VOWEL DURATION AND CONSONANT LENGTHENING IN DJAMBARRPUYNGU

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ABSTRACT

This paper presents an analysis of acoustic duration of vowels in Djambarrpuyŋu, a Yolŋu Matha language spoken in Arnhem Land, in northern Australia. Djambarrpuyŋu has been described as having phonologically long and short vowels, and there have also been suggestions that consonants following short vowels undergo compensatory lengthening. The aims of this study are to investigate the phonetic nature of phonologically long and short vowels in Djambarrpuyŋu, and assess whether there is any evidence of consonantal lengthening.

Results show that there are significant duration differences between the phonologically long and short vowels, and furthermore that consonants following short vowels have significantly greater duration than those after long vowels.

Keywords: Yolngu Matha, Australian, vowels, duration, consonant lengthening

1. INTRODUCTION

Interest in the phonetic systems of Australian languages has focused in recent times on their rich consonant inventories, with a small number of studies of vowel inventories, e.g. [6, 7, 14]. This study will primarily investigate the proposed quantity contrast in the vowel system of Djambarrpuyŋu. A further aim is to see whether consonants after phonologically short vowels are lengthened, suggesting that a compensatory lengthening phenomenon is at play in Djambarr-puyŋu as suggested for other YM varieties [15].

1.1 Phonemic vowel length, consonant duration and compensatory lengthening

Many languages of the world have phoneme inventories containing vowels of similar quality that contrast in terms of length. Many languages also exhibit restrictions regarding where length contrasts can occur within the word.

In the Italian variety of Friulian, phonologically long vowels are restricted to occurring in stressed word-final syllables [1]. Stressed vowels in other positions are phonologically short. Similarly, in Swedish and Norwegian, the vowel length contrast is limited to stressed syllables [5, 10]. Quantity contrast in vowels is also correlated with vowel quality and diphthongization in Swedish [5]. While vowel quality is not examined in this study, a lowering of phonologically long high vowels /i:/ and /u:/ to [e] and [o] is proposed for Djinang, another Yolŋu Matha variety [15].

In various languages with a quantity contrast in the vowel system, there is a relationship between the vowel and the following consonant. For example, in Swedish there is a complementarity between vowels and the following consonant whereby a consonant following a phonologically long vowel is shorter in duration than a consonant after a phonologically short vowel [8].

Change in vowel length is just one of a number of reasons why compensatory lengthening can occur, but is recognised as a strategy to preserve preferred syllable durations regardless of segmental content (see e.g. [9]).

For some Australian languages it is hypothesised that consonant lengthening occurs as part of the way word level prominence is signalled [3].

1.2 Vowel quantity and consonants in Djambarrpuyŋu

Contrastive vowel quantity has been reported for a number of Yolŋu Matha (YM) varieties but has not yet been investigated phonetically.

Djambarrpuyŋu is a YM language variety of Arnhem Land, northern Australia. The Yolŋu Matha language group is an isolate within the Pama-Nyungan language family. Djambarrpuyŋu is spoken traditionally by people on the northeast coast of Arnhem Land, including at Galiwin'ku, Milingimbi, Ramingining and Yirrkala along with other YM varieties. There are approximately three thousand Djambarrpuyŋu speakers [12]. Djambarrpuyŋu is a relatively strong language. It is passed onto children and is also reported as becoming a regional lingua franca for speakers of other YM varieties [16].

Like many Australian languages, Djambarrpuyŋu has a large consonant inventory, making use of six places of articulation, as well as a glottal stop, resulting in 25 consonants (see Table 1). The two series of stops is an areal phenomenon found in YM languages and also neighbouring non-Pama-Nyungan languages [16]. A length difference is also

reported to exist between the stop series in a related YM variety [11], but this has not yet been examined phonetically for Djambarrpuyŋu.

Table 1: Consonant phoneme inventory: Djambarrpuyŋu

	Peripheral		Apical		Laminal		Glottal
	bilab.	velar	alv.	post alv	dental	palatal	
Lenis	p	k	t	ʈ	t̪	c	
Fortis	p:	k:	t:	ʈ:	t̪:	c:	
Glottal							ʔ
Nasals	m	ŋ	n	ɳ	n̪	ɲ	
Laterals			l	ɭ			
Rhotics			r	ɻ			
Approx	w					j	

Table 2: Vowel phoneme inventory: Djambarrpuyŋu

	front		back	
high	i	i:	u	u:
low		a	a:	

There are six vowels; three qualities and a length distinction (see Table 2) [16]. There is a phonotactic tendency for long vowels to occur in a stressed syllable, which is putatively the first syllable of a word [16].

It is hypothesised that proposed phonologically long and short vowels in Djambarrpuyŋu will show durational differences in initial syllables. Furthermore, it is hypothesised that consonants in the post-tonic position will be lengthened after short vowels. We also expect that a sequence of a long vowel and consonant is similar in duration to a sequence of a short vowel and consonant.

2. METHODS AND MATERIALS

The experimental materials were drawn from a corpus comprised of real $C_1V_1C_2V_2$ words in citation form, recorded in May, 2010, in Galiwin'ku, Arnhem Land by the second author. The word lists were spoken by nine adult speakers of Djambarrpuyŋu, aged 28 years to 60 years. There are three women speakers (DB, TA and VY) and six men speakers (JM, MK, PY, RY, SN and TY). Speakers repeated each word three times. All speakers were reimbursed for their time.

Recordings were made using an Edirol R-09HR hand-held recorder and a Røde Procaster large diaphragm dynamic microphone approximately 20cm from the mouth off-axis. All speech samples were recorded in mono at a 24bit bit-depth and a 48kHz sample rate.

A subset of these corpus materials were selected for the present study. Where possible, minimal pairs or near minimal pairs were selected for comparison. The segments of interest were vowels in the initial syllables of words (V_1) given that the phonemic vowel length distinction occurs only in this position [16]. We also measured the duration of consonants following these vowels and therefore occurring in a word-medial position (C_2).

Segments were identified and labelled in Praat [2] using waveform and wideband spectrograms. Vowel length as it is marked in the orthography was followed when labelling segments. Consonants in the word-medial position were labelled to encode whether they occurred following a short or long vowel. A database was created in the EMU Speech Database System [4] from the labelled Praat files, and data were then queried in R [13] using the EMU package.

A statistical analysis was undertaken in R using the packages *lme4* and *multcomp*. A general linear mixed effects model was run for vowel length in the first syllable, and for word-medial consonant length. Speaker, word and repetition were included as random factors and the main effects of length of vowels and length of consonants were tested. The vowel and consonant categories respectively are both two levelled factors (short and long; after short and after long).

Table 3 shows the total number of vowel tokens in this study. There is an imbalance in the number of long and short vowels and different vowel qualities due to overall lexical frequency. However, the imbalance was taken into account in the choice of words.

Table 3: Total number of tokens V_1

	i	a	u	i:	a:	u:	Total
n (all speakers)	27	98	61	49	102	53	390

3. RESULTS

Table 4 summarises mean duration values (ms), standard deviations, and number of tokens for each segment category analysed in this study.

Table 4: Duration of vowels in first syllable and following consonant

	mean duration, ms (SD)	number of tokens
short vowel	126 (50)	186
long vowel	211 (61)	204
consonant post-short V.	236 (94)	204
consonant post-long V.	191 (66)	186

3.1 Duration of vowels in the first syllable

Figure 1 shows difference in duration for all phonologically long vowels compared to all phonologically short vowels, plotted for all speakers. In Figure 2, separate boxplots are shown for each vowel. The plots indicate that phonologically long and short vowels differ in duration values, across vowel qualities, though differences by vowel quality can also be observed.

Figure 1: Boxplots of durations of Djambarrpuyŋu short vowels and long vowels

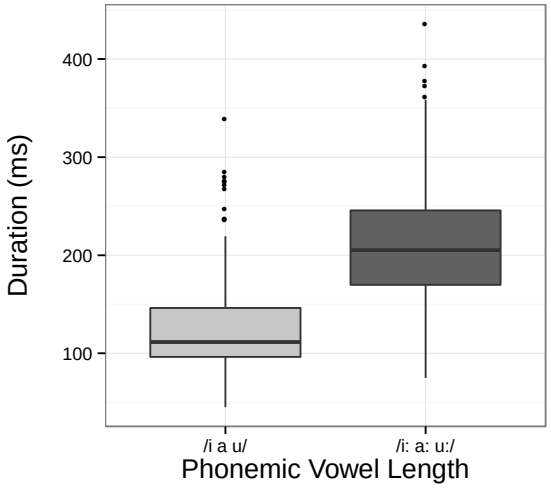
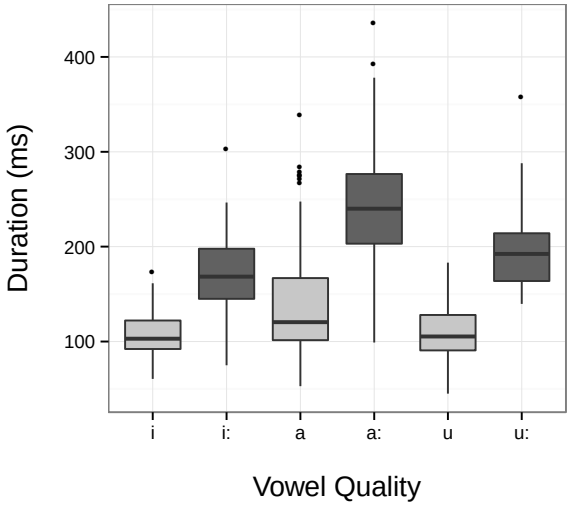


Figure 2: Boxplots of durations of the six Djambarrpuyŋu vowels



The linear mixed effects regression is highly significant $\chi^2(6, N=390)=16.7$, $p<.001$) for a main effect of vowel duration with vowel length (short or long) as a fixed factor and speaker, word and word repetition included as random factors. The difference in duration of each pair of vowels in the first syllable is statistically significant. Based on the results of a linear mixed effects model, the phonologically long vowels have a mean duration that is 102ms ± 21ms longer than phonologically short vowels ($p<.001$), and the ratio of short to long vowels is 1:1.8.

3.2 Duration of consonants after vowels in disyllabic words

Figure 3: Boxplots of durations of Djambarrpuyŋu consonants

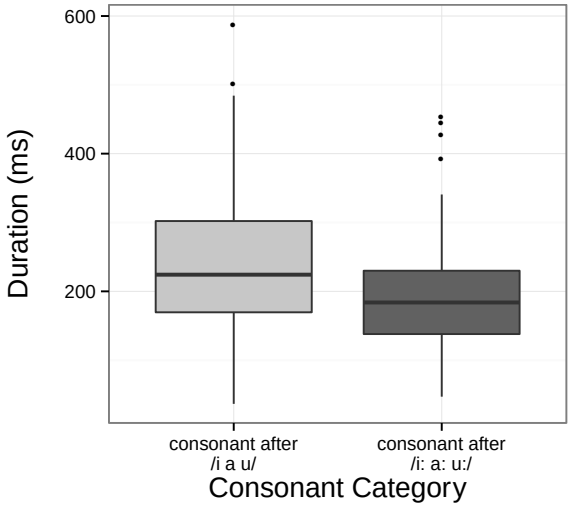


Figure 3 presents boxplots of duration values for consonants post-long vowels and consonants post-short vowels. The linear mixed effects regression is significant ($\chi^2(5, N=390)=36.1$, $p<.001$) for a main effect of consonant duration with consonant context (after long vowel, after short vowel) as a fixed factor and speaker and word repetition as random factors. In this model when word was added as a random factor the likelihood ratio test was not significant, indicating that place of articulation of consonant may be a significant factor.

Consonants which occurred after short vowels have a mean duration that is 45ms ± 7ms longer than consonants which occur after long vowels ($p<.001$) when run in a linear mixed effects model. The ratio of consonants after long vowels to consonants after short vowels is 1:1.2.

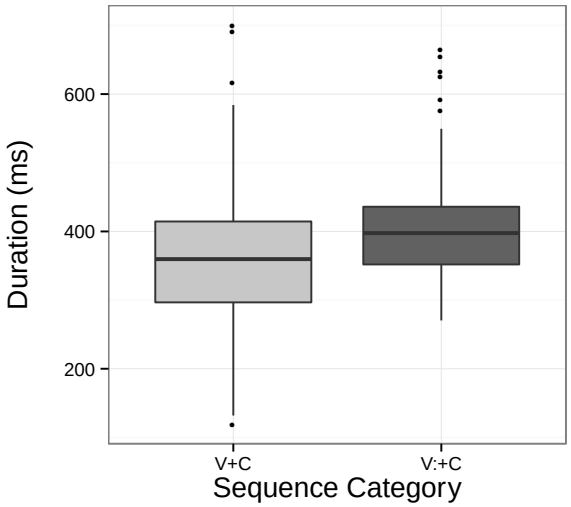
3.3 Duration of vowel and consonant sequences

For vowel and consonant sequences the linear mixed effects regression cannot be used – for a main effect of vowel duration with vowel length (short or long) as a fixed factor and speaker, word and word repetition as random factors – as the likelihood ratio failed $\chi^2(6, N=390)=1.92$, $p<.17$). The duration of a short vowel and a following consonant (V+C) was, on average, 363ms (SD=103), and a long vowel and a following consonant (V:+C) was on average 402ms (SD=72). The average duration of a word in

the corpus was 695ms (SD=152). The duration of a sequence of a short vowel and a consonant is on average 52% of the total duration of the word, and a sequence of a long vowel and a consonant is 58% of the total duration of the word.

The combined duration of vowels and consonants in the word-medial position (i.e. $C_1\mathbf{V_1C_2}V_2$) are presented in the boxplots in Figure 4.

Figure 4: Boxplots of durations of short vowel and consonant sequences and long vowel and consonant sequences



4. DISCUSSION AND CONCLUSIONS

This study provides phonetic evidence for the proposed phonological length contrast in the vowel system of Djambarrpuyŋu, with results indicating that phonologically long vowels have significantly higher duration values than phonologically short vowels. In addition, it is shown that consonants which follow phonologically short vowels have higher duration values than consonants which follow phonologically long vowels.

This study also gives acoustic phonetic support for orthographic conventions of marking vowel length in Djambarrpuyŋu and supports an analysis of consonant lengthening post-short vowels as reported in previous phonological research. Conversely, it may be found with further investigation and a more tightly controlled corpus that vowels are shortened before fortis consonants.

The results suggest the possibility of compensatory lengthening of consonants post-short vowels in Djambarrpuyŋu. This is supported by the duration of the two vowel consonant sequences being not significantly different from each other.

It appears that Djambarrpuyŋu's vowel length contrast patterns closely to that of Swedish (e.g. [5]) in a number of ways. Firstly, phonologically long vowels are restricted as to their placement within the word. Consonants in post-vocalic position may be conditioned by the phonological quantity of the preceding vowel and are lengthened following phonologically short vowels, similarly to Swedish. Also, it appears that in Djambarrpuyŋu, there is a complementarity between the vowel in the first syllable of a word and the duration of the following consonant.

Additionally, while the difference in consonant duration after short and long vowels was shown to be statistically significant in Djambarrpuyŋu, it is likely that there will be variation depending on the consonant type. The significance of the consonant duration contrast may also be strengthened if consonant identity (e.g. sonorant, obstruent; place of articulation) as well as vowel identity are taken into account. These effects will be investigated in continuing work.

Further, these results suggest that phonetic analysis of segmental duration in Djambarrpuyŋu may be fruitful in describing other prosodic features such as stress. While stress is not under investigation in this study, it appears that Djambarrpuyŋu vowel length may interact with stress as it does in Swedish and Friulian [1, 5] as vowels are also restricted in where they are permitted to occur within a word. Consonants will also be studied further with regards to possible interaction with word prominence.

This study provides deeper understanding of the phonetics of the vowel quantity contrast in Djambarrpuyŋu and can be used as a basis for further phonetic research in segmental quantity in other Yolŋu Matha varieties.

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