INTERACTIONS OF LEXICAL STRESS, VOWEL LENGTH AND PHARYNGEALISATION IN PALESTINIAN ARABIC

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ABSTRACT

Research on prosody in varieties of Arabic has expanded in recent years, but no work has examined lexical stress in Palestinian Arabic. The current study examined the acoustic correlates of lexical stress in disyllabic and trisyllabic words with penultimate stress and either a phonologically long or short vowel (/a/) in the stressed syllable. The effects of being adjacent to a pharyngealised consonant were also examined. Results indicated that stressed vowels had higher mean f0 and intensity than unstressed vowels. Stressed long vowels had greater duration than unstressed long vowels, but this pattern did not extend to short vowels. Pharyngealisation was found to interact in complex ways with stress and length in terms of its effect on vowel quality. This research provides a phonetic description of lexical stress in Palestinian Arabic, and examines the interaction among stress, phonemic length and pharyngealisation.

Keywords: lexical stress, prosody, acoustics, pharyngealisation, Palestinian Arabic

1. INTRODUCTION

Lexical stress is the prominence of a syllable (or syllables) within a word, and cues to stress include a variety of correlates (see section 1.1), with some cross-linguistic variation [18, 2, 6, 20].

A quantitative phonetic examination of the acoustic correlates of stress in Palestinian Arabic has not yet been conducted. The goal of the current study is to address this gap, thereby adding to typological literature on lexical stress as well as phonetic descriptions of suprasegmental aspects of Arabic varieties. The current study investigates a number of measures of f0, intensity, duration and vowel quality, as well as examining the interaction of stress and length, and the effects of adjacent pharyngealised sounds.

1.1. Cross-linguistic correlates of lexical stress

Research on lexical stress across many languages has found some common correlates of stressed vowels, such as increased duration, higher intensity and more peripheral quality [19, 7]. Higher f0 may also be a correlate of stress, although controlled experiments on English suggest that higher f0 is a correlate of focus (sentence accent) rather than lexical stress [33, 6, 20]. As such, English is described as using primarily duration and vowel quality to express stress [6, 33], while Spanish has been described as using mainly duration and intensity [30].

1.2. Stress and phonemic length in varieties of Arabic

Palestinian Arabic is a variety of Levantine Arabic, a branch of Arabic spoken in Lebanon, Syria, Jordan and Palestine. Arabic is known to be a stress-accent language, similar to English and Dutch [29, 7, 33, 8, 16, 25, 32]. This means that a syllable can be made prominent regardless of whether it bears a pitch accent. That is, f0 alone is not the primary acoustic correlate of prominence. Stress accent languages differ in how they weight the various cues of f0, duration and intensity [15, 32]. Lexical stress in Arabic is described as falling on: first, a word-final super-heavy syllable, in the absence of that, then on a heavy penult, and finally, on the antepenult, whether heavy or light [28, 1, 12, 34]. Long vowels without primary stress have sometimes been described as having secondary stress [29].

Recent research on prosody in Arabic includes work on lexical stress and focus in Jordanian Arabic [16, 17], on the intonation of focus in Egyptian Arabic [24, 23] and one variety of Lebanese Arabic [12, 14], and work on intonation in Emirati Arabic [9]. The correlates of lexical stress in Arabic have been examined in a small number of varieties: in Egyptian, greater duration, mean f0 and intensity were found to correlate with lexical stress [14], and in Jordanian, greater duration and higher F1 were found in stressed vowels [16]. In Moroccan, no acoustic correlates of lexical stress were found [11].

In the Tripoli variety of Lebanese Arabic, spoken in the north of the country, [13] examined lexically stressed syllables with the (short) vowels [a i u] when unaccented, accented and nuclear accented, and found that f0, intensity, duration and quality differed in each of these conditions.

Arabic has a quantity distinction in both vowels and consonants. Long vowels in Jordanian Arabic were found to be about 70 milliseconds (120%) longer than their short counterparts [17].

Syllable structure can interact with duration because Palestinian Arabic has compensatory shortening in closed syllables [36, 22]. The position of a syllable in a word also affects duration, due to final lengthening [5]. As such, these factors will be taken into account in the analysis of duration.

Arabic also has "emphatic" or pharyngealised consonants, which have the acoustic effect of a higher F1 and lower F2 in adjacent vowels [35, 26]. As such, being adjacent to a pharyngealised consonant may have an effect on the same correlates that are used to express stress. In this study, this is examined as another factor, along with length and stress.

In the current study, I investigate a number of acoustic measures relating to f0, intensity, duration and vowel quality, in order to examine how stress, phonemic length and pharyngealisation interact in this variety.

2. METHODS

Data was collected by [22], using a method developed by [21]. Stimuli consisted of the target word and two colloquial frame sentences presented in the Arabic script.

2.1. Participants

Recordings were analyzed of seven female and seven male speakers who were native speakers of Palestinian Arabic, students at Tel Aviv University or University of Haifa aged 21-27, proficient also in Hebrew and English [22].

2.2. Materials

Stimuli examined in the current study were a subset of those collected by [22], specifically those that had the vowel /a/ in the target syllables. All words had penultimate stress. In disyllabic words, some had a long vowel in the stressed syllable, and some had a short vowel in the stressed syllable. The vowel length contrast in trisyllabic words was on the initial syllable. The target words was followed by another word, either monosyllabic or disyllabic. The target words are shown in Table 1.

[mɪnʔu:l X ħe:k] We say X like this.
[ʕam bɪʔu:l X ɪs:a] I am saying X now.

Disyllabic		Trisyllabic
[ˈfadˤəl]	[ˈfa:dˤel]	[saˈbaqna]
[ˈfasˤəl]	[ˈfa:sˤel]	[qaˈtˤaʕna]
[ˈʒabha]	[ˈʒa:bha]	[daˈfaʕna]
[ˈʒablak]	[ˈba:tˤel]	[sa:ˈbaqna]
[ˈsˤatˤəl]	[ˈʔasˤəl]	[qa:ˈtˤaʕna]
[ˈħa:sˤel]		[da:ˈfaʕna]

Table 1: Target words

2.3. Measurements and analysis

A variety of acoustic correlates of stress were examined in the current study (in Praat [10]), all on the vowel /a/: mean f0 (semitones (re 1 Hz)), mean intensity (dB), duration (msec), and F1 & F2 (Hz) at the midpoint. Recordings had been labelled previously for segment boundaries as described in [22]. Praat scripts were run to collect measurements.

Linear mixed effects regression tests were run in R [31] using the *lmerTest* [27] package with the independent variables stress (stressed or unstressed), vowel length (long or short) and pharyngealisation (yes or no) and the dependent variables each of the above measures. Token and speaker were included as random intercepts. For mean f0, male and female speakers were examined separately. For the duration measure, as noted above, syllable structure, syllable position and number of syllables could also affect this, but the data was not balanced for these, so they were explored as random factors. For each measure, model comparison was conducted using the *anova* function in R, building up models term by term to find the best one to explain the data. The reference levels were stressed, long and non-pharyngealised.

2.4. Hypotheses

Based on previous research, it is expected that stressed vowels will have longer duration, higher intensity, more peripheral quality, and possibly higher f0 than unstressed syllables. Long vowels are expected to have longer duration than short vowels. Pharyngealisation is expected to be associated with a higher F1 and lower F2 in the adjacent vowel.

3. RESULTS

The total number of tokens was 1715.

For intensity, the best model was one with stress as a fixed effect, where stressed vowels had higher intensity than unstressed vowels (Fig. 1, left panel; Coef.=-1.75, p<0.001) (R code: lmer(Mean.Intensity ∼ Stress + (1|Spk) + (1|Token))).

For duration, the best model was one with the fixed factors stress and vowel length with an interaction, with syllable position and syllable structure as added random factors (R code: lmer(Duration ∼ Stress*VLength + (1|Spk) + (1|Token) + (1|Syl.Pos) + (1|Syl.Str))). Pairwise tests were conducted using the *emmeans* package in order to determine which factors differed significantly from one another. These results revealed that long vowels were significantly longer than short vowels when both stressed (Coef.=48, p<0.001) and unstressed (Coef.=22, p<0.001). Stressed vowels were longer than unstressed vowels when both were phonemically long (Coef.=38, p<0.001), but there was no significant effect of stress when they were short (Coef.=12, p=0.167) (Fig. 2). Mean duration for unstressed long /a/ was 70 msec, unstressed short /a/ 54 msec and stressed long /a/ 108 msec and stressed short /a/, 59 msec.

For mean f0, the best model for the male speakers was one with stress and pharyngealisation (R code: lmer(MeanF0 ∼ Stress + Pharyn + (1|Spk) + (1|Token), data=PAm)), where mean f0 was higher when a vowel was stressed (Coef.=-1.4, p<0.001) or pharyngealised (Coef.=0.6, p<0.01). For the female speakers, the best model included only stress, not pharyngealisation (R code: lmer(MeanF0 ∼ Stress + (1|Spk) + (1|Token), data=PAf)). Again, mean f0 was higher in stressed than unstressed vowels for these speakers (Coef.=-1.7, p<0.001) (Fig. 1, right panel).

For F1, the best model was one with stress, vowel length and pharyngealisation and interactions among all three (R code: lmer(F1 ∼ Stress*Vlength*Pharyn + (1|Spk) + (1|Token))). The pairwise results showed a significant effect of pharyngealisation only for short vowels (Figure 3), whereby pharyngealised stressed vowels had a higher F1 than non-pharyngealised stressed vowels (Coef.=-152, p<0.001), while pharyngealised unstressed vowels had a lower F1 than non-pharyngealised unstressed vowels (Coef.=102, p<0.001). There was a significant effect of stress also only for short vowels, whereby stressed pharyngealised vowels had a higher F1 than unstressed pharyngealised vowels (Coef.=210, p<0.001) while stressed non-pharyngealised vowels had a lower F1 than unstressed non-pharyngealised vowels (Coef.=-44, p<0.001).

For F2, the best model was one with stress and pharyngealisation and an interaction (R code: lmer(F2 ∼ Stress*Pharyn + (1|Spk) + (1|Token))). F2 was lower in pharyngealised vowels than non-pharyngealised vowels (stressed: Coef.=175, p<0.001; unstressed: Coef.=275, p<0.001). F2 was lower in stressed vowels than unstressed vowels when non-pharyngealised (Coef.=-123, p<0.001), but there was no significant effect of stress in pharyngealised vowels (Coef.=-23, p=0.582) (Fig. 4).

Table 2 summarises which factors had a significant effect on each measure.

Measure	Stress	Length	Pharyn.
Intensity	*		
Duration	*	*	
Mean f0	*		M
F1	*		*
F2	*		*

Table 2: Significant effects for each measure (* = significant effect; M = only male speakers)

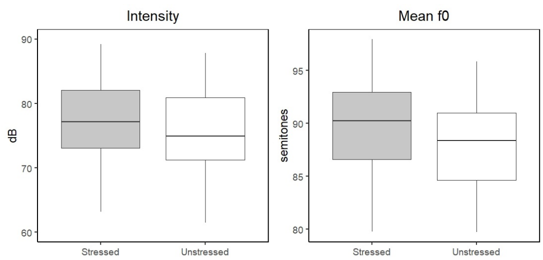

Figure 1: Boxplots showing intensity and mean f0.

4. DISCUSSION

The results found here show a complicated interaction among stress, length and pharyngealisation for the data examined. Both stress and length cause longer duration, however, stress only significantly increases duration in phonemically long vowels. Fig. 2 shows that an unstressed long vowel is similar in duration to a stressed or an unstressed short vowel. This leads to the question of whether this can cause confusion for listeners, and to what extent they use contextual cues to disambiguate these categories. Overall, the

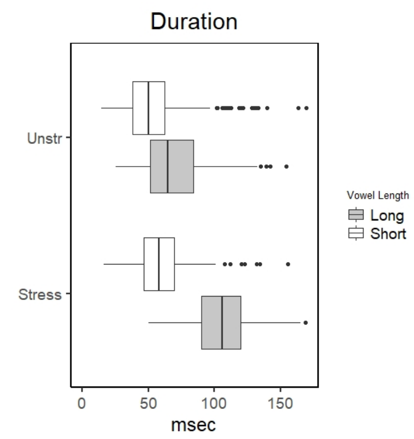

Figure 2: Boxplot showing duration.

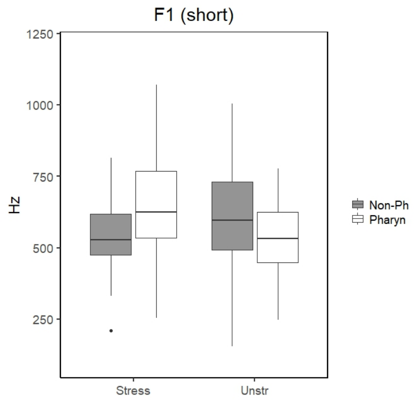

Figure 3: Boxplot showing F1 (short vowels only).

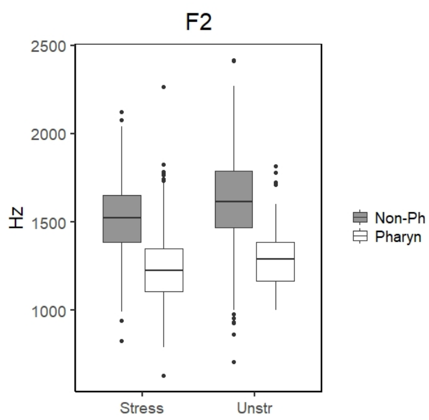

Figure 4: Boxplot showing F2.

correlates of stress for Palestinian Arabic are similar to what has been reported for Egyptian [14].

Pharyngealisation was shown to interact in complex ways with length and stress. First, there was a significant effect of pharyngealisation only on phonemically short vowels. Second, for stressed vowels, pharyngealisation was associated with a higher F1 (lower vowel), while for unstressed vowels, pharyngealisation was associated with a lower F1 (higher vowel). Examining other vowels may shed light on these interactions.

Gender has been reported to interact with pharyngealisation in Arabic, with differing results: in Jordanian, [3] found that male speakers produced stronger cues while [4] found that female speakers produce stronger cues. In this study, f0 was affected by pharyngealisation only among male speakers.

While in some varieties of Arabic, short vowels have been described as being more centralised, in the current study, F2 was not significantly affected by phonemic length. F1 interacted with length in terms of the effects of stress and pharyngealisation only being found on short vowels.

It should also be mentioned that these analyses focused only on the vowel /a/, so further vowels need to be examined in order to understand the broader picture. Similarly, the effects of syllable structure and syllable position are factors that would benefit from more detailed analysis in future work. However, this work is already a contribution to phonetic and acoustic analysis of segmental and suprasegmental patterns in an understudied variety of Arabic and can guide future work into what effects need to be taken into account when analysing lexical stress in Arabic or other languages with stress and phonemic length and/or secondary factors such as pharyngealisation.

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