The Effect of Post-tonic Lengthening and F0 in Syrian Arabic Prosody

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Abstract
The role of final boundary is well-known in the intonation literature, but whether post-tonic lengthening influences intonation and prosodic structure in languages is not very well-known. In this paper, we investigate the role of F0 and post-tonic lengthening in Syrian Arabic and show how they play an important role in Syrian Arabic (henceforth SyrA) sentence-level prosody. The results have implications for understanding prosodic contrasts in SyrA intonation and the role of F0 and duration in languages that have not been studied before.

Index Terms: Syrian Arabic prosody, F0, duration, post-tonic lengthening, intonation.

1. Introduction
In stress-accent languages, such as Arabic, duration and fundamental frequency (F0) serve as the primary cues to signal lexical and phrasal distinctions. Cross-linguistically, duration and F0 have been considered crucial parameters to cue prominence in the sentence and word-level prosody along with other factors.

Within the (AM) theory of intonation, the temporal alignment of F0 peaks and valleys with respect to syllables has been claimed to distinguish pitch accent categories. In several studies related to sentence-level prosody, F0 has been the most studied parameter [1], [2], [3], and [4] among many others, which, by many researchers, has been considered to be the most significant factor in modeling intonation. F0 was also found to play an important role in marking pitch accents in SyrA [5]. In fact, F0 may not be the only important factor that marks prominence in intonation. Rather, segmental duration may be an important cue marking prominence at the phrasal level.

Duration adjustment near constituent boundaries, i.e., phrase final lengthening, has been widely examined. Klatt [6] states that durations cues have the potential to carry considerable linguistic information in connected speech. Final Lengthening refers to an increase in segmental duration at the right edge of different types of prosodic domains above the word level.

There is some literature on prosodically conditioned post-tonic lengthening across languages, but the additional factor in SyrA is the pragmatic factor. Edwards et al [7], examined the effect of final lengthening at prosodic boundaries by studying articulator movement patterns. They found that decreasing intragustural stiffness slows down the syllable, affecting the tempo of the spoken word and causing the syllable to be lengthened. [8] investigates the effect of prosodic boundaries on the duration of post-tonic syllables in Brazilian Portuguese. Their results show that the only prosodic boundary that has significant lengthening is theintonational phrase, and that its application relates to both post-tonics and tonics. In a study performed by Esposito [9] on phrase-final post-tonic lengthening in American English. He studied the effect of gender variation in the production of phrase-final lengthening. He found that gay men and straight women lengthen their phrase-final post-tonic syllables equally and that both groups do so more than straight men.

In this paper, we examine and validate the widely accepted hypothesis of final lengthening which states that segments are lengthened directly before a prosodic boundary compared to the ones not followed by a boundary and that F0 alignment differences cue relative prominence differences at the phrase level in Syrian Arabic.

To our knowledge, there is no work regarding the role of post-tonic lengthening and F0 associated with prosodic levels in SyrA or any other variety of Arabic and the present study could be useful in comprehending how prosodic boundaries influence on final syllable lengthening in SyrA. Quantitative analysis of this kind contributes to the description of Arabic prosody in general and SyrA in particular and enriches the typological studies within the Auto-segmental-Metrical (AM) framework by shedding some light on a prosodically less-studied variety of Arabic.

The language under study is SyrA, a colloquial dialect of Standard Arabic spoken in Syria. The study is mainly based on the dialect of Damascus (Damascene).

2. Material
Six native speakers of SyrA (4 males and 2 females) participated in this experiment, all are pursuing their studies in India. Their ages ranged from 27 to 37. Twenty Utterances of statements and questions were recorded in this experiment. Ten statements (5 VSO word order & 5 SVO word order), and ten questions (5 wh- & 5 yes/no questions).

The alignment of F0 peaks and valleys in the utterances along with the duration of the phrase-final segments were investigated. Durational measures were obtained from statements (SVO word order) question utterances (wh & yes/no) to determine the acoustic features of post-tonic vowel lengthening occurring in ips (non-utterance-final units) and in questions. In addition, similar utterances of statements were compared with the yes/no question utterances to determine the degree of post-tonic lengthening (PTL) occurring in questions. The target words consisted of two syllables representing short and long vowels in stressed and unstressed conditions with stress falling on the penultimate syllable.

Recordings were carried out in a soundproof recording booth at the Phonetics and Phonology lab at IIT Guwahati, India. Utterances were recorded using a Tascam DR-100 MKIII voice recorder connected to a Shure uni-directional head-worn microphone.
The corpus was segmentally labelled using Praat [10] and transliterated based on IPA phonetic symbols. The ToBI-style transcription of the data was also carried out. To avoid micro-prosodic consonantal effects, the pitch contour curves were smoothened in some utterances (10 to 30 %) using Vocal Toolkit plugin on Praat.

A statistical analysis of one-way ANOVA followed by Post-hoc Bonferroni test was conducted using the lmer function from the lme4 package in R [11].

3. The role of F0 in SyrA Acccentual Phrase (AP)

[5] proposed an analysis of three levels of phrasing for SyrA intonation, the Acccentual Phrase (AP), the Intermediate Phrase (ip), and the Intonational Phrase (IP). The AP in SyrA contains one or more prosodic words, and the IP can have more than one AP.

F0 was found to play a crucial role in conveying the prominence (pitch accents) and boundary information within the AP in SyrA. The AP in SyrA is marked on its left edge by a high tone H* realized on the stressed syllable and marked by a low tone La on the right edge of the AP. This suggests that the stressed syllable is the locus of the High tone and is associated with the rising tonal pattern of the AP. The default pattern of APs in SyrA was realized as [H* La], as shown in Figures 1 and 2 below.

4. The role of F0 & PTL in SyrA Intermediate Phrase (ip)

F0 and duration were considered to be important factors in cueing the Intermediate Phrase (ip) in SyrA. The Intermediate Phrase (ip) is a domain of a syntactic structure SVO (the subject, the verb, and the direct object) in SVO (Subject – Verb (ditransitive) – Direct Object – Indirect Object) word order.

The ip in SyrA is characterized by a rising contour with a high tone aligned to its right edge. The ip boundary tone H- is distinct from the AP-initial tone H* in which the ip boundary tone H- has a higher pitch and boosted pitch range than the AP-initial tone H*. In Figure 3 below, the peak on the last syllable of the word [’lsbeh] ‘doll’ is higher than the preceding H* peak, breaking the declination slope among H* peaks. This higher peak is an ip boundary tone H- marking the direct object of the sentence. In addition to this, durational lengthening was reported in the ip (utterance-non-final item). The vowel duration of the last unstressed syllable [be] of the word [’lsbe] is longer than the preceding stressed counterpart (Figure 4).

4.1. Statistical analysis

A linear mixed-effects model was created using the lmer function from the lme4 package in R [5] as follows: Full model: duration ~ vowel + stress + (1 | speaker) + (1 | gender), Null model: duration ~ stress + (1 | speaker) + (1 | gender). The model showed a significant effect of duration where the first stressed vowel and the second unstressed counterpart were different. The intercept was about 66.40 which represents the first vowel. Post-tonic lengthening thus affects duration ($\chi^2(1) = 14.33, df = 1, p = 0.0001534$).

Table 1: Fixed effects of mid-vowel duration contrast between first (stressed) and second (unstressed) syllables for post-tonic vowel lengthening in statements.

<table>
<thead>
<tr>
<th>Fixed effects</th>
<th>Estimate</th>
<th>Std. Error</th>
<th>t value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mid vowel duration</td>
<td>Intercept</td>
<td>66.40</td>
<td>75.77</td>
</tr>
<tr>
<td></td>
<td>second</td>
<td>106.16</td>
<td>107.07</td>
</tr>
</tbody>
</table>
5. Effects of F0 & PTL on SyrA questions

The pitch contour of Wh-questions in SyrA is characterized by a !H% boundary tone on the last unstressed syllable of the phrase-final content word. The reason for this final downstepped boundary tone in SyrA question tunes is due to phrase-final PTL.

Yes/no questions in SyrA have no morphological markings or syntactical means to differentiate them from statements. Since they have the same morpho-syntactic form, yes/no questions are distinguished from statements by intonation only.

To determine the degree of PTL occurring in yes/no questions, similar utterances of statements were compared with the yes/no question utterances. The durational differences between statements and questions are shown in Figure 7.

PTL was found to be a common feature of questions in SyrA. Post-tonic short vowels are lengthened phrase-finally in word-final position. In yes/no questions, the phrase-final up-step in yes/no questions is accompanied by a phrase-final PTL. In SyrA questions, post-tonic short vowels are lengthened phrase-finally in word-final position.

A linear mixed-effects model was created using the lmer function from the lme4 package in R as follows: Full model: duration ~ vowel + stress + question + (1 | speaker) + (1 | word), Null model: duration ~ question + (1 | speaker) + (1 | word). The model showed a significant effect of duration where long stressed vowels and short unstressed counterparts were different. The intercept was about 137.3 which represents the long vowels. Post-tonic lengthening thus affects duration ($\chi^2(1)=39.76, df = 1, p = 0.00000000002872$), lengthening it by about 71.6 ms ± 5.6 (standard errors).

Figure 4: Vowel duration of stressed vs. unstressed vowels representing post-tonic vowel lengthening SyrA statements in the ip-final word of the utterance in Figure 3.

Figure 5: Wh-Q in the utterance [we:n ’sa:ken ’ya:del?] "Where is Adel staying?"

Similarly, the utterance-final up-step in yes/no questions is accompanied by a phrase-final PTL. In SyrA questions, post-tonic short vowels are lengthened phrase-finally in word-final position.

Figure 6: YNQ in the utterance ['na:met 'le:la?] "Did Laila sleep?"

Figure 7: Post-tonic vowel lengthening in SyrA questions, and Yes/no utterances compared to similar statement utterances.

5.1. Statistical analysis

A linear mixed-effects model was created using the lmer function from the lme4 package in R as follows: Full model: duration ~ vowel + stress + question + (1 | speaker) + (1 | word), Null model: duration ~ question + (1 | speaker) + (1 | word). The model showed a significant effect of duration where long stressed vowels and short unstressed counterparts were different. The intercept was about 137.3 which represents the long vowels. Post-tonic lengthening thus affects duration ($\chi^2(1)=39.76, df = 1, p = 0.00000000002872$), lengthening it by about 71.6 ms ± 5.6 (standard errors).
Table 2: Fixed effects of mid-vowel duration contrast between long stressed vowels and short unstressed counterparts for post-tonic vowel lengthening in questions.

<table>
<thead>
<tr>
<th>Fixed effects</th>
<th>Estimate</th>
<th>Std. Error</th>
<th>t value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mid vowel duration</td>
<td>137.300</td>
<td>5.256</td>
<td>26.123</td>
</tr>
<tr>
<td>Short vowels</td>
<td>71.695</td>
<td>7.433</td>
<td>9.646</td>
</tr>
</tbody>
</table>

6. Discussion

The realization of F0 peaks or valleys in the vicinity of the stressed syllables in SyrA is taken as evidence of the association of pitch accents to these lexically stressed syllables. Most H tones were seen anchoring stress with F0 peaks aligned in time with the stressed syllables. The location of the stressed syllable is associated with the rising tonal pattern of the Accental Phrase in SyrA which shows that the analysis of the AP in SyrA is different from what has been reported in other Arabic dialects— for example, Farasani Arabic [12]. Stressed syllables in Farasani Arabic are not apparent in non-focused sentences; rather, stressed syllables carry a pitch accent only when a word is a focused constituent or a Wh-word.

PTL was found to play an essential discourse-level function in SyrA prosody at the phrasal level, which is found to be a typical feature of SyrA differentiating it from the other dialects of Arabic. The utterance-final up-step in SyrA questions is accompanied by a phrase-final PTL which is referred to by Kulk et al. [13] as a "singing intonation." PTL in SyrA is both prosodically conditioned and at the discourse pragmatic level. Prosodic boundaries that have significant lengthening are the IP and the question IPs.

Duration has been shown to play a significant role in the dialects of Arabic such as Lebanese [14], Egyptian [15], and Jordanian [16]. However, SyrA is unique in the role that PTL plays at the level of intonation, not just in lengthening unstressed syllables but influencing the up-stepped F0 in yes/no questions and the downstepped !H! boundary tone in wh-questions. These results are consistent with crosslinguistic data indicating that the magnitude of PTL role is greater in SyrA than in the other dialects of Arabic.

7. Conclusions

We conclude that our experimental data largely supported our analysis that SyrA employs acoustic cues at the phrasal levels such as F0 to mark pitch accents, and PTL to cue intonation and play an essential discourse-level function in SyrA prosody at the phrasal level. The results verified the hypothesis that F0 alignment differences cue relative prominence differences and convey boundary information at the phrase level in Syrian Arabic. These findings have consequences for our understanding of SyrA prosody.

8. References