Interaction of pitch and vowel length in two Dene tone languages: Tłı̨chǫ Yatıì (drg) and Dene Sųłine (chp)

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ABSTRACT

This study concerns the interaction of pitch, morphology and vowel length in Tłı̨chǫ Yatıì (Dogrib) and Dene Sųłine (Chipewyan), Dene (Athabaskan) tone languages of the Mackenzie River Drainage. Starting from an earlier study we extend it to investigate the realization of tone on long vowels in Tłı̨chǫ Yatıì. Our results indicate that slope is a feature of vowel length contrast.

Keywords: tone, vowel length, tonal alignment, intonation.

1. INTRODUCTION

Of the Dene tone languages, which are primarily bitonal (H vs. L), Sapir [20] famously stated that pitch is morphologically complex and phonologically simple. This disparity is interesting because morphological category affects segmental phonology, especially with respect to the phonotactics of stems versus prefixes, or non-stems as we will call them. Stems are monosyllabic, word final and prominent in Dene. The rich segmental contrasts of the Dene inventory are asymmetrically realized in stems versus non-stems, where some contrasts may be neutralized. This is also true of tonal contrasts, resulting in a characterization of tone markedness, or default tone.

This study investigates the interaction of pitch, morphology and vowel length contrast in two Dene (Athabaskan) tone languages with polar tone systems, Tłı̨chǫ Yatıì (Dogrib, NWT) and Dene Sųłine (Chipewyan, Alberta). The Dene (The People) are traditionally hunter-gatherers who have lived in small communities in the boreal forest over a vast and inaccessible area of northern North America. Recent research by Vadja [24] has evidenced connections between the Dene and the Yenesian people in Siberia. From the time of Sapir [19] the Dene languages have been known for their unique and complex verbal morphology, their resistance to outside borrowings, and their general and significant structural stability across the languages in the family. McDonough & Wood [13] demonstrated the consistency in the details of several phonetic patterns across the tone languages in the Mackenzie River drainage group, including the two languages under study.

The verbal morphology in the Dene languages is complex and unique. Stems carry lexical content and are inflected for aspect and valence. The verbs, with the stems in final position, may be specified for a very rich system of inflectional and derivational marking. As such, a word resides in a dense neighbourhood of related forms, distinguished from each other along several parameters by a small class of subphonemic features, such as voicing, or tone. The verbs and noun stems are closed class and monosyllabic. The minimal verbal word is two syllables, the word final stem, preceded by an aspect morpheme inflected for person and number (Figure (1)). The morphological structure results in Dene words exhibiting strong internal phonotactic asymmetries. McDonough [14] illustrated this along with the phonetic prominence of stems in Navajo, a phenomenon also observed in phonetic studies of other languages in the family by Alderete [1], Hargus [4], Bird [2] and Tuttle [22] and others. An illustration of a minimal verb is found in (1), adapted from Saxon & Martel's [21] work on Tłı̨chǫ Yatıì.

(1) wheda 'he is sitting'
whe – da
3s.IPV – 'sit'.IPV
pre-stem – stem

This is the minimal or core verb. More morphemes may be prefixed to the penult syllable. Inflectional variants for aspect, person and number may be realized by tone, vowel length and other features.

With respect to tone, Krauss [11], Leer [12] and Kingston [10] laid out a tonogenesis hypothesis, which argues that H and L tone arose from the loss of glottalic resonants in the stem's codas, and the incorporation of a residual glottalic gesture into the nucleus of the stem developing into tonal contrasts. Finally the Dene tone languages exhibit the phenomenon of polar tone or 'tone reversal' in stem tone systems; Tłı̨chǫ Yatıì and Dene Sųłine have polar or reverse tones. This hypothesis addresses the genesis of tonal contrasts in stems only. In the pre-stem domain, tone is less lexical; there is a phenomenon of default or 'marked' tone, either H or L by language. This markness is also related to polar tone. For these studies, Tłı̨chǫ Yatıì and Dene Sųłine were chosen because they have polar tonal specification, being sotermed 'low-' and 'high-marked' languages respectively by Krauss [11] and Leer [12].

Another difference between the languages is vowel length contrasts. Though many Dene languages are argued to exhibit vowel length contrasts, this contrast is not straightforward because of morphological considerations. TY and DS differ in reports on the role of vowel length contrasts. Both languages have orthographic long vowels but only TY considers these phonemic.

The questions that we are asking in this study concern the realization of tonal contrasts in these systems and their interactions in the morphology. Are all the tonal systems alike, as the tonogenesis hypothesis predicts. How do the languages differ from each other? How does pitch interact with the stem contrasts? With respect to polar tone and default tone, do the polar tone systems realize H vs. L tones distinctly? The goal of this study is to understand the role of tonal alignment in realizing vowel contrasts in TY.

2. TONE SHAPE

An earlier study tested the Discrete Cosine Transform (DCT) as a way to compare tone patterns [22]. That study looked only at two-syllable words in Tłîchô Yatiì (TY) and Dene Sųłine (DS). This section of the current study expands that previous work to a larger selection of words in those two languages.

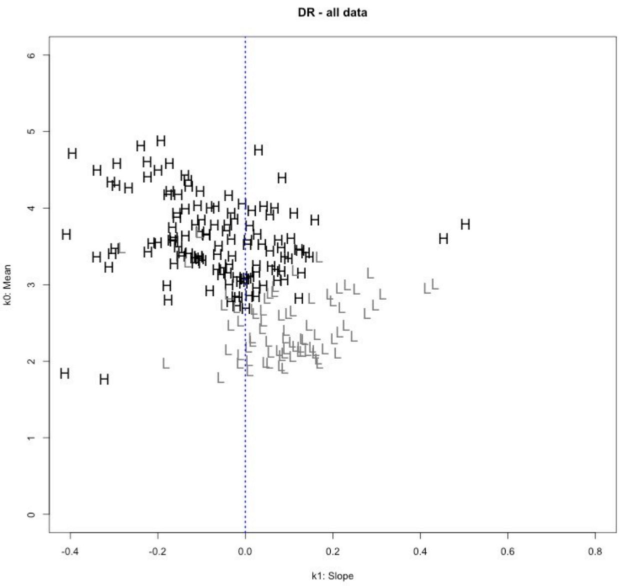
2.1. Discrete Cosine Transform

The DCT decomposes a spline down into a set of component coefficients (k_0-k_n), very much like an FFT. Watson and Harrington [25] showed that k_0 is proportional to mean f_0; k_1 to slope and k_2 to (parabolic) curve. Furthermore, the coefficients are all real numbers resulting in real-number correlates to spline shape. These numbers can then be graphed or used for statistical analysis.

2.2. Procedure

This study is based on word list recordings from speakers of TY (NT) and DS (Alberta). Word lists were prepared and recordings were made of speakers repeating those words. Existing recordings were used. Because of speaker participation in the development of the wordlists, some word lists used differed from one speaker to the next. Words ranged in length from 1 to 4 syllables. For TY there were 2 female speakers and a total of 128 words giving 261 tokens (205 of the tokens were short vowels and were used for the first analysis). For DS there were also 2 female speakers and a total of 228 words giving 597 tokens. Because in TY there were many more short than long vowels, and because in DS, vowel length is not reported to be contrastive, we used only short vowels.

Figure 1: Interactions of k_0 (mean) and k_1 (slope) for high and low tones in Tłįchǫ Yatiì



The recordings were segmented in PRAAT [3], marking out the vowels. Thirty equally spaced F_0 measurements were taken from each vowel, the values were converted to Barks and the DCT coefficients for each contour were calculated using the emu package [6] in R [16].

2.3. Results

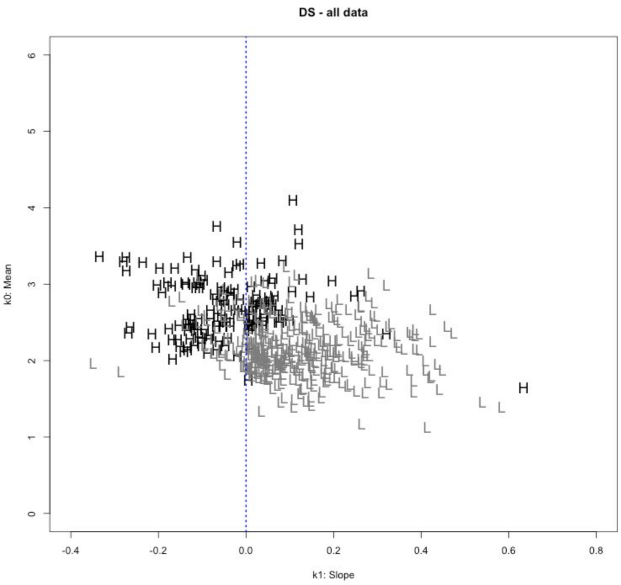
Figures 1 and 2 show the interactions of k_0 (pitch) and k_1 (slope) for TY and DS respectively. A plot along the central, vertical line ($k_1 = 0$) indicates a flat contour, plots to the right (positive k_1 values) correspond to a negative slope or a falling contour with the slope increasing as the k_1 value increases. Negative k_1 values correspond to a rising slope and increasing pitch contour. The mean pitch corresponds directly with k_0 so a higher k_0 equals a higher pitch. In both graphs high tones are represented by a black H and low tones by a grey L.

The calculations for each language were fitted separately to a linear model with k_0 (pitch) as the dependent variable and tone as the independent variable (high tone as the intercept). Results were significant for both DS ($F(1, 561)$, $t = -16.68$) and TY ($F(1, 204)$, $t = -14.93$). A similar model was fitted for k_1 (slope) and the results were also significant for both DS ($F(1, 561,)$ $t=16.27$) and TY ($F(1, 204)$, $t=8.17$)

2.4. Discussion

These results replicate the earlier findings of [22] which suggest that both slope and pitch play a role in tone production in these languages. Note the asymmetry in the number of H vs. L tones in each language, reflecting the default status of a tone. Also

Figure 2: Interactions of k_0 (mean) and k_1 (slope) for high and low tones in Dene Sųłine



note that slope was not found to be a significant contributor for TY in the earlier study of 2-syllable words but it is significant here.

Examination of the graphs shows clear clustering with DS showing somewhat more overlap and clustering near 0 slope, i.e. flatter tones. Furthermore DS tends to show a falling contour with low tones (default or 'marked' tone) and a flat contour with H tones. This accorded with the visual inspection of the data made by the authors. H tones in stems especially tended to be flat. In contrast, in TY, speakers in general appeared to use more contours in the realization of tonal contrasts. We now turn our attention to long vowels and their interaction with tone in TY.

3. LONG VOWELS AND TONE IN TLĮCHǪ YATIÌ

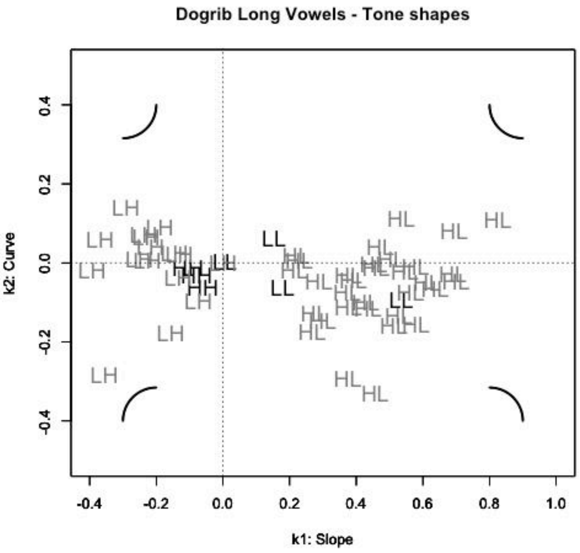
3.1. Duration

Phonemic vowel length contrasts exist in some of the Dene languages, but it is not always recognized, arguably due to the different phonotactics in the stems versus pre-stem morphemes. This study also demonstrated that the vowels of the stems were longer for both long and short vowels in stems than in the pre-stem domain. While not all Dene languages have reported vowel length, when it does occur, as Saxon & Martel [21] demonstrated in Dogrib, the contrast is not straightforward – in part due to the complexity of the morphology, as noted. A preliminary analysis by Saxon & Martel [21] found that the contrast between phonemically long and short vowels in stems versus the pre-stem (called the *prefix domain* in Saxon & Martel) were very different. In the morphemes in the pre-stem position, long vowels were significantly longer than short vowels, but this was not the case in the stems. We tested this on our data before analysis. A t-test was carried out including all syllables comparing the durations of long and short vowels. The test found that short and long vowels differed significantly in duration ($t = 9.3009$, $df = 79.091$, $p = 2.491 \times 10^{-14}$). An ANOVA was then carried out to determine if the length difference interacted with the position within the word. There was no significant interaction. Finally, a t-test was carried out only on the vowels that appear in stem syllables and found a significant difference in length ($t = 7.3049$, $df = 63.839$, $p = 5.485 \times 10^{-10}$). Even allowing for the Bonferroni correction the results were still highly significant. In the data examined here, the two speakers made a phonetic distinction in duration that matched the phonological distinction. These results conflict with Saxon & Martel. We attribute these findings to the differences in the data analysed: S&M used read texts, our data are taken from word lists, that is words spoken in isolation. This difference is likely due to the differences in register between the two data. However, if there is a neutralization of vowel length in stems in the read text, then the positions of the stems, word and sentence final, is of interest, because final position is often a lengthening position. These facts present an opportunity to study the interaction of tone and intonation in this neutralization pattern. To begin this, we analysed the role of H and L tone, their opposing default status and their interaction with vowel length and morphology.

3.2. Tone Shape on Long Vowels

The 56 long vowels in the TY word list recordings were segmented and annotated in PRAAT and four distinct contours were identified among the long vowels (3 HH; 32 HL; 17 LH; 4 LL). Note that flat tones were uncommon among the long vowels. One question that arises is the interaction of the pitch contour with vowel length contrast. Long vowels for this analysis included both (orthographically) geminate vowels and two-vowel sequences, which may be related to derived concatenations. As in the previous analysis, thirty equally spaced F_0 measurements were taken from each vowel, the values were converted to Barks and the DCT coefficients for each contour were calculated. Figure 3 is a graph of k_1 (slope) on the y-axis and k_2 (curve) on the x-axis. Note that this is a graph of the shape of the contour, unlike the graphs in the previous section. The correlate for pitch (k_0) is not included in Figure 3. In this plotting, tokens falling at the intersection of the two dashed lines are flat and horizontal. The further right they go, the more they slope downward and the further left they go the more they slope upward. The vertical axis correlates to the degree of rounding; the

Figure 3: Interactions of k_1 (slope) and k_2 (curve) for high and low tones in Tłı̨chǫ Yatıì



higher the tokens are the greater the curve upward and the lower they are the greater the curve downward.

The arcs in the four quadrants are reader references to the shape of the splines in those quadrants. Long vowels with contour tones (HL and LH) are shown in grey and those with unchanging or flat tones (HH and LL) are shown in black. The graph suggests that slope is the primary differentiator of the contour tones over long vowels, as expected. A t-test shows that HL tones have slopes that are significantly different from LH tones on long vowels in Dogrib. ($t = 16.6764$, $df = 38.151$, p-value $< 2.2 \times 10^{-16}$). A further t-test looking at the absolute values of the slopes of tones in Dogrib finds that the slopes also differ significantly between the long and short vowels ($t = 8.5758$, $df = 63.091$, p-value $= 3.488 \times 10^{-12}$). Regardless of their slope (rising or falling), the long vowels have steeper slopes than the short vowels. There is no significant difference in absolute curve values (after the Bonferroni correction). But the long vowels have steeper slopes than the short vowels. This suggests that the shape of the tone curve is not as important as the overall slope (whether it rises or falls).

3.3. Turning Point of Long Vowels with pitch contours

If slope is a strong marker of sequential tones in TY, this raises a question concerning the role of tonal alignment. Work by House [8, 9] has shown that, rather than aligning directly with the start of the vowel, in order for pitch contours to be perceived as changing the start of the slope occurs 30-50 msec into the vowel, after the period of new spectral information has diminished. This predicts that turning points in TY long vowels should occur after approximately 50 msec into the vowel. This is what we found.

The turning points for a sample of the long vowels with changing tone were determined by hand for the two Dogrib speakers. There were a total of 35 tokens (23 HL; 12 LH). Turning point was taken to be either the peak or trough of a parabolic curve (if such existed) or the point at which a flat pitch contour started to either ascend or descend. These were determined by visual examination of the pitch contour in PRAAT. The mean time of the turning point was 85.58 msec (s.d. = 73.29 msec) into the vowel. The mean duration of the syllables was 319.34 msec (s.d. = 74.86 msec) and the mean turning point as a percentage of the total duration was 25.03% (s.d. = 18.25%). There is considerable variation but 22 of the 35 tokens had turning points after 50 msec into the vowel (25 had turning points after 30 msec).

2.3. Discussion

Remeijsen [17] and Roettger at al. [18] have demonstrated that the alignment of the pitch can play a role in the realization of phonemic contrast. Given the House constraint, we might expect that short vowels with pitch contours might exhibit steeper slopes than long vowels, since long vowels have more time to reach their target. We do not find this. The steepness occurs on H tone vowels in TY, a H-tone marked language.

This preliminary examination of tone on long vowels in Tłîchô Yatiì suggests that slope is an overt marker of tone for long vowels and vowel/vowel sequences in this language. This follows House's model of optimal tone perception [8, 9], the initiation of the fall tends to occur after the 30-50 msec period of new spectral information. Our next study examines the relationship between contour and vowel length in DS and between the stems and non-stem morphemes. We are particularly interested in the role of tonal alignment across the boundary between the penult (non-stem) and final (stem) syllable.

4. CONCLUSIONS

Descriptions of the tonal systems and prosody in the Athabaskan languages, especially in the Hargus et al. volume [6], indicate that their prosodic structures may vary considerably between the languages, despite the similarities of their morphological and phonemic inventory. While this is not surprising, it offers a chance to understand the role of tonal alignment in morphologically complex systems.

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