LEXICAL TONE IN LOPIT

Rosey Billington

University of Melbourne
rbil@unimelb.edu.au

ABSTRACT

This paper presents the results of an acoustic investigation of lexical tone in the Dorik dialect of Lopit, an Eastern Nilotic language. Tonal phenomena in Nilotic languages are complex, and in many cases vastly underdescribed. In the limited descriptive work on Lopit, there is not yet a clear picture of the number of tones used for lexical contrasts, and the various grammatical functions of tone are only beginning to emerge. Acoustic results indicate that there are three distinct lexical tones: a High level tone, a Low level tone, and a Falling contour tone.

Keywords: tone, f0, contour, Nilotic, Lopit

1. INTRODUCTION

1.1. Background

Lopit is an Eastern Nilotic (Nilo-Saharan) language spoken in the Lopit Mountains of South Sudan, and by diaspora groups elsewhere in Africa and overseas. It is a minority language, and has received only limited descriptive attention. Existing phonological observations include proposals that Lopit has an inventory of tones used for lexical and grammatical contrasts, but the number and nature of these has not been investigated in detail. The current study is part of a wider documentation project underway with a small community of Lopit speakers in Melbourne, and presents selected results from a large acoustic experiment investigating tonal phenomena in Lopit.

1.2. Lopit segmental phonology

Lopit has voiced and voiceless stops at four places of articulation, with corresponding nasals, plus a glottal stop. There are three (or four) fricatives, and as well as a tap and trill there are lateral, palatal and labio-velar approximants, which may all be geminated (as for alveolars). The nine monophthongs include a 'tongue root' contrast and no length contrast. Preferred syllable structure is C(C)V(C). Codas tend to be sonorants, but word-final /ʔ/ is common, followed by /k/ and /t/. Words generally have at least two or three syllables, and may have up to six.

1.3. Lexical tone in Lopit

In early work, four contrastive tones were observed for Lopit: High, Low, Mid, and High-Falling [10]. Later work noted High, Low and Falling [9], and more recently High, Low, Falling, and a rare Rising tone [8]. In the present research, impressions are of three lexical tones: High and Low level tones, and a Falling contour. True minimal pairs are rare, but do occur; typically, members differ in word class, but often, segmental differences provide additional cues, as in the favourite Lopit example /xìtó/ 'child.SG', /xìtô/ 'scorpion.SG', and /xìtːò/ 'bottom.SG'. Level tones distinguished by relative pitch are common in Africa [11], but many language families have contour tones, including Nilotic [7]. In Lopit, the Falling tone has a restricted distribution, but occurs in all word positions, and [9] suggests it may be longer, which has been observed for contours elsewhere [4]. The syllable is proposed as the tone-bearing unit by [8], and in the current work.

1.4. Grammatical tone in Lopit

Both [9] and [8] suggest that in Lopit, tone has a lower lexical than grammatical functional load, and ongoing description [5] indicates that tone is important in the nominal and particularly verbal morphology (e.g., for marking case and aspect). Given the greater importance of tone grammatically than lexically, but the as yet limited understanding of grammatical tone, it may seem premature to embark on a phonetic investigation of tone in Lopit. However, given that the proposed High, Low and Falling tones all appear to be relevant morphologically as well as lexically, a better understanding of these contrasts will be useful. In addition, if there are fewer possibilities for lexical ambiguity on the basis of tone alone, it is of interest to see *how* distinct they are.

2. RESEARCH AIMS

While there are many questions relating to tonal phenomena in Lopit, only results addressing the following will be presented here: Are the proposed High (H), Low (L) and Falling (F) lexical tones distinct, and if so, how do they differ phonetically?

3. METHODS

3.1. Materials

Tonal classifications for selected words were first extensively checked with a Lopit speaker using Toney [1] to sort and group spoken forms. Experimental materials were then compiled including monosyllables (not discussed) and 100 disyllabic nouns with all possible tonal combinations. The present paper discusses results for the three proposed tones adjacent to L - **H**L, **F**L, **L**L, and L**H**, L**F**, L**L**, e.g. for initial syllables /márwák/ 'animalhorn.PL', /mârwàk/ 'oldperson.PL', and /màrɪŋ/ 'fence.SG'. The materials attempt to minimise various phonetic effects to the extent possible given available lexical data; onsets were primarily sonorants, nuclei were mainly non-close vowels, but word-final possibilties included open syllables, sonorant codas, and some obstruent codas. A balance of these was aimed for but there were more word-final glottal stops for LH words. Two frames were selected to elicit forms in accusative case (tonally matching citation) and nominative case (tonally marked) as well as citation forms, but only citation data are reported here. The final dataset used an average of 24 tokens per tone, speaker, and word position, for a total of 435 tokens.

3.2. Participants

Participants were three male speakers of Lopit aged 53, 36 and 29, all from the Dorik dialect area of the Lopit Mountains. They are part of a small Lopit community in Melbourne, and arrived in Australia between 2000-2009. Members of the community are all multilingual, as is the norm for many Lopit people both in South Sudan and in the diaspora, but Lopit is the main language used in daily life.

3.3. Elicitation and recording procedures

The author produced spoken English prompts to elicit the corresponding Lopit target utterances, and, as a reference point if required, the English prompts were simultaneously presented in slideshow format on a notebook computer, with the corresponding Lopit utterance written in the working orthography currently used for the wider project (which does not indicate tone). Each target utterance was elicited at least three times, and each had a separate slide (numbered 1, 2, or 3). Participants waited for the slides to advance before producing the second and third repetitions, and were asked to repeat an utterance if needed due to e.g. coughing. Data were recorded at 16-bit/44.1kHz in a quiet room, using a Zoom H4N audio recorder, MixPre-D pre-amp, and AudioTechnica AT892c headset microphone.

3.4. Data processing and analysis

Data were segmented and labelled in Praat [2], then imported to the Emu Speech Database System [3] to extract acoustic data. Selected results for duration (in ms), fundamental frequency (f0, using ESPS method, in Hz) and amplitude (RMS, root mean square, in dB) are presented for the sonorant portion of the syllable rhyme (assuming the syllable as tone-bearing unit, but some onset/coda variation). Data were queried and plotted in R [6] with the `emu` package, and tested with Linear Mixed Effects Models using the `lme4` package and post-hoc tests (fixed effect: tone, random effect: speaker). Comparisons for f0 and RMS were made at various points; results at 25%, 50% and 75% are reported here.

4. RESULTS

4.1. Duration

Boxplots showing duration values for the tones in initial and final syllables are presented in Fig. 1, with statistical results summarised in Table 1. The effect of speaker was not significant for duration data (or for f0 and RMS data). In initial syllables (a), duration values for F are significantly higher than for both H and L, which do not significantly differ from one another. However, in final syllables (b), F and L do not significantly differ from one another in duration, but H has significantly lower values than both. The more common obstruent codas may have a role here but it is interesting that there is minimal variation and CV tokens also have low duration values.

Figure 1: Duration values (ms) for H, F, and L tones in disyllabic Lopit words (averaged across three speakers, for sonorant portion of syllable rhyme), before L in (a), following L in (b).

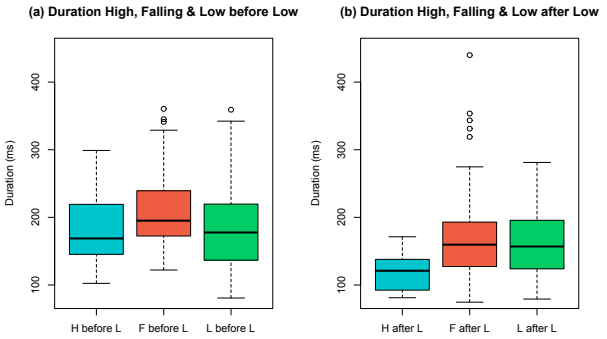
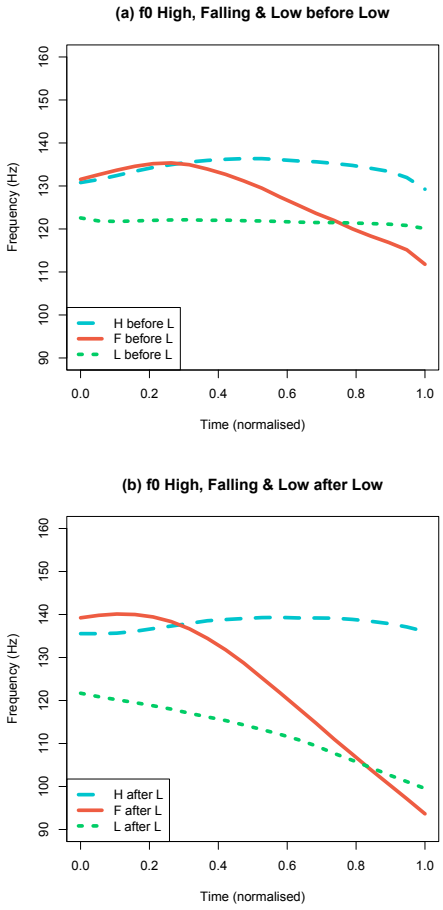


Table 1: Results of statistical comparisons between tone categories for duration values (***=p<0.001, **=p<0.01, *=p<0.05, - = NS).

Duration comparison	Syll 1	Syll 2
High – Falling	***	***
Falling – Low	***	–
Low – High	–	***

4.2. f0 traces and selected measures

Figure 2: Time-normalised f0 (Hz) for H, F and L tones in disyllabic Lopit words (averaged across three speakers, for sonorant portion of syllable rhyme), before L in (a), following L in (b).



As can be seen in Fig. 2, there are clear differences between the f0 traces for the three tone categories. In initial syllables (a), the H and F tones begin with similarly high f0 values, while the L tone begins with lower average f0 values. Both H and L are quite level, though H does rise slightly from the onset, whereas the F tone diverges from H early in the rhyme, and f0 then falls below that of the L tone. In final syllables (b), the patterns are broadly similar but differences in the realisations of tone categories can be observed. The F tone in this context begins with f0 values slightly higher than for the H tone, but still begins to fall similarly early in the rhyme. In this context, f0 traces for both F and L fall quite low, which is not unsurprising utterance-finally, but f0 values for H remain relatively level.

Results for f0 at 25%, 50% and 75% are summarised in Table 2. At 25% into the rhyme in initial syllables, f0 values for L are significantly lower than for both H and F, but H and F do not significantly differ from one another. At 50%, f0 values for L remain significantly lower than for H and F, but the difference between H and F as f0 falls for F is not yet significant. At 75%, differences between L and F are no longer significant, as the f0 trace for F has only just begun to fall below that of L, but values for H are significantly higher than for both F and L. In final syllables, results are the same for all comparisons but one; at 25% into the rhyme, values for F are significantly higher than for both L *and* H.

Table 2: Results of statistical comparisons between tone categories for f0 values at selected measurement points (***=p<0.001, **=p<0.01, *=p<0.05, - = NS).

f0 comparison	at	Syll 1	Syll 2
High – Falling	25%	–	–
	50%	–	***
	75%	***	***
Falling – Low	25%	***	***
	50%	***	***
	75%	–	–
Low – High	25%	***	***
	50%	***	***
	75%	***	***

4.3. RMS amplitude traces and selected measures

Amplitude traces are presented in Fig. 3, and results at selected points are summarised in Table 3. At 25% in initial syllables, the L has significantly lower dB values than both the H and the F, but differences between the H and F do not reach significance. At 50%, values for the L tone are again significantly lower than for the H and F, but differences between the H and F do not reach significance. At 75% the L tone remains significantly lower than the H and the F, but there are no significant differences between the H and F. In final syllables, the results are the same for all comparisons except that the difference beween H and F at 25% does reach significance.

Figure 3: Time-normalised RMS (dB) for H, F and L tones in disyllabic Lopit words (averaged across three speakers, for sonorant portion of syllable rhyme), before L in (a), following L in (b).

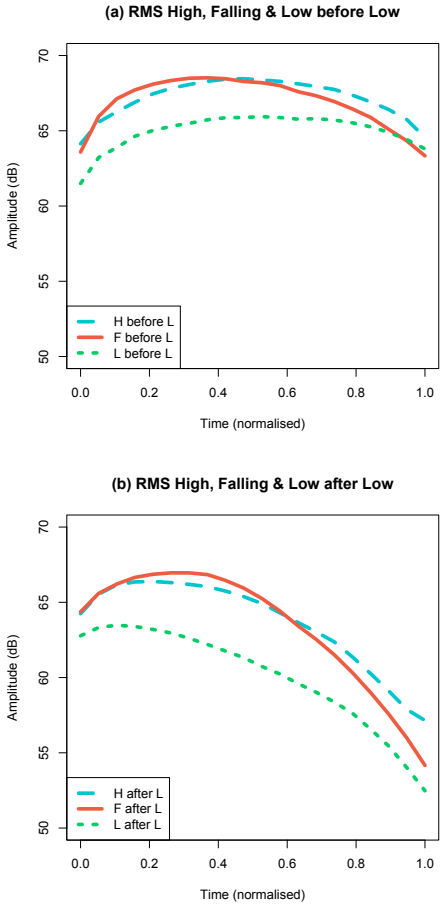


Table 3: Results of statistical comparisons between tone categories for RMS amplitude values at selected measurement points (***=p<0.001, **=p<0.01, *=p<0.05, - = NS).

RMS comparison	at	Syll 1	Syll 2
High – Falling	25%	–	*
	50%	–	–
	75%	–	–
Falling – Low	25%	***	***
	50%	***	***
	75%	***	***
Low – High	25%	***	***
	50%	***	***
	75%	***	***

5. DISCUSSION AND CONCLUSIONS

This paper has tested the validity of a phonological analysis of three lexical tones in Lopit by exploring whether the putative High, Falling and Low tones are phonetically distinct in disyllabic nouns. Results indicate that they are. H and L are differentiated by H having higher f0 and RMS amplitude values across the rhyme of initial and final syllables, and lower duration values in final syllables. The F clearly falls from high to low targets; it is differentiated from L by higher f0 values early in the rhyme and higher RMS across the rhyme, plus higher duration values in initial syllables, and from H by lower f0 values later in the rhyme, and higher duration values in final syllables. The duration differences are interesting given speculation that F tones may be longer [9]; in this data, duration does seem to be a good separator of H and F, with F being longer in initial and final syllables. While segmental influences on duration (as well as f0 and RMS) are still being investigated in more detail, it is worth noting that word-finally, H and F are particularly confusable at least to non-native ears; duration may provide perceptual support to f0 changes for the contour.

Though this paper only discusses H, F and L adjacent to L tones, and not the effects of different neighbouring tones, some work on this is underway, and indications are that earlier proposals of a Mid tone [10] may be related to contextual variants of H and L. However, dialectal differences in Lopit tone inventories are also possible, given previous work has focused on the southern and central dialects [10] [9] [8], and the Dorik area is in the north. While a lexical Rising tone has not been observed in Dorik Lopit, as it has been (rarely) by [8], a Rising tone is used to mark nominative case on many nouns, and is being investigated with the additional frame data collected in this study. Many questions remain regarding the realisation and use of tone in Lopit, but as the first phonetic investigation of tone in the language, this study provides a timely contribution to the linguistic description and informs ongoing work on Lopit and other Eastern Nilotic languages.

6. ACKNOWLEDGEMENTS

Sincere thanks to members of the Lopit community, particularly AL, DA and VH, for contributing their time and knowledge to this project, and to Janet Fletcher and Jonathan Moodie for discussions and comments. Support from the ARC Centre of Excellence for the Dynamics of Language, ARC grant DP0984419, and the University of Melbourne is gratefully acknowledged.

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