

ENGLISH LEXICAL STRESS CUES IN NATIVE ENGLISH AND NON-NATIVE ARABIC SPEAKERS

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ABSTRACT

Individuals who speak English as a second language vary in their ability to produce appropriate stress, which often impedes their intelligibility. The present study investigated the production of lexical stress by native speakers of English as well as learners of English. Minimal pairs were recorded by 8 native speakers of English and 8 Arabic learners of English. A second experiment examined use of acoustic cues to indicate stressed syllables in Arabic (8 speakers). In both experiments, four acoustic cues were examined: duration, fundamental frequency, amplitude, and second formant frequency. Differences in the use of these cues were observed across speaker groups (native and non-native speakers) for fundamental frequency and second formant frequency. These differences in use of cues to signal stress were only partially related to use of these acoustic cues in the speakers' first language.

Keywords: lexical stress, acoustic cues, Arabic learners of English, Arabic

1. INTRODUCTION

A number of studies have investigated the phonetic correlates of lexical stress in English, often examining the acoustic correlates in English words that differ in grammatical class, where the change from a noun to a verb is linked to a shift of stress from the first to the second syllable [1, 5, 6, 8]. These studies found that stressed syllables were longer in duration, higher in fundamental frequency, and greater in amplitude. In addition, unstressed vowels were often neutralized, exhibiting a lower second formant frequency for front vowels and a raised second formant frequency for back vowels. These acoustic differences were even observed in English words which maintain an invariable stress pattern across syntactic class (noun to verb, such as *control*) [9].

The production of lexical stress by non-native speakers of English (Spanish learners [3], Japanese learners [11], Chinese learners [10] and Farsi and Hausa [4] learners) has also been examined. The results generally show that second language speakers transfer the acoustic cues indicating stress from their first language. That is, non-native learners with different first languages were more likely to produce words with lexical stress cues that correspond to the pattern of acoustic correlates of their L1. The present study investigated the acoustic cues used by native speakers of Arabic when producing English minimal pairs.

2. EXPERIMENT 1

Experiment 1 investigated cues to lexical stress in English, comparing native speakers of English to Arabic second language learners of English. This experiment specifically examined whether these second language learners have mastered the cues that are used by native speakers of English to indicate lexical stress.

2.1. Participants

Eight participants (4M, 4F) were native speakers of English. All were students at the University of Kansas. Eight additional participants (4M, 4F) were native speakers of Arabic who all spoke English as a second language. All were Jordanian students studying at the University of Kansas. The Arabic learners began studying English at age 11 and had lived in the U.S. for an average of 3.6 years. The Arabic learners had significant exposure to English.

2.2. Stimuli

The stimuli consisted of 8 minimal pairs ('re.cord-re.'cord, 're.bel-re.'bel, 'ob.ject-ob.'ject, 'pre.sent-pre.'sent, 'pro.gress-pro.'gress, 'pro.ject-pro.'ject, 'con.tract-con.'tract, 'con.flict-con.'flict). Half were nouns with stress on the first syllable and the remaining were verbs with stress on the second

syllable. All stimuli were high frequency words. All words were placed at the end of a carrier sentence. Participants read the list of sentences at a normal speaking rate and were asked to repeat the last word in each sentence five times. All speakers were recorded in an anechoic chamber at the University of Kansas using a Fostex DAT recorder. Only three repetitions were analyzed (number 2, 3 and 4). The recordings were digitized (sampling rate of 22 kHz) and analyzed using PRAAT [2].

2.3. Measurements

Four measurements were taken for each syllable: vowel duration, fundamental frequency, amplitude, and second formant frequency. First and second syllable vowels were identified using both visual and auditory information. Vowel duration (in ms) was measured from the start of F1 to the end of F2 in each vowel. F_0 (in Hz) and amplitude (in dB), were averaged across the entire vowel and F2 (in Hz) was measured at vowel midpoint.

Average vowel duration, average f_0 , average amplitude, and average F2 values were determined for each syllable. The ratio of the first syllable to second syllable was then computed for each pair to control for variation in speaker and speaking rate.

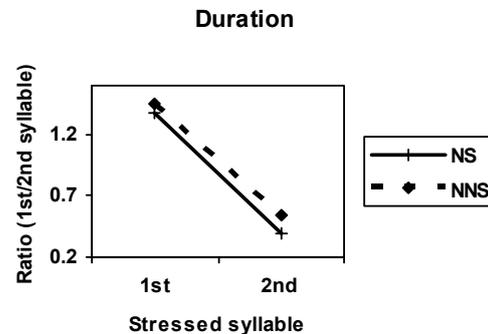
2.4. Results

A 2 X 2 Repeated Measures ANOVA was conducted to examine Stress (first syllable versus second syllable stress) and Speaker (native English versus Arabic learner of English) for each acoustic correlate (duration, f_0 , amplitude, and F2). Only the interaction between Stress and Speaker will be presented.

2.4.1. Duration

There was no significant interaction between Stress and Speaker for duration [$F(1,93)=.39$, $p=.54$]. As shown in Figure 1, native English speakers show substantial duration ratio differences for stimuli stressed on the first syllable (1.37) as compared to stimuli stressed on the second syllable (.40) and non-native Arabic learners of English showed a similar distinction between stimuli stressed on the first syllable (1.45) as compared to stimuli stressed on the second syllable (.55). Both native speakers of English and Arabic learners of English make similar distinctions in duration between stressed and unstressed vowels. Arabic learners of English resemble native speakers of English in their use of duration information.

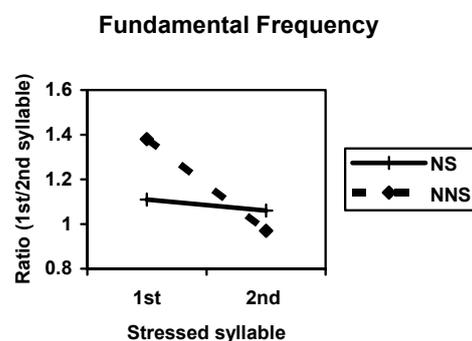
Figure 1: Duration ratio of the first to second syllable for minimal pairs which contrast in stressed syllable for English native speakers (NS) and Arabic learners of English (NNS).



2.4.2. Fundamental frequency

There was a significant interaction between Stress and Speaker for f_0 [$F(1,93)=22.42$, $p=.001$]. As shown in Figure 2, while native English speakers show f_0 ratio differences for stimuli stressed on the first syllable (1.11) as compared to stimuli stressed on the second syllable (1.06), non-native Arabic learners of English show significantly greater f_0 distinctions between stimuli stressed on the first (1.38) compared to the second (.97) syllable. Arabic learners of English make distinctions between stressed and unstressed vowels in terms of f_0 and that difference is significantly greater than the f_0 difference used by native speakers. Arabic learners of English use fundamental frequency cues to a greater extent than native speakers of English.

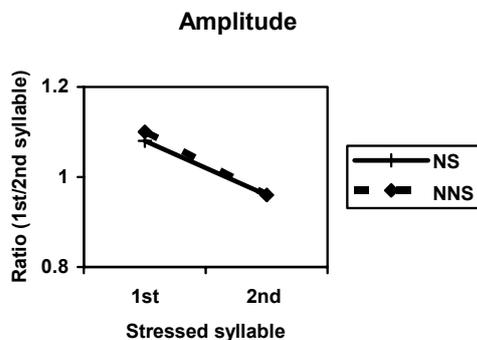
Figure 2: F_0 ratio of the first to second syllable for minimal pairs which contrast in stressed syllable for English native speakers (NS) and Arabic learners of English (NNS).



2.4.3. Amplitude

There was no significant interaction between Stress and Speaker for amplitude [$F(1,93)=2.26, p=.136$]. As shown in Figure 3, while native English speakers show amplitude ratio differences for stimuli stressed on the first syllable (1.08) as compared to the second syllable (.96), non-native Arabic learners of English show a similar difference (1.10 compared to .96). Both native speakers of English and Arabic learners of English make similar distinctions in amplitude between stressed and unstressed vowels. Arabic learners of English resemble native speakers of English in their use of amplitude information.

Figure 3: Amplitude ratio of the first to second syllable for minimal pairs which contrast in stressed syllable for English native speakers (NS) and Arabic learners of English (NNS).



2.4.4. Second formant frequency

Analyses examining second formant frequencies were done separately for the first and second syllables and for front and back vowels. For all interactions, a significant difference was found between the native speaker productions and the Arabic learners of English. For native speakers, the F2 of front vowels is lowered in stressed syllables and the F2 of back vowels is raised in stressed syllables. In all cases, native speakers showed significant vowel reduction in unstressed syllables whereas the Arabic learners of English did not.

3. EXPERIMENT 2

To understand the pattern of results for the Arabic learners, a second experiment examined the acoustic correlates of stress in Arabic. In a previous study investigating Arabic stress in words spoken in five different prosodic conditions [7],

differences in duration and f_0 across conditions were analyzed. Vowels in stressed syllables were longer and had a higher fundamental frequency than unstressed vowels. Neither amplitude nor vowel quality was examined. The present study contrasted minimal pairs in Arabic, similar to the English word pairs of Experiment 1, where stress is phonemic. Six minimal pairs are examined. The pairs represent differences in grammatical class (noun versus comparative adjective) with a shift in stress from the first to the second syllable. Duration, amplitude, fundamental frequency and second formant frequency values were collected in order to systematically study the acoustic correlates of stress in Arabic.

3.1. Participants

Eight participants (4M, 4F) were recorded. All participants were native speakers of Jordanian Arabic and were students at Yarmouk University.

3.2. Stimuli

The stimuli consisted of six minimal pairs ('a.sad-a.'sad, 'a.rag-a.'rag, 'a.had-a.'had, 'a.lam-a.'lam, 'a.mal-a.'mal, 'a.mar-a.'mar). These 12 bisyllabic Arabic words differ in stress with 6 nouns stressed on the first syllable and their minimal pair comparative adjective counterparts stressed on the second syllable. All words were spoken in simple sentences, where each word occupied the final position. Participants read the list of sentences three times at a normal speaking rate in a quiet chamber at the Yarmouk University Speech and Hearing Center using a portable Sony DAT recorder. The recordings were digitized (sampling rate of 22 kHz) and analyzed using PRAAT. All three repetitions were examined.

3.3. Measurements

Measurement procedures were identical to those used in Experiment 1. Average vowel duration, f_0 , amplitude, and F2 values were computed for each stimulus for each speaker. The ratio of the first syllable to the second syllable was then computed for each pair.

3.4. Results

A Repeated Measures ANOVA was conducted to examine Stress (first versus second syllable stress) for each correlate of stress (duration, f_0 , amplitude, and F2).

3.4.1. Duration

First syllable stressed words in Arabic have a higher duration ratio than second syllable stressed words, with nouns having a duration ratio of .87 and adjectives a ratio of .68. Arabic speakers do use duration to cue lexical stress, showing significant duration differences between stressed and unstressed syllables.

3.4.2. Fundamental frequency

First syllable stressed words in Arabic have a higher f_0 ratio than second syllable stressed words, with nouns having an f_0 ratio of 1.12 and adjectives a ratio of .96. Arabic speakers use fundamental frequency to cue lexical stress, showing significant pitch differences between stressed and unstressed syllables.

3.4.3. Amplitude

First syllable stressed words in Arabic have a higher amplitude ratio than second syllable stressed words, with nouns having an amplitude ratio of .98 and adjectives a ratio of .94. Arabic speakers use amplitude to cue lexical stress, showing significant amplitude differences between stressed and unstressed syllables.

3.4.4. Second formant frequency

Second formant analyses were done separately for the first and second syllable. In the first syllable, F2 values for stressed vowels in nouns (1329 Hz) were not significantly different from F2 values for stressed vowels in the first syllable of adjectives (1357 Hz). In the second syllable, F2 values for stressed vowels in nouns (1327 Hz) again were not significantly different from F2 values for stressed vowels in the second syllable of adjectives (1357 Hz). There was no reduction of unstressed vowels in either syllable. Arabic speakers do not reduce vowels to indicate lack of stress.

4. CONCLUSIONS

The present study investigated the production of lexical stress by native English speakers, Arabic speakers of English, and native speakers of Arabic. Two experiments were conducted. The first experiment inspected acoustic cues to lexical stress in English minimal pairs. Stressed vowels were compared to unstressed reduced vowels. Minimal pairs were recorded by native speakers of English and Arabic learners of English. Four acoustic cues

were examined: duration, fundamental frequency, amplitude, and second formant frequency. Results showed that native speakers of English consistently use all four cues to signal stress, with lower f_0 , shorter duration, lower amplitude, and more reduced vowel quality for unstressed syllables. The Arabic learners of English were similar to native speakers in their use of duration and amplitude cues. Interestingly, Arabic second language speakers used f_0 cues to a greater extent than native English speakers. Also, Arabic second language speakers did not reduce unstressed vowels, with little difference in F2 between stressed and unstressed vowels. In a second experiment, Arabic bisyllabic minimal pairs contrasting in stress placement were examined to observe the cues used by Arabic speakers in their native language. The results consistently showed that Jordanian Arabic speakers use duration, amplitude and f_0 to cue stress in Arabic but do not reduce vowels in Arabic to cue stress. In English, however, Arabic speakers increase their use of amplitude and duration cues to resemble English speakers but Arabic speakers do not appropriately reduce unstressed vowels in English. Instead, they over-use fundamental frequency cues.

5. REFERENCES

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