	H	2	5	S	299	2076	138	281	F
rain	mihae	i	H	1	1	S	310	2272	205	88	I
rain	mihae	i	H	2	1	S	331	2186	170	73	I
exchange	miha	i	H	1	1	S	340	2319	190	64	I
exchange	miha	i	H	2	1	S	336	2214	173	86	I

swamp	didio	i	H	1	1	S	327	2207	223	87	I
swamp	didio	i	H	2	1	S	338	2035	171	77	I
tears	idebi	i	H	1	1	S	325	2197	174	52	I
tears	idebi	i	H	2	1	S	335	2487	166	47	I
black	idi'idi	i	H	1	1	S	390	2227	211	77	I
black	idi'idi	i	H	2	1	S	370	2151	198	57	I
evening high tide	mihimihi	i	H	1	1	S	265	1834	146	63	I
evening high tide	mihimihi	i	H	2	1	S	289	2037	144	61	I
flexible	mihemihe	i	H	1	1	S	294	2201	149	67	I
flexible	mihemihe	i	H	2	1	S	275	2363	143	105	I
shell of crab	piku	i	H	1	1	S	427	2006	229	68	I
shell of crab	piku	i	H	2	1	S	370	1967	170	71	I
design	titi	i	H	1	1	S	335	2020	252	48	I
design	titi	i	H	2	1	S	370	2048	186	57	I
thief	piro	i	H	1	1	S	361	2002	230	71	I
thief	piro	i	H	2	1	S	376	2007	194	88	I
jealousy	gi'e	i	H	1	1	S	307	2286	237	142	I
jealousy	gi'e	i	H	2	1	S	350	2205	201	118	I
peace	miro	i	H	1	1	S	374	2108	212	102	I
peace	miro	i	H	2	1	S	342	2277	176	99	I
idol	agibe	i	H	1	2	S	366	2292	212	50	M
idol	agibe	i	H	2	2	S	339	2202	172	65	M
stud	atiho	i	H	1	2	S	334	2153	204	71	M
stud	atiho	i	H	2	2	S	340	2020	166	79	M
backbone	gimiri	i	H	1	2	S	384	1986	202	99	M
backbone	gimiri	i	H	2	2	S	349	2015	173	90	M

ladle	ga'iba	i	H	1	2	S	415	2058	204	80	M
ladle	ga'iba	i	H	2	2	S	376	1995	186	82	M
breadfruit	ibito	i	H	1	2	S	335	2126	215	81	M
breadfruit	ibito	i	H	2	2	S	352	1980	202	60	M
evening high tide	mihimihi	i	H	1	2	S	281	1976	138	76	M
evening high tide	mihimihi	i	H	2	2	S	284	1991	135	65	M
black	idi'idi	i	H	1	3	S	352	2247	133	89	M
black	idi'idi	i	H	2	3	S	315	2162	170	123	M
flexible	mihemihe	i	H	1	3	S	322	2245	162	117	M
flexible	mihemihe	i	H	2	3	S	293	2155	144	115	M
top of foot	otoipikui	i	H	1	3	S	317	1752	173	62	M
top of foot	otoipikui	i	H	2	3	S	326	1834	163	66	M
hamstring	otoga'ibi	i	H	1	4	S	361	1930	181	131	M
hamstring	otoga'ibi	i	H	2	4	S	434	1900	144	106	M
cat	pusi	i	L	1	2	S	305	2130	111	154	F
cat	pusi	i	L	2	2	S	307	2143	106	137	F
clearing	hau'i	i	L	1	2	S	226	2571	119	225	F
clearing	hau'i	i	L	2	2	S	217	2257	115	230	F
belly	topi	i	L	1	2	S	291	2113	105	187	F
belly	topi	i	L	2	2	S	295	2121	106	181	F
design	titi	i	L	1	2	S	309	2149	113	178	F
design	titi	i	L	2	2	S	297	2109	110	176	F
nose	modi	i	L	1	2	S	299	2159	114	251	F
nose	modi	i	L	2	2	S	287	2159	113	182	F
story	odi	i	L	1	2	S	297	2131	109	237	F
story	odi	i	L	2	2	S	295	2084	109	146	F

backbone	gimiri	i	L	1	3	S	306	2068	128	234	F
backbone	gimiri	i	L	2	3	S	306	2116	130	171	F
black	idi'idi	i	L	1	4	S	272	2140	116	159	F
black	idi'idi	i	L	2	4	S	276	2158	113	190	F
evening high tide	mihimihi	i	L	1	4	S	252	2070	112	98	F
evening high tide	mihimihi	i	L	2	4	S	253	2231	109	181	F
baby	mere'upi	i	L	1	4	S	271	2082	113	169	F
baby	mere'upi	i	L	2	4	S	223	2265	109	152	F
baby	merekehi	i	L	1	4	S	277	2267	105	146	F
baby	merekehi	i	L	2	4	S	288	2182	104	137	F
red	oratoti	i	L	1	4	S	295	1981	116	159	F
red	oratoti	i	L	2	4	S	291	1913	107	146	F
calf	ototopi	i	L	1	4	S	286	2095	112	266	F
calf	ototopi	i	L	2	4	S	311	2056	105	228	F
jump	iamagauri	i	L	1	4	S	346	1932	111	204	F
jump	iamagauri	i	L	2	4	S	321	1935	103	197	F
playground	oriohau'i	i	L	1	5	S	314	2153	116	218	F
playground	oriohau'i	i	L	2	5	S	237	2118	103	134	F
toes	otoikakahi	i	L	1	5	S	399	2104	145	244	F
toes	otoikakahi	i	L	2	5	S	284	2099	121	211	F
sun	himio	i	L	1	1	S	314	2137	168	77	I
sun	himio	i	L	2	1	S	316	2097	160	74	I
barrimundi	gidobu	i	L	1	1	S	316	2159	156	87	I
barrimundi	gidobu	i	L	2	1	S	306	2181	148	94	I
backbone	gimiri	i	L	1	1	S	315	2137	160	86	I
backbone	gimiri	i	L	2	1	S	297	2131	148	71	I

eye	idobai	i	L	1	1	S	300	2165	155	50	I
eye	idobai	i	L	2	1	S	307	2140	153	41	I
breadfruit	ibito	i	L	1	1	S	306	2153	157	57	I
breadfruit	ibito	i	L	2	1	S	315	2049	156	74	I
black	idi'idi	i	L	1	2	S	367	2180	200	84	M
black	idi'idi	i	L	2	2	S	363	2041	190	59	M
evening high tide	mihimihi	i	L	1	3	S	267	1982	127	95	M
evening high tide	mihimihi	i	L	2	3	S	266	2064	126	94	M
know	umoo	o	H	1	2	L	548	859	169	264	F
know	umoo	o	H	2	2	L	521	894	140	232	F
woman	obo	o	H	1	1	L	571	855	168	171	I
woman	obo	o	H	2	1	L	573	918	150	190	I
buttress	doodo	o	H	1	1	L	555	1080	156	143	I
buttress	doodo	o	H	2	1	L	557	1059	145	174	I
chest	goobo	o	H	1	1	L	534	925	181	156	I
chest	goobo	o	H	2	1	L	527	876	164	153	I
basket	gooro	o	H	1	1	L	557	946	177	240	I
basket	gooro	o	H	2	1	L	575	963	173	217	I
face	hooho	o	H	1	1	L	596	1006	197	181	I
face	hooho	o	H	2	1	L	605	974	178	162	I
river	oobo	o	H	1	1	L	576	815	169	162	I
river	oobo	o	H	2	1	L	574	923	154	164	I
adze	oobo	o	H	1	1	L	596	990	155	167	I
adze	oobo	o	H	2	1	L	542	882	144	160	I
village	go'ooto	o	H	1	2	L	606	921	202	136	M
village	go'ooto	o	H	2	2	L	575	859	172	188	M

water	obo	o	H	1	2	S	489	827	146	126	F
water	obo	o	H	2	2	S	545	906	141	103	F
woman	obo	o	H	1	2	S	522	858	167	171	F
woman	obo	o	H	2	2	S	551	897	149	150	F
path	gabo	o	H	1	2	S	527	857	169	122	F
path	gabo	o	H	2	2	S	525	895	136	131	F
step	gabo	o	H	1	2	S	523	796	158	132	F
step	gabo	o	H	2	2	S	554	855	143	130	F
inside	goro	o	H	1	2	S	554	1079	180	128	F
inside	goro	o	H	2	2	S	568	1055	150	124	F
sago flower stalk	hoho	o	H	1	2	S	577	971	162	147	F
sago flower stalk	hoho	o	H	2	2	S	546	910	138	146	F
hunting	komo	o	H	1	2	S	537	855	183	124	F
hunting	komo	o	H	2	2	S	487	826	159	141	F
river	oobo	o	H	1	2	S	524	850	169	159	F
river	oobo	o	H	2	2	S	522	878	149	152	F
thorn	oro	o	H	1	2	S	648	1034	170	150	F
thorn	oro	o	H	2	2	S	590	1060	152	148	F
foot	oto	o	H	1	2	S	588	1061	161	177	F
foot	oto	o	H	2	2	S	581	1102	138	154	F
tree	ooto	o	H	1	2	S	608	1009	164	174	F
tree	ooto	o	H	2	2	S	569	1055	139	173	F
to cry	ooto	o	H	1	2	S	592	996	161	172	F
to cry	ooto	o	H	2	2	S	573	1038	141	180	F
sago pounder	ooto	o	H	1	2	S	599	985	167	157	F
sago pounder	ooto	o	H	2	2	S	570	1026	146	171	F

sleep	uro	o	H	1	2	S	512	939	157	161	F
sleep	uro	o	H	2	2	S	449	1676	132	189	F
pot	uro	o	H	1	2	S	536	958	160	168	F
pot	uro	o	H	2	2	S	518	1003	137	188	F
bushfowl	mabo	o	H	1	2	S	502	860	217	161	F
bushfowl	mabo	o	H	2	2	S	528	860	169	151	F
peace	miro	o	H	1	2	S	614	1177	203	235	F
peace	miro	o	H	2	2	S	582	1144	164	218	F
platform	toto	o	H	1	2	S	644	1129	195	127	F
platform	toto	o	H	2	2	S	599	1156	167	149	F
group	to'o	o	H	1	2	S	636	1134	226	91	F
group	to'o	o	H	2	2	S	635	1045	173	176	F
hungry	dubobo	o	H	1	3	S	550	838	164	140	F
hungry	dubobo	o	H	2	3	S	532	985	142	165	F
ear	hepato	o	H	1	3	S	536	984	176	177	F
ear	hepato	o	H	2	3	S	558	1071	142	151	F
bird	momo'o	o	H	1	3	S	508	875	143	199	F
bird	momo'o	o	H	2	3	S	558	842	152	166	F
well	bobo	o	H	1	1	S	510	885	177	70	I
well	bobo	o	H	2	1	S	513	885	177	77	I
ripe	bo'u	o	H	1	1	S	470	898	207	85	I
ripe	bo'u	o	H	2	1	S	441	867	187	99	I
without/forget	dodo	o	H	1	1	S	541	1240	177	81	I
without/forget	dodo	o	H	2	1	S	551	1219	174	97	I
deep part of river	gobo	o	H	1	1	S	519	939	194	103	I
deep part of river	gobo	o	H	2	1	S	518	921	175	94	I

bandicoot	goro	o	H	1	1	S	558	1113	198	103	I
bandicoot	goro	o	H	2	1	S	513	983	164	90	I
fishing camp	komo	o	H	1	1	S	576	866	208	57	I
fishing camp	komo	o	H	2	1	S	535	947	185	60	I
shark / tree w white bark	obe	o	H	1	1	S	607	976	205	89	I
shark / tree w white bark	obe	o	H	2	1	S	493	1765	191	99	I
urine	oro	o	H	1	1	S	617	880	176	66	I
urine	oro	o	H	2	1	S	602	1000	159	66	I
thorn	oro	o	H	1	1	S	628	990	170	72	I
thorn	oro	o	H	2	1	S	600	1073	155	65	I
foot	oto	o	H	1	1	S	644	1078	169	78	I
foot	oto	o	H	2	1	S	585	1143	143	71	I
river bank	dodoro	o	H	1	1	S	558	1296	192	79	I
river bank	dodoro	o	H	2	1	S	500	1307	163	83	I
soft	hobobo	o	H	1	1	S	595	1010	205	90	I
soft	hobobo	o	H	2	1	S	606	1029	174	81	I
mountain	no'oa	o	H	1	1	S	587	1137	187	77	I
mountain	no'oa	o	H	2	1	S	635	1182	171	72	I
thorny vine	orotabi	o	H	1	1	S	615	1157	170	81	I
thorny vine	orotabi	o	H	2	1	S	591	1086	152	66	I
plenty of short ones	komukomu	o	H	1	1	S	517	930	142	76	I
plenty of short ones	komukomu	o	H	2	1	S	519	939	145	63	I
boy	ohio	o	H	1	1	S	591	966	203	48	I
boy	ohio	o	H	2	1	S	584	983	191	56	I

sandal	ototama	o	H	1	1	S	625	1137	161	68	I
sandal	ototama	o	H	2	1	S	603	1106	150	54	I
hamstring	otoga'ibi	o	H	1	1	S	620	1199	180	58	I
hamstring	otoga'ibi	o	H	2	1	S	510	1177	143	48	I
shin	otoihoro	o	H	1	1	S	630	1203	170	37	I
shin	otoihoro	o	H	2	1	S	434	1074	141	57	I
bone	horo	o	H	1	1	S	637	1088	219	70	I
bone	horo	o	H	2	1	S	563	1027	182	64	I
toes	otoikakahi	o	H	1	1	S	623	1096	163	63	I
toes	otoikakahi	o	H	2	1	S	579	1194	149	38	I
little toe	otoikere	o	H	1	1	S	575	1185	183	59	I
little toe	otoikere	o	H	2	1	S	608	1154	163	65	I
narrow part above ankle	otoimarui	o	H	1	1	S	589	1192	175	51	I
narrow part above ankle	otoimarui	o	H	2	1	S	564	1203	166	65	I
heel	otoimokoi	o	H	1	1	S	676	1082	168	57	I
heel	otoimokoi	o	H	2	1	S	625	1005	164	75	I
heel	moko	o	H	1	1	S	567	908	212	73	I
heel	moko	o	H	2	1	S	519	840	173	73	I
top of foot	otoipikui	o	H	1	1	S	546	1205	170	72	I
top of foot	otoipikui	o	H	2	1	S	518	1179	145	48	I
calf	ototopi	o	H	1	1	S	572	1229	171	55	I
calf	ototopi	o	H	2	1	S	519	1173	148	42	I
belly	topi	o	H	1	1	S	583	1245	223	78	I
belly	topi	o	H	2	1	S	532	1230	180	57	I
tree	kopue	o	H	1	1	S	524	960	219	129	I
tree	kopue	o	H	2	1	S	507	941	212	138	I

nose	modi	o	H	1	1	S	580	1246	208	113	I
nose	modi	o	H	2	1	S	500	1296	164	93	I
house	moto	o	H	1	1	S	568	1188	223	86	I
house	moto	o	H	2	1	S	565	1165	181	78	I
sweet	topo	o	H	1	1	S	581	1136	230	52	I
sweet	topo	o	H	2	1	S	566	1254	178	68	I
sago grub	ore	o	H	1	1	S	576	922	233	99	I
sago grub	ore	o	H	2	1	S	592	1024	160	73	I
story	odi	o	H	1	1	S	630	1037	240	95	I
story	odi	o	H	2	1	S	614	1133	170	93	I
platform	toto	o	H	1	1	S	611	1275	197	56	I
platform	toto	o	H	2	1	S	579	1237	168	64	I
hungry	dubobo	o	H	1	2	S	471	862	170	73	M
hungry	dubobo	o	H	2	2	S	484	861	143	74	M
coconut	go'ota	o	H	1	2	S	627	1044	216	89	M
coconut	go'ota	o	H	2	2	S	580	1027	173	84	M
barrimundi	gidobu	o	H	1	2	S	572	1239	197	78	M
barrimundi	gidobu	o	H	2	2	S	513	1302	166	82	M
rat	gero'o	o	H	1	2	S	586	1145	198	89	M
rat	gero'o	o	H	2	2	S	603	1147	167	90	M
eye	idobai	o	H	1	2	S	514	1374	197	87	M
eye	idobai	o	H	2	2	S	522	1311	177	71	M
wind	korobo	o	H	1	2	S	563	1031	186	77	M
wind	korobo	o	H	2	2	S	586	988	164	75	M
thorny vine	orotabi	o	H	1	2	S	587	1221	169	76	M
thorny vine	orotabi	o	H	2	2	S	578	1262	154	60	M
white	bogobogo	o	H	1	2	S	479	963	199	68	M
white	bogobogo	o	H	2	2	S	497	939	181	64	M

overgrown	gorogoro	o	H	1	2	S	523	1134	165	91	M
overgrown	gorogoro	o	H	2	2	S	515	1100	158	71	M
sandal	ototama	o	H	1	2	S	483	1161	172	61	M
sandal	ototama	o	H	2	2	S	432	1128	156	59	M
hamstring	otoga'ibi	o	H	1	2	S	560	1193	191	86	M
hamstring	otoga'ibi	o	H	2	2	S	512	1512	148	105	M
calf	ototopi	o	H	1	2	S	502	1197	183	47	M
calf	ototopi	o	H	2	2	S	467	1167	164	66	M
overgrown	gorogoro	o	H	1	3	S	487	965	155	82	M
overgrown	gorogoro	o	H	2	3	S	495	993	143	68	M
heel	otoimokoi	o	H	1	3	S	603	952	195	87	M
heel	otoimokoi	o	H	2	3	S	564	953	165	85	M
calf	ototopi	o	H	1	3	S	555	1139	186	78	M
calf	ototopi	o	H	2	3	S	546	1137	164	85	M
tree	ooto	o	L	1	1	L	593	897	148	174	I
tree	ooto	o	L	2	1	L	522	918	133	170	I
to cry	ooto	o	L	1	1	L	553	925	137	189	I
to cry	ooto	o	L	2	1	L	600	902	128	171	I
sago pounder	ooto	o	L	1	1	L	587	906	145	164	I
sago pounder	ooto	o	L	2	1	L	565	943	138	155	I
well	bobo	o	L	1	2	S	461	852	126	120	F
well	bobo	o	L	2	2	S	426	813	117	106	F
without/forget	dodo	o	L	1	2	S	553	1108	127	83	F
without/forget	dodo	o	L	2	2	S	541	1172	123	119	F
buttress	doodo	o	L	1	2	S	566	1054	123	146	F
buttress	doodo	o	L	2	2	S	563	1059	124	135	F
chest	goobo	o	L	1	2	S	471	838	123	128	F
chest	goobo	o	L	2	2	S	456	813	119	108	F

deep part of river	gobo	o	L	1	2	S	504	719	124	135	F
deep part of river	gobo	o	L	2	2	S	475	843	125	107	F
basket	gooro	o	L	1	2	S	582	979	117	170	F
basket	gooro	o	L	2	2	S	556	962	125	137	F
bandicoot	goro	o	L	1	2	S	588	1117	147	112	F
bandicoot	goro	o	L	2	2	S	565	1161	124	87	F
face	hooho	o	L	1	2	S	569	877	126	217	F
face	hooho	o	L	2	2	S	557	902	125	207	F
fishing camp	komo	o	L	1	2	S	468	708	122	123	F
fishing camp	komo	o	L	2	2	S	471	733	121	121	F
adze	oobo	o	L	1	2	S	492	744	128	128	F
adze	oobo	o	L	2	2	S	447	755	117	146	F
urine	oro	o	L	1	2	S	570	1031	131	125	F
urine	oro	o	L	2	2	S	540	1053	126	103	F
catfish	uho	o	L	1	2	S	527	909	176	177	F
catfish	uho	o	L	2	2	S	500	876	131	158	F
go into	umo	o	L	1	2	S	291	817	117	128	F
go into	umo	o	L	2	2	S	377	840	119	85	F
woven wall	sero	o	L	1	2	S	557	1009	119	100	F
woven wall	sero	o	L	2	2	S	528	1387	120	92	F
bone	horo	o	L	1	2	S	567	1034	117	201	F
bone	horo	o	L	2	2	S	542	1023	116	164	F
heel	moko	o	L	1	2	S	490	887	117	143	F
heel	moko	o	L	2	2	S	451	880	110	147	F
hair	muho	o	L	1	2	S	541	944	115	201	F
hair	muho	o	L	2	2	S	436	844	111	205	F

thief	piro	o	L	1	2	S	550	1022	115	184	F
thief	piro	o	L	2	2	S	517	1337	111	183	F
tail	mapo	o	L	1	2	S	443	756	112	215	F
tail	mapo	o	L	2	2	S	421	783	110	176	F
house	moto	o	L	1	2	S	570	1075	114	206	F
house	moto	o	L	2	2	S	526	2437	108	204	F
sweet	topo	o	L	1	2	S	502	809	128	132	F
sweet	topo	o	L	2	2	S	532	877	111	182	F
stud	atiho	o	L	1	3	S	524	941	137	150	F
stud	atiho	o	L	2	3	S	468	975	116	157	F
tree	diobo	o	L	1	3	S	426	823	118	151	F
tree	diobo	o	L	2	3	S	396	795	109	142	F
river bank	dodoro	o	L	1	3	S	584	1148	116	123	F
river bank	dodoro	o	L	2	3	S	499	963	111	121	F
village	go'ooto	o	L	1	3	S	538	1012	118	130	F
village	go'ooto	o	L	2	3	S	507	1041	110	133	F
rat	gero'o	o	L	1	3	S	586	930	131	201	F
rat	gero'o	o	L	2	3	S	580	931	122	168	F
soft	hobobo	o	L	1	3	S	512	850	134	153	F
soft	hobobo	o	L	2	3	S	488	790	124	173	F
wind	korobo	o	L	1	3	S	502	801	121	171	F
wind	korobo	o	L	2	3	S	466	837	114	145	F
breadfruit	ibito	o	L	1	3	S	523	1020	124	201	F
breadfruit	ibito	o	L	2	3	S	528	1167	121	209	F
white	bogobogo	o	L	1	4	S	490	940	126	133	F
white	bogobogo	o	L	2	4	S	453	934	125	109	F
overgrown	gorogoro	o	L	1	4	S	527	1027	117	148	F
overgrown	gorogoro	o	L	2	4	S	535	1053	120	86	F

shin	otoihoro	o	L	1	4	S	561	1108	115	204	F
shin	otoihoro	o	L	2	4	S	537	1022	106	187	F
water	obo	o	L	1	1	S	514	867	128	64	I
water	obo	o	L	2	1	S	508	929	130	67	I
inside	goro	o	L	1	1	S	521	1073	152	91	I
inside	goro	o	L	2	1	S	530	1039	139	75	I
sago flower stalk	hoho	o	L	1	1	S	516	939	135	81	I
sago flower stalk	hoho	o	L	2	1	S	522	902	127	70	I
hunting	komo	o	L	1	1	S	539	894	148	56	I
hunting	komo	o	L	2	1	S	516	849	146	61	I
moon	obe	o	L	1	1	S	563	870	146	77	I
moon	obe	o	L	2	1	S	441	776	136	93	I
coconut	go'ota	o	L	1	1	S	546	856	183	82	I
coconut	go'ota	o	L	2	1	S	512	951	155	73	I
village	go'ooto	o	L	1	1	S	555	987	185	116	I
village	go'ooto	o	L	2	1	S	586	922	153	85	I
sago beetle	gogabe	o	L	1	1	S	409	931	146	61	I
sago beetle	gogabe	o	L	2	1	S	419	875	130	104	I
wind	korobo	o	L	1	1	S	555	1015	159	61	I
wind	korobo	o	L	2	1	S	552	973	142	56	I
white	bogobogo	o	L	1	1	S	462	906	153	54	I
white	bogobogo	o	L	2	1	S	435	868	148	66	I
overgrown	gorogoro	o	L	1	1	S	463	1052	152	66	I
overgrown	gorogoro	o	L	2	1	S	507	1022	144	83	I
bird	momo'o	o	L	1	1	S	448	821	134	88	I
bird	momo'o	o	L	2	1	S	402	802	131	98	I

blood	ora	o	L	1	1	S	540	1039	138	79	I
blood	ora	o	L	2	1	S	460	925	135	85	I
red	oratoti	o	L	1	1	S	600	1222	146	57	I
red	oratoti	o	L	2	1	S	540	1061	141	68	I
game	orio	o	L	1	1	S	551	969	157	110	I
game	orio	o	L	2	1	S	567	1028	144	140	I
playground	oriohau'i	o	L	1	1	S	539	1119	154	80	I
playground	oriohau'i	o	L	2	1	S	483	1017	135	119	I
joke	oriobade	o	L	1	1	S	502	1112	163	98	I
joke	oriobade	o	L	2	1	S	473	1065	141	104	I
knee	popu	o	L	1	1	S	510	866	169	55	I
knee	popu	o	L	2	1	S	530	903	148	66	I
group	to'o	o	L	1	1	S	618	1051	200	134	I
group	to'o	o	L	2	1	S	626	1074	153	76	I
river bank	dodoro	o	L	1	2	S	543	1247	155	71	M
river bank	dodoro	o	L	2	2	S	524	1182	136	78	M
soft	hobobo	o	L	1	2	S	465	755	172	75	M
soft	hobobo	o	L	2	2	S	452	791	160	83	M
bird	momo'o	o	L	1	2	S	446	748	127	101	M
bird	momo'o	o	L	2	2	S	474	803	132	100	M
white	bogobogo	o	L	1	3	S	487	810	177	72	M
white	bogobogo	o	L	2	3	S	445	810	164	70	M
plenty of short ones	komukomu	o	L	1	3	S	472	842	112	82	M
plenty of short ones	komukomu	o	L	2	3	S	480	869	118	101	M
red	oratoti	o	L	1	3	S	476	1200	177	56	M
red	oratoti	o	L	2	3	S	492	1261	148	77	M

shin	otoihoro	o	L	1	3	S	574	1199	173	65	M
shin	otoihoro	o	L	2	3	S	542	1162	143	76	M
tree by river	ubuu	u	H	1	2	L	336	728	186	230	F
tree by river	ubuu	u	H	2	2	L	335	678	166	235	F
long	tutuu	u	H	1	2	L	382	850	210	317	F
long	tutuu	u	H	2	2	L	337	848	170	290	F
dog	ubu	u	H	1	2	S	359	750	189	140	F
dog	ubu	u	H	2	2	S	342	714	162	124	F
ripe	bo'u	u	H	1	2	S	392	835	197	122	F
ripe	bo'u	u	H	2	2	S	354	692	172	92	F
handle	tutu	u	H	1	2	S	399	860	211	164	F
handle	tutu	u	H	2	2	S	354	964	157	182	F
shell of crab	piku	u	H	1	2	S	422	866	216	190	F
shell of crab	piku	u	H	2	2	S	401	803	147	203	F
knee	popu	u	H	1	2	S	408	605	219	149	F
knee	popu	u	H	2	2	S	341	674	163	145	F
tree	eburu	u	H	1	3	S	361	877	179	167	F
tree	eburu	u	H	2	3	S	361	874	145	115	F
tree by river	ubuu	u	H	1	1	S	360	728	175	65	I
tree by river	ubuu	u	H	2	1	S	381	635	161	66	I
catfish	uho	u	H	1	1	S	363	548	192	128	I
catfish	uho	u	H	2	1	S	317	637	152	156	I
go into	umo	u	H	1	1	S	358	647	192	194	I
go into	umo	u	H	2	1	S	360	689	197	179	I
handle	tutu	u	H	1	1	S	397	1281	213	54	I
handle	tutu	u	H	2	1	S	352	1212	166	72	I
cat	pusi	u	H	1	1	S	368	911	179	73	I
cat	pusi	u	H	2	1	S	400	911	152	81	I

fly	hu'ure	u	H	1	1	S	375	780	181	87	I
fly	hu'ure	u	H	2	1	S	357	839	162	103	I
all	turiaha	u	H	1	1	S	402	1169	206	64	I
all	turiaha	u	H	2	1	S	379	1269	170	70	I
raised lump	ubu	u	H	1	1	S	452	641	232	89	I
raised lump	ubu	u	H	2	1	S	365	736	181	88	I
hair	muho	u	H	1	1	S	369	576	218	137	I
hair	muho	u	H	2	1	S	401	733	185	85	I
nipa palm	utu	u	H	1	1	S	412	804	239	86	I
nipa palm	utu	u	H	2	1	S	395	825	209	89	I
cough	ure	u	H	1	1	S	419	681	248	83	I
cough	ure	u	H	2	1	S	364	694	173	90	I
tree	nu'a	u	H	1	1	S	433	967	244	113	I
tree	nu'a	u	H	2	1	S	426	1046	184	110	I
vein	he'ube	u	H	1	2	S	387	982	185	89	M
vein	he'ube	u	H	2	2	S	416	926	168	84	M
fly	hu'ure	u	H	1	2	S	377	771	184	175	M
fly	hu'ure	u	H	2	2	S	368	873	178	125	M
one	ga'ubuo	u	H	1	2	S	642	1301	191	67	M
one	ga'ubuo	u	H	2	2	S	499	984	167	87	M
plenty of short ones	komukomu	u	H	1	2	S	406	796	133	73	M
plenty of short ones	komukomu	u	H	2	2	S	407	806	139	79	M
baby	mere'upi	u	H	1	3	S	430	1357	177	70	M
baby	mere'upi	u	H	2	3	S	356	1250	156	71	M
body hair	tawaibuhoi	u	H	1	3	S	419	846	217	79	M
body hair	tawaibuhoi	u	H	2	3	S	369	925	159	84	M

raised lump	ubu	u	L	1	2	S	347	696	107	222	F
raised lump	ubu	u	L	2	2	S	352	598	115	182	F
neck	maru	u	L	1	2	S	445	1007	138	126	F
neck	maru	u	L	2	2	S	318	932	113	146	F
nipa palm	utu	u	L	1	2	S	356	830	117	266	F
nipa palm	utu	u	L	2	2	S	355	856	117	219	F
barrimundi	gidobu	u	L	1	3	S	407	686	115	159	F
barrimundi	gidobu	u	L	2	3	S	389	765	123	146	F
chief	paidubu	u	L	1	3	S	375	753	110	159	F
chief	paidubu	u	L	2	3	S	192	935	104	175	F
plenty of short ones	komukomu	u	L	1	4	S	374	678	107	84	F
plenty of short ones	komukomu	u	L	2	4	S	327	739	105	121	F
hungry	dubobo	u	L	1	1	S	337	947	152	83	I
hungry	dubobo	u	L	2	1	S	338	1004	136	87	I
dog	ubu	u	L	1	1	S	301	695	138	81	I
dog	ubu	u	L	2	1	S	339	715	142	90	I
know	umoo	u	L	1	1	S	362	692	157	138	I
know	umoo	u	L	2	1	S	334	726	150	133	I
sleep	uro	u	L	1	1	S	354	595	136	85	I
sleep	uro	u	L	2	1	S	374	711	125	103	I
pot	uro	u	L	1	1	S	321	664	138	171	I
pot	uro	u	L	2	1	S	278	682	128	136	I
long	tutuu	u	L	1	1	S	335	1422	136	46	I
long	tutuu	u	L	2	1	S	340	1277	151	40	I
not long	tutubia	u	L	1	1	S	305	1617	167	33	I
not long	tutubia	u	L	2	1	S	369	1421	154	53	I

wasp	gu'ario	u	L	1	1	S	341	822	163	118	I
wasp	gu'ario	u	L	2	1	S	350	877	161	107	I
lizard	tu'a	u	L	1	1	S	379	984	175	65	I
lizard	tu'a	u	L	2	1	S	382	1035	160	83	I
not long	tutubia	u	L	1	2	S	369	1125	190	107	M
not long	tutubia	u	L	2	2	S	370	1093	155	93	M
tree	eburu	u	L	1	2	S	356	933	157	75	M
tree	eburu	u	L	2	2	S	352	849	137	88	M
chief	paidubu	u	L	1	2	S	355	1343	155	66	M
chief	paidubu	u	L	2	2	S	371	1162	131	96	M

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