Linguistic Portfolios

Volume 3 Article 7

2014

The Acoustic Correlates of Stress-Shifting Suffixes in Native and Nonnative English: An Overview

Paul Keyworth
St. Cloud State University

THE ACOUSTIC CORRELATES OF STRESS-SHIFTING SUFFIXES IN NATIVE AND NONNATIVE ENGLISH: AN OVERVIEW

PAUL KEYWORTH

ABSTRACT

Although laboratory phonology techniques have been widely employed to discover the interplay between the acoustic correlates of English Lexical Stress (ELS) – fundamental frequency, duration, and intensity - studies on ELS in polysyllabic words are rare, and cross-linguistic acoustic studies in this area are even rarer. Consequently, the effects of language experience on L2 lexical stress acquisition are not clear. This investigation of adult Arabic (Saudi Arabian) and Mandarin (Mainland Chinese) speakers analyzes their ELS production in tokens with seven different stress-shifting suffixes; i.e., Level 1 [+cyclic] derivations to phonologists. Stress productions are then systematically analyzed and compared with those of speakers of Midwest American English using the acoustic phonetic software, Praat. In total, one hundred subjects participated in the study, spread evenly across the three language groups, and 2,125 vowels in 800 spectrograms were analyzed (excluding stress placement and pronunciation errors). Nonnative speakers completed a sociometric survey prior to recording so that statistical sampling techniques could be used to evaluate acquisition of accurate ELS production. The speech samples of native speakers were analyzed to provide norm values for cross-reference and to provide insights into the proposed Salience Hierarchy of the Acoustic Correlates of Stress (SHACS). The results support the notion that a SHACS does exist in the L1 sound system, and that native-like command of this system through accurate ELS production can be acquired by proficient L2 learners via increased L2 input. Other findings raise questions as to the accuracy of standard American English dictionary pronunciations as well as the generalizability of claims made about the acoustic properties of tonic accent shift.

1.0 Introduction

It is widely accepted that certain suffixes in English cause a shift in stress in the root morpheme to the syllable directly preceding the suffix (Celce-Murcia, Brinton, & Goodwin, 1996; Kreidler, 2004). These stress-shifting suffixes have been labeled Level 1 [+cyclic] suffixes by generative phonologists (Kisparsky, 1982; Halle and Kenstowicz, 1991). Pronunciation experts, including Celce-Murcia et al. (1996), have claimed that the resultant shift in stress in turn causes a change in the neutralization or vowel reduction in the unstressed syllable. Koffi (personal communication, September 11, 2012) has affirmed that these claims about lexical stress shifts have not yet been supported quantitatively by the subfield of laboratory phonology.

In addition to this concern about validity, although various studies on the acoustic properties of English word stress do exist, there is a lack of consensus in the literature as to the relative importance of the acoustic correlates of stress -- fundamental frequency (F0) (i.e., pitch), duration, intensity, and spectral reduction. Indeed, various contrasting versions of what the author hereby coins the *Salience Hierarchy of the Acoustic*

Correlates of Stress (SHACS) have been proposed: F0 > duration > intensity (e.g., Fry, 1955, 1958; Ladefoged, 2003), duration > F0 > intensity (e.g., Adams & Munro, 1978), and duration > intensity > F0 (e.g., Beckman & Edwards, 1994). The latter have reasoned that F0 is only a relevant acoustic correlate of stress with regards to sentential pitch accent.

Furthermore, most studies have not explored the acoustic properties of the full range of Level 1 [cyclic] suffixes in the lexicon. In fact, studies on English Lexical Stress (ELS) in *polysyllabic* words in general have largely been ignored in favor of disyllabic minimal stress pairs, as in Fry's original studies (1955, 1958).

Moreover, there is a dearth of cross-linguistic acoustic data on comparisons of productions of Level 1 [+cyclic] derivations by native speakers of English (NES) and nonnative speakers of English (NNES) of different proficiencies and first language (L1) backgrounds. Although the extent of L2 accentedness is related to many determinants, including language environment and age of speakers, the main mediator of individual differences in L2 accents is the "sound system" of their L1 (Zhang, Nissen, & Francis, 2008, p. 4498). For example, there is growing evidence to suggest that Mandarin L1 speakers have problems pronouncing L2 English stress contrasts because of "strong interference from the Mandarin *tonal* system" (Zhang et al., 2008, p. 4500). As Zhang et al. have stated, even when syllabic stress *is* placed appropriately by Mandarin NNES, they have problems manipulating the acoustic correlates of stress in a native-like manner. Conversely, various phonetic studies on rhythmic typology strongly indicate that Arabic is a stress-timed language that is "a very likely language to exhibit the same correlates to stress as does English" (de Jong & Zawaydeh, 1999, p.5).

This paper aims to validate the widely-held impressionistic assertions in the literature about the morphophonemic properties Level 1 [+cyclic] suffixes by providing quantifiable data. Therefore, the current study is based on quantitative acoustic analyses of the data using laboratory phonology techniques which have the advantage of "replicability and robustness" (Post & Nolan, 2012, p. 544) if suitable sampling and statistical methods are employed. In addition, this project investigates the dichotomous claims made my acoustical phonetics experts about SHACS. To do this, syllabic F0, duration, and intensity productions are analyzed in Level 1 [+cyclic] derivations by native speakers of Midwestern American English (MWAE) dialect. Due to limitations of time, the researcher does not measure the acoustic correlate of vowel quality (i.e., first and second formants (F_1 and F_2), which is in accordance with Lieberman's study (1960).

From a second language acquisition (SLA) research perspective, the other purpose of this study is to observe whether there is a correlation between exposure to the L2 and/or L1 background and production accuracy of Level 1 [+cyclic] suffix derivations. As Zhang et al. (2008) have succinctly noted, most research in the area of English lexical stress "confound the phonological issue of stress placement with the phonetic problem of native-like stress production" (p. 4498). Thus, production accuracy here refers to a twofold distinction: 1) L2 knowledge of *where* to place the stress in derived words, and 2) *native-like* production of the acoustic correlates of stress. More specifically, this study examines the acoustic correlates of productions of English Level 1 [+cyclic] derivations by Arabic L1 and Mandarin L1 NNES.

Ancillary findings also raise questions as to the accuracy of IPA pronunciations of certain Level 1 [+cyclic] derivations provided by Standard American English (SAE) dictionaries as well as the generalizability of claims made about the acoustic properties of *tonic accent shift*. The latter is a theory proposed by Ladefoged and Johnson (2010, p. 119) that suggests primary-stressed vowels only differ from secondary-stressed vowels with regards to an increase in F0, making the syllable [+tonic].

2.0 Data Collection

The researcher digitally recorded productions of Level 1 [+cyclic] tokens by L1 speakers of Midwest American English, Saudi Arabian Arabic, and Mainland Chinese Mandarin. Participants read aloud eight tokens inside a carrier phrase *"Say __________ again"*. The stimuli included the stem word <HIStory> in addition to seven derived words formed by the addition of seven different stress-shifting suffixes: <hisTORic>, <hisTORical>, <histoRICity>, <hisTORian>, <hisTORify>, <hisTORial>, and <HisTORious>. Each of these suffixes has a corpus frequency of approximately 1% (Carroll, Davies, & Richman, 1971). The suffix, <tion>, which has a corpus frequency of around 4% (Carroll, Davies, & Richman, 1971), was purposefully omitted to keep this variable constant. The carrier phrase was designed so that the words to be studied did not carry an onset rise or a pitch accent *(Maeda, 1976; Ladefoged & Johnson, 2010; Post & Nolan, 2012)*. To limit ordering effects (See Cowart, 1997), tokens were presented randomly by shuffling the cards.

Prior to recording, subjects completed a short sociometric survey so that statistical sampling techniques could be used to evaluate acquisition of accurate ELS production. The speech samples of native speakers were analyzed to provide *norm values* for cross-reference and to provide insights into the proposed SHACS. In total, 100 subjects participated in the study, spread evenly across the three language groups (Figure 1).

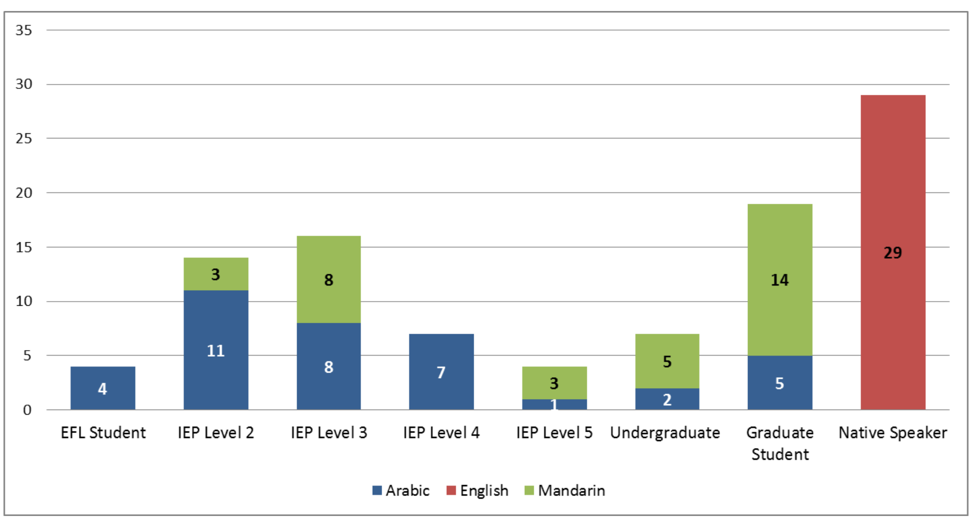

Figure 1: Participants by L1 and English Proficiency Level

3.0 Data Analysis

The acoustic phonetic researcher analyzed productions using *Praat,* delineated vowels, and measured the *relative primary stressed to non-primary stressed vocalic ratios*[1] for: mean F0 (Hz), mean intensity (dB), and duration (ms). This methodology is similar to Flege and Bohn (1989), Zhang et al. (2008), and Lee and Cho (2011) using *Praat* Version 5.3.31 (Boersma & Weenink, 2013). However, to the best of the author's knowledge, the proposed method of comparing vowels was novel in that the acoustic correlates in vowels with primary stress were examined in relation to those of *all* the other vowels in the utterance – as opposed to just one of the unstressed vowels (e.g., Flege & Bohn, 1989; Lee & Cho, 2011). In other words, the [+tonic acc.] vowel in each token was acoustically compared to the [-tonic acc.] vowel (Ladefoged, 2001). The rationale being, that if a vowel has primary stress, the acoustic cues should be prominent to all the other vowels in word. Scripts were used to semi-automate delineation of vowels (Ryan, 2005) and retrieve stress analysis data (Yoon, 2008) which greatly reduced the potential for human error. In total, 2,125 vowels in 800 spectrograms were analyzed as in Figure 2, which excluded *stress placement* and *pronunciation* errors which were entered into a separate data pool. The latter error type could also include stress placement errors but is was deemed more serious with regards to intelligibility as it could (also) include a deletion, and/or addition, and /or substitution of a segment or cluster of segments. Naturally, any productions containing errors had to be excluded from the main dataset as it would not be a fair test to compare the vocalic relative stress values in words which had been pronounced differently.

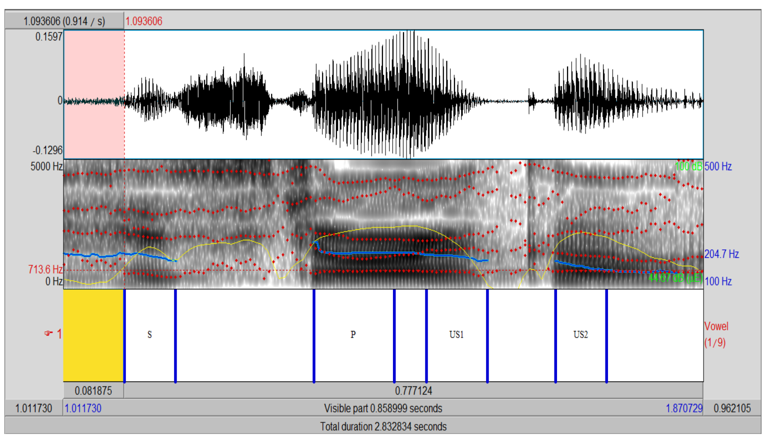

Figure 2: <Historical> as spoken by a Midwest American female

P = primary-stressed vowel *S* = secondary-stressed vowel *US* = unstressed vowel

3.1 Statistical Analyses

- Paired sample *t*-tests were used to identify significant differences ($p < .05$) between the primary [+tonic] and non-primary stressed [-tonic] vowels (*P vs. All*) in each token.

- Paired sample *t*-tests were used to identify significant differences ($p < .05$) between the primary [+tonic, +stress] and secondary stressed [-tonic, +stress] vowels (*P vs.* S) in each token.

[1]Two ratios used: a) [+tonic]/[-tonic] (*P vs. All*) b) [+stress, + tonic]/[+stress, -tonic] (*P vs. S*)

- Mean vocalic relative stress ratios of each factor were submitted to ANOVAs, as well as Tukey HSD post hoc tests, to see if there were significant differences in stress production among the language groups. Productions of the stem token, <history>, were omitted from comparisons.

- Pearson Product-Moment Correlations were used to determine strength of relations and effect sizes for the operationalized variables of: L1 background, L2 exposure, L2 input, and L2 proficiency. Productions of the stem token, <history>, were omitted from comparisons.

4.0 Results and Discussion

4.1 Quantitative Observation of Stress-Shifts in ES Level 1 [+cyclic] Word Productions

NES produced primary-stressed vowels with higher F0, greater intensity, and longer duration than the average of the rest of the vowels combined as indicated by the positive ratios in Table 1.

Language Group	F0	SD	Intensity	SD	Duration	SD
Arabic	1.07	0.30	1.05	0.06	1.29	0.70
English	1.13	0.34	1.06	0.04	1.61	0.63
Mandarin	1.08	0.18	1.04	0.05	1.57	0.58

Table 1: Mean Relative Stress Ratios of Primary [+tonic acc.] to Non Primary Vowels [-tonic acc.] for the Three Acoustic Correlates by Language Group

Paired sample *t*-tests revealed that, for each token, at least one correlate had a significantly different value in the primary-stressed vowel than in the mean of all the other vowels combined. Notwithstanding, the *pentasyllabic* token <historicity> was idiosyncratic as it was only significantly different (negatively) with regards to duration. Since primary vowels were prominent due to the contrast in one or more acoustic features, we can conclude that stress-shifts in Level 1 [+cyclic] derivations can be observed quantitatively, at least in words with fewer than five syllables. Table 2 summarizes the significant findings from all the *P* vs. *All* paired-sample *t*-tests for all three language groups, so that the reader may have a better overall picture of the ways in which lexical stress manifests itself in the speech of the different L1 groups.

Token	Language Group	F0	Intensity	Duration
<history>	English	✘	✓	✓(negative)
	Arabic	✘	✘	✘
	Mandarin	✓	✓	✘
<historial>	English	✓	✓	✓
	Arabic	✓	✓	✓
	Mandarin	?	✓	✓
<historian>	English	✘	✓	✓
	Arabic	✓	✓	✓
	Mandarin	✓	✓	✓
<historic>	English	✘	✓	✓
	Arabic	✘	✓	✘
	Mandarin	✘	✘	✓
<historical>	English	✓	✓	✓
	Arabic	✘	✓	✘
	Mandarin	✘	✓	✓
<historicity>	English	✘	✘	✓(negative)
	Arabic	✘	✓	✓(negative)
	Mandarin	✘	✓	✘
<historify>	English	✘	✓	✓(negative)
	Arabic	✘	✘	✓(negative)
	Mandarin	✓	✓	✘
<historious>	English	✘	✓	✓
	Arabic	✘	✓	✓
	Mandarin	✓	✓	✓

Table 2: Most Salient Acoustic Correlates of Primary Stressed [+tonic] Vowels in Level 1 [+cyclic] Derivations per Language Group

✓ = salient acoustic correlate ✘ = non-salient acoustic correlate

? = borderline saliency based on a non-significant difference between *P* and *All* but a large effect size

4.2 Salience Hierarchy of the Acoustic Correlates of Stress (SHACS)

Paired sample *t*-tests on the *P* vs. *All* analyses of MWAE NES productions (Table 2) provide a more convincing description of SHACS than the mean vocalic relative stress ratios alone. Antithetically, at least with regards to many of the leading theories on SHACS (e.g., Fry, 1955, 1958; Adams & Munro, 1978), the results from this study suggest that intensity is at least the most reliable, if not the most salient, cue to ELS. Intensity of the primary-stressed [+tonic, +stress] vowel was statistically greater than the mean intensity of the non-primary [-tonic, +stress] vowels in all eight tokens. Based on frequency of significances, duration was the next most salient cue to ELS as it was also statistically different in *P* vs. *All* in all the tokens, albeit with a shorter duration in three of the tokens. In sum, SHACS in Level 1 [+cyclic] derivations in MWAE appears to be:

intensity > duration > F0

4.3 Nonnative Ordering of the Acoustic Correlates of Stress

On average, both Arabic L1 NNES and Mandarin L1 NNES produced primary-stressed vowels with higher F0, greater intensity, and longer duration, albeit with smaller vocalic relative stress ratios for each of the acoustic correlates than NES (Table 1). These ratios were in roughly the same proportions as for NES; i.e., duration > F0 > intensity. However, since the ratios for each acoustic cue are measured in different units (i.e., Hertz, decibels, and milliseconds) which are not calibrated to be perceptively equivalent or directly comparable, one cannot assert that this is the SHACS for these speakers. Thus, further statistical tests were conducted for both NNES groups.

4.31 Mandarin L2 English

One-way ANOVA tests showed that there were significant differences between the language groups with regards to intensity as a prosodic cue, $F(2, 481) = 5.25$, $p < .01$. The Tukey HSD post hoc comparison revealed that Mandarin L1 NNES ($M = 1.04$, $SD = .05$) were statistically different from NES ($M = 1.06$, $SD = .04$) as they used a significantly lower ratio of intensity in stress contrasts (Figure 3). Notwithstanding, intensity was still the most reliable cue to stress according to the P vs. All *t*-tests (Table 2).

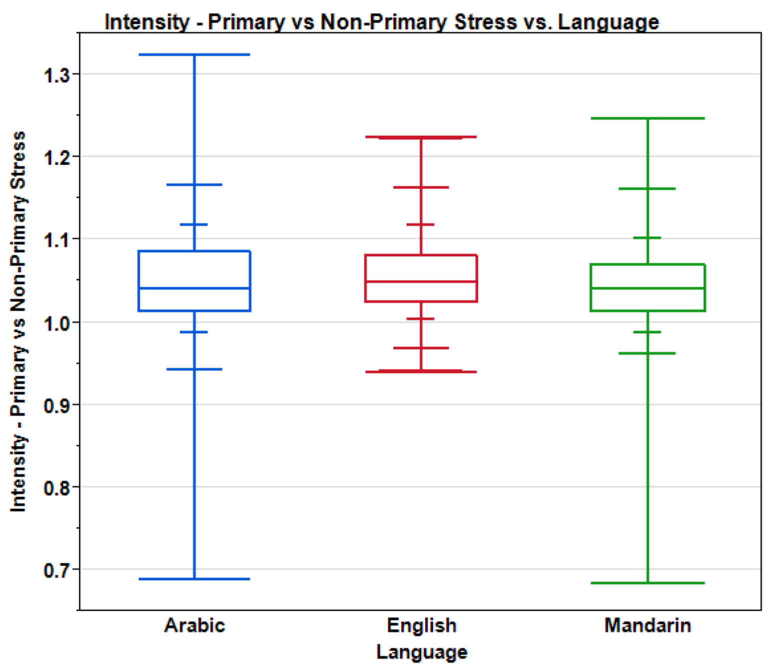

Figure 3: Comparative Usage of Intensity as an Acoustic Cue to ELS in Level 1 [+cyclic] Derivations

Paired sample *t*-tests also revealed that Mandarin English L2 speakers deviated more from the NES norm in that they tended to use F0 as a salient acoustic cue to ELS more often (Table 2). Thus, the results seem to concur with earlier studies (e.g., Zhang, Nissen, & Francis, 2008; Keating and Kuo). In general, SHACS for Mandarin English L2 speakers appears to be:

$$\text{intensity} > \text{F0} \geq \text{duration}$$

4.32 Arabic L2 English

One-way ANOVA tests showed that there were significant differences between the language groups with regards to duration as a prosodic cue, $F(2, 481) = 11.90$, $p < .01$. The Tukey HSD post hoc comparison revealed that Arabic L1 NNES ($M = 1.29$, $SD = .70$) were statistically different from both NES ($M = 1.61$, $SD = .63$) and Mandarin L1 NNES ($M = 1.57$, $SD = .58$) in their usage of durational stress contrasts (Figure 4); i.e., their relative vocalic stress ratios were much smaller.

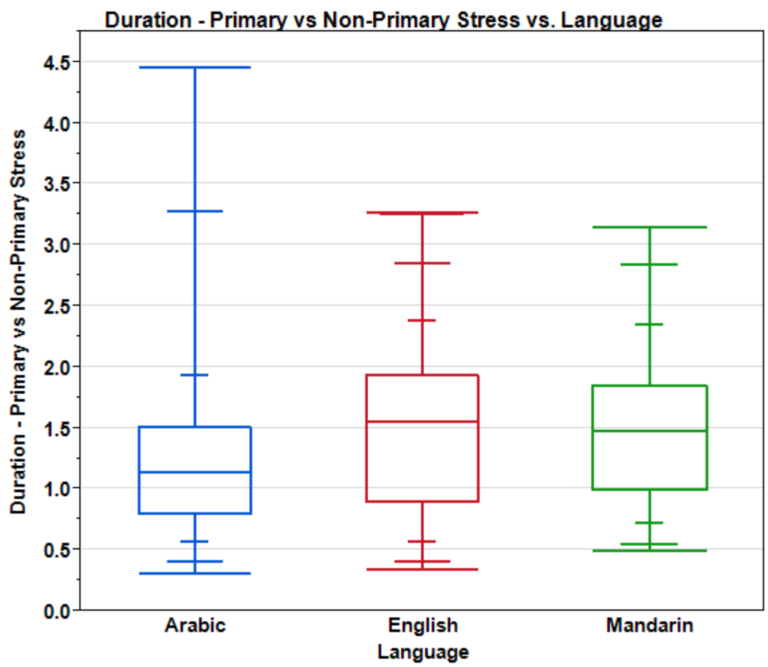

Figure 4: Comparative Usage of Duration as an Acoustic Cue to ELS in Level 1 [+cyclic] Derivations

Paired sample *t*-tests revealed that durational contrasts between *P* and *All* were not as numerous as they were for NES although Arabic English L2 speakers also produced negative duration ratios for <historicity> and <historify> (Table 2). In sum, SHACS for Arabic L1 NNES appears to be:

intensity >> duration > F0

4.4 Problematic Acoustic Correlates for Arabic L1 and Mandarin L1 Speakers

4.41 Fundamental frequency

Paired sample *t*-tests of *P* vs. *All* indicated that Chinese subjects tend to use more pitch contrasts than NES to differentiate ELS, which almost certainly leads to accentedness (Table 2). However, one-way ANOVA found that neither Arabic L1 NNES ($M = 1.07$, $SD = .30$) nor Mandarin L1 NNES ($M = 1.08$, $SD = .18$) were statistically different from NES ($M = 1.13$, $SD = .34$) with regards to F0 usage although the *p* value was close to being significant, ($F (2, 481) = 2.80$, $p = 0.6$). Therefore, differences in relative vocalic stress ratios of F0 production in *P* vs. *All* were very small; that is, Mandarin L1 speakers use a slightly smaller F0 range than NES which seems to confirm the findings of Li and Shuai (2011).

4.42 Intensity

As reported in 4.31, one-way ANOVAs revealed that Mandarin L1 NNES significantly under-use intensity contrasts between *P* and *All* to emphasize primary stress. This was somewhat unexpected based on previous studies of Mandarin English L2. Still, paired sample *t*-tests revealed that intensity *was* significantly different in *P* vs. *All* in all but one of the tokens (Table 2). Thus, it seems that although intensity is an important acoustic cue for Mandarin L1 NNES, they still do not employ it in a native-like manner.

4.43 Duration

As reported in 4.32, one-way ANOVAs revealed that Arabic L1 NNES significantly under-use durational contrasts between *P* and *All* to emphasize primary stress. This may be due to the fact that Arabic English L2 speakers tend not to reduce vowels as suggested by Zuraiq and Sereno (2005). Not reducing the unstressed vowels in a token would certainly result in smaller durational contrasts between the primary [+tonic] and non-primary [-tonic] vowels. The ANOVA results also support Bouchhioua's (2008) study which found that duration is not an important correlate of lexical stress in Tunisian Arabic as it is in English and negative transfer may lead to non-native accentedness, if not unintelligibility.

4.44 Summary of distinct features of nonnative stress production

To recapitulate the findings in 4.4, Arabic L1 NNES use significantly smaller durational contrasts to denote primary stress, perhaps caused by a tendency to not reduce unstressed vowels in Level 1 [+cyclic] derivations. Conversely, Mandarin L1 NNES use F0 more often than NES as a salient marker of primary stress while significantly under-using intensity contrasts. The author hypothesizes that these features of Arabic and Mandarin accented English are direct results of transfer from the predictable stress and tonal L1 sound systems, respectively.

4.5 Correlations between Amount of L2 Exposure, Amount of L2 Input and L2 Proficiency

4.51 Accurate placement of stress in Level 1 [+cyclic] derivations

Figure 5 shows the percentage of correct responses by token and language group. Also, as one might expect, <historicity> caused the most problems.

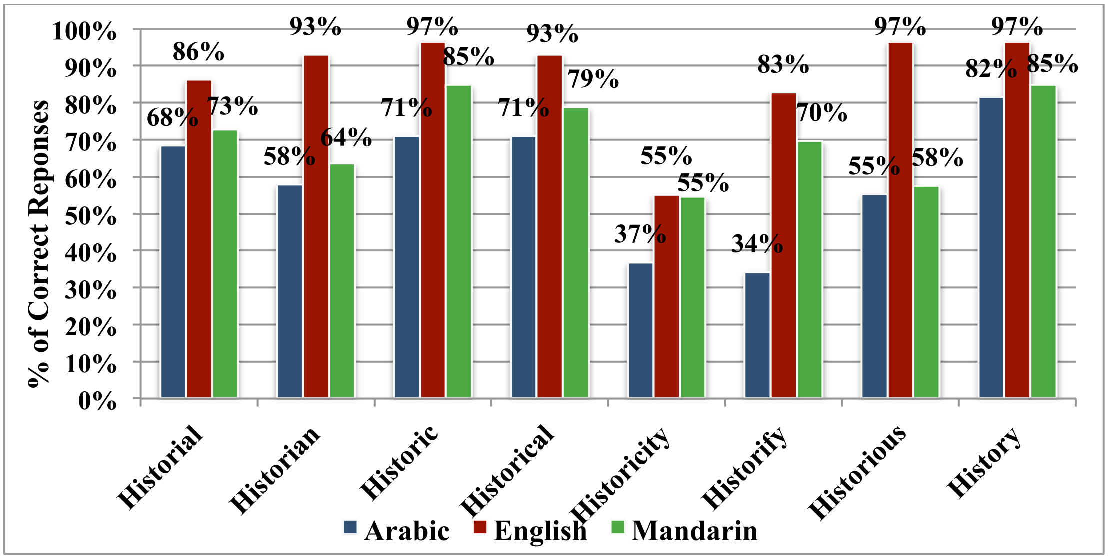

Figure 5: Proportion of Correct Responses by Token and Language Group

In fact, NES were no better at accurately producing this word than Mandarin speakers. However, it is important to note that for the two nonsense words (i.e., <historious> and <historial>), the NES performed much better. It is the researcher's contention that although these are not real words, NES were able to use the stress-shifting rules that are stored in the lexicon. Nevertheless, the smooth curve in Figure 6 shows that a significant correlation was found ($r = -.26$, $p < .05$.) for years of English language study and frequency of errors. Therefore, the longer learners of English have spent studying the language (i.e., increased L2 input), the fewer pronunciation and stress-placement errors they make in stress-suffixed words.

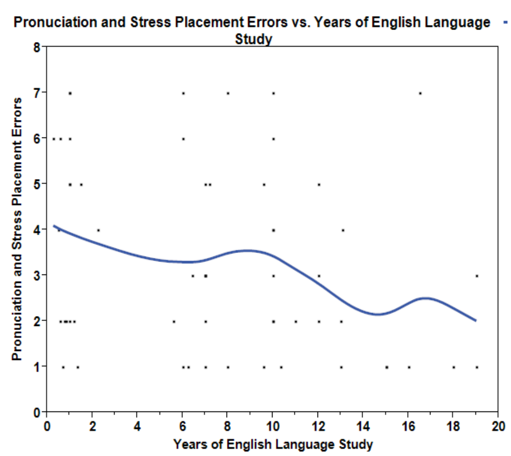

Figure 6: Frequency of Pronunciation and Stress-Placement Errors vs. Years of L2 Study

From a psychological viewpoint, this strong correlation may relate to how many years of English L2 education subjects *feel* they have received. When L2 exposure (i.e., years of residence in L2 country) was plotted against number of errors, it did not yield significant correlations. However, the author posits that the study did not have a large enough range for this variable. As expected, Arabic and Mandarin L1 NNES produce fewer errors the higher the level of their English L2 proficiency with a significance of $p < 0.00$ and a medium effect size of $r = -.05$ (Figure 7).

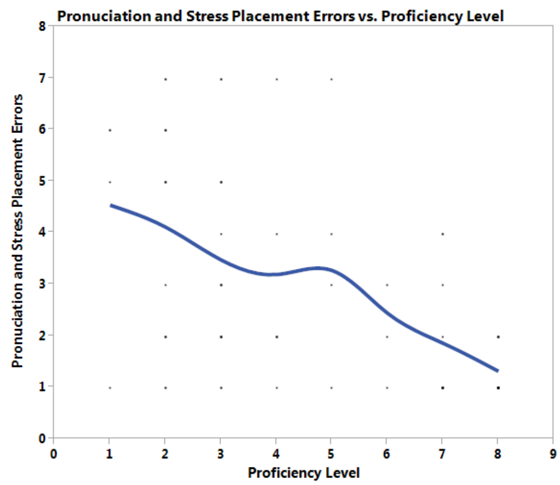

Figure 7: Frequency of Pronunciation and Stress-Placement Errors vs. English Proficiency Level

4.52 Native-like production of the acoustic correlates of stress in Level 1 [+cyclic] derivations

Correlations did not find any significant relationship between any of the independent variables and native-like production of intensity. However, based on the paired sample *t*-tests, it is suggested that intensity is already employed as a prosodic correlate in almost every token by both groups of NNES. Perhaps this is why previous studies have claimed that intensity is the least important cue to ELS; i.e., because it is not hard for NNES to manipulate, it is not a determiner of accentedness, comprehensibility, or intelligibility. Nevertheless, F0 and duration did yield interesting distinctions.

4.53 Mandarin L2 English

Figure 8 represents a statistically significant correlation ($p < 0.05$) and a moderate effect size ($r = -.5$) between amount of L2 input (i.e,, years of English L2 study) and Mandarin L1 NNES' ability to produce native-like F0 contours in lexical stress contrasts.

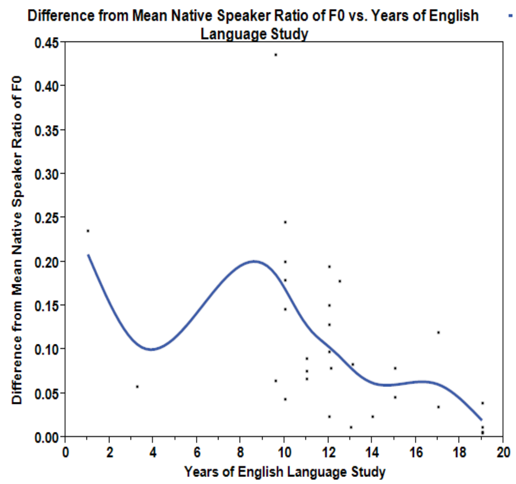

Figure 8: Difference of Mean Mandarin L1 Speaker Ratio of F0 from Mean Native Speaker Ratio of F0 vs. Years of L2 English Study

Figure 9 shows significant correlations were also found when native-like production of F0 was correlated with English L2 proficiency level, albeit with a very small effect size ($r = -0.0$, $p < 0.05$).

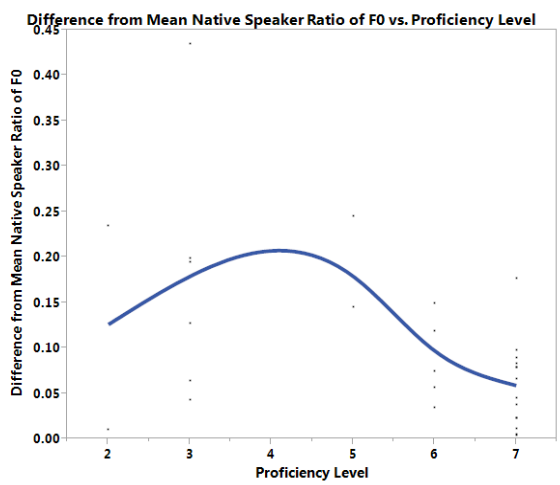

Figure 9: Difference of Mean Mandarin L1 Speaker Ratio of F0 from Mean Native Speaker Ratio of Duration vs. English Proficiency Level

Encouragingly, the results suggest that Chinese learners of English are able to overcome their innate difficulties when producing F0 as an acoustic cue to ELS through increased L2 study.

4.54 Arabic L2 English

Correlations of production accuracy of duration versus amount of L2 study and proficiency level both yielded significances, approximately $r = -.3$, $p < 0.05$ in each case (Figures 10-11).

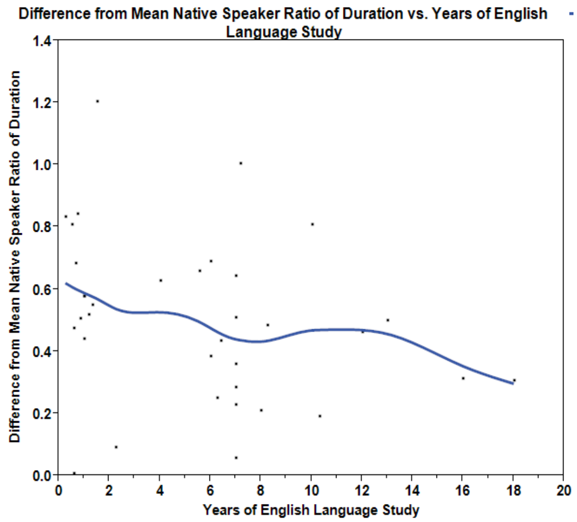

Figure 10: Difference of Mean Arabic L1 Speaker Ratio of Duration from Mean Native Speaker Ratio of Duration vs. Years of L2 English Study

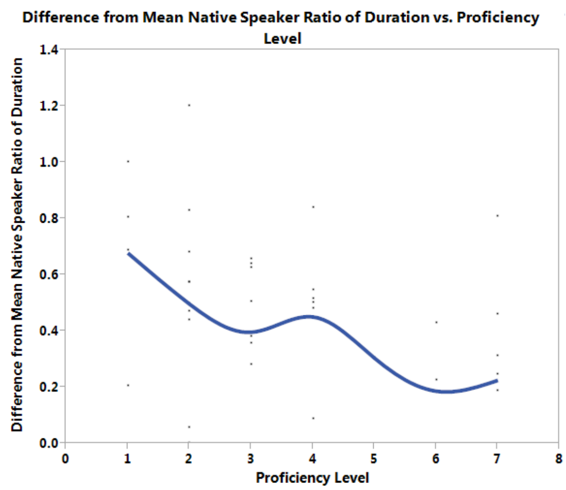

Figure 11: Difference of Mean Arabic L1 speaker Ratio of Duration from Mean Native Speaker Ratio of Duration vs. English Proficiency Level

Comparing these results with those from the ANOVA (Figure 4), it is proposed that through increased acquisition of the English language, Saudi learners are also able to overcome the detrimental effects of negative transfer from their L1 sound system.

4.6 Palatal glide epenthesis in the stress-shifting suffixes: <ian>, <ious>, and <ial>

The researcher identified a surprisingly high incidence of /j/ epenthesis in the tokens <historian>, <historious>, and <historial> (Figure 12).

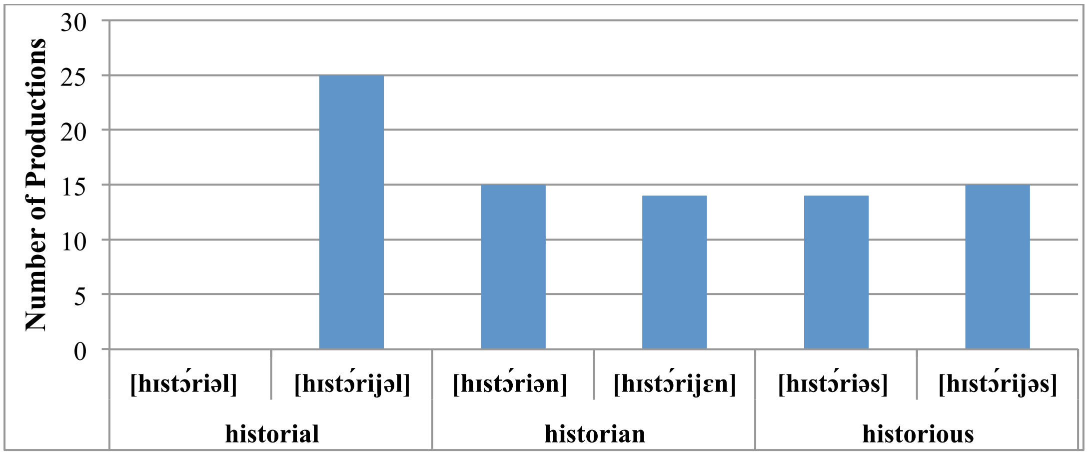

Figure 12: Proportion of Standard American English Dictionary Pronunciations
vs. Proportion of Alternative Pronunciations with Epenthetic Palatal Glide by MWAE NES

The results suggest that [hɪˈstɔri**j**ən] be included as an alternative pronunciation to [hɪˈstɔriən] in standard American English dictionaries since almost half of the MWAE NES subjects pronounced it this way (Figure 13-14). The author concludes that American English dictionary pronunciation entries for words containing Level 1 [+cyclic] suffixes, <ian>, <-ial>, and <-ious> may need to be revised.

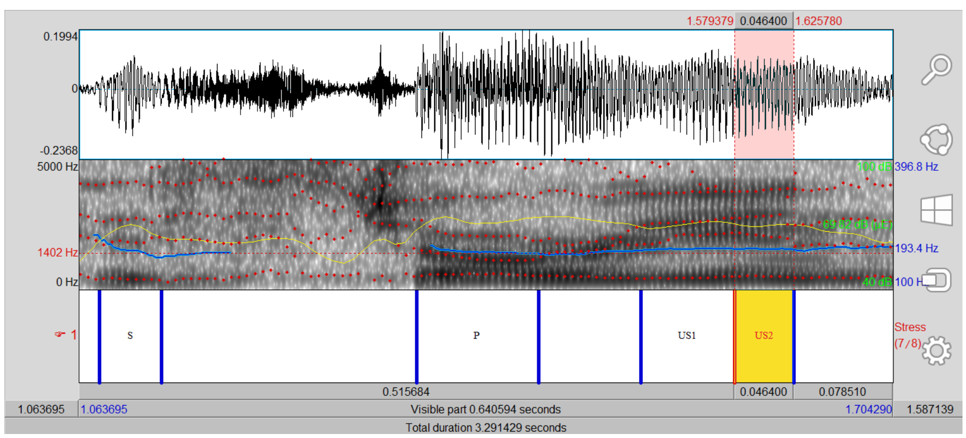

Figure 13: <Historian> Produced by a Midwest American Male
in Accordance with the Standard Dictionary Pronunciation, [hɪstɔ́riən], *without* an Epenthetic /j/

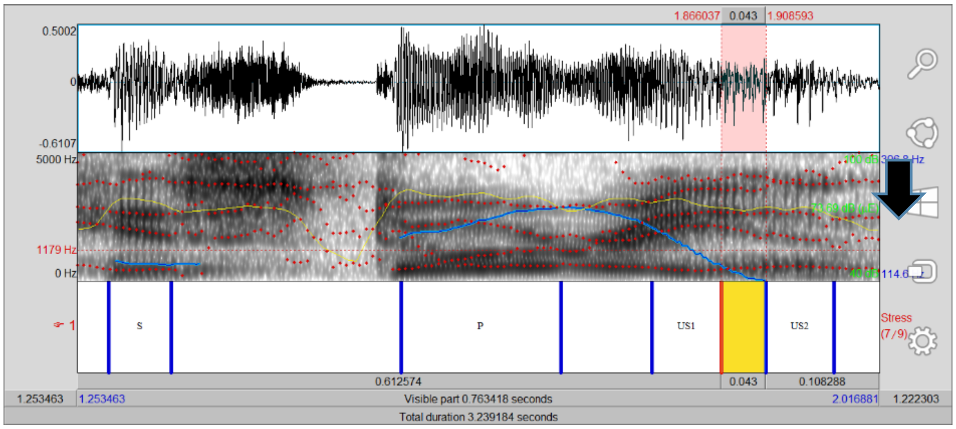

Figure 14: <Historian> Produced by a Midwest American Male as [hɪstɔ́rijən] *with* an Epenthetic /j/ in the Onset of the Ultima

4.7 Lack of evidence for "tonic accent shift" in polysyllabic Level 1 [+cyclic] derivations

Paired sample *t*-tests failed to support Ladefoged and Johnson's (2010) notion that tonic accent shift (i.e., the differentiator between primary (*P*) and secondary-stressed (*S*) syllables) is caused by a "major pitch change" (p. 119) in the primary-stressed vowel, at least with respect to polysyllabic Level 1 [+cyclic] derivations. Contrarily, the results reveal that intensity and duration are the relevant prosodic correlates in assigning primary status to a vowel. Even in the disyllabic stem word, <historic>, these two correlates were the most salient. Table 3 provides an overview of the relevant acoustic correlates for each token with respect to tonic accent shift (i.e., primary vs. secondary stress). Clearly, more studies on the features of tonic accent shift in polysyllabic words should be conducted to determine whether the theory is tenable.

Token	F0	Intensity	Duration
<history>	✗	✓	✓
<historial>	✗	✓	✓
<historian>	✗	✓	✓
<historic>	✗	✓	✓
<historical>	✓	✓	✓
<historicity>	✗	✗	✗
<historify>	✗	✓	✓
<historious>	✗	✓	✓

Table 3: Most Salient Acoustic Correlates of Tonic Accent Shift in Primary-Stressed Vowels [+tonic, +stress]
✓ = salient acoustic correlate ✗ = non-salient acoustic correlate

5.0 Conclusion

The results presented in this paper yield insight into several interdependent issues related to lexical stress in polysyllabic English words containing stress-shifting suffixes. First and foremost, this study provides support to the view that the acoustic correlates of stress do indeed have a hierarchy of relative salience, hereinafter named SHACS. The SHACS proposed here is intensity > duration > fundamental frequency (F0). While this does not exactly match any of the schemes described in the literature, it most closely resembles the SHACS postulated by Beckman and Edwards (1994): duration > intensity > F0. Most likely, SHACS is context dependent. For instance, Fry's (1955, 1958) notion of SHACS (i.e., F0 > duration > intensity>) may only be relevant to disyllabic homographs while intensity may only be the most salient acoustic cue in three and four syllable words. Clearly, more studies on English lexical stress (ELS) in a wide range of polysyllabic words are needed to validate this hypothesis. What is certain though is that relative vocalic stress ratios of the three acoustic cues play an important role in differentiating lexical stress patterns, and there does appear to be a native-norm for ordering these acoustic signals. Indeed, the various significant correlations described in this paper support this notion.

From a second language acquisition perspective, there is good evidence to suggest that native-like command of the acoustic correlates *is* attainable for English language learners. Although speakers with different inherent L1 sound systems encounter different problems when trying to acquire native-like stress production, it favorably appears that they can overcome these difficulties through increased input of the L2. Not only do experienced English language learners produce fewer pronunciation errors, they also produce prosodic contrasts in a more native-like manner. For instance, although Saudi speakers inherently under-use duration as acoustic cue to ELS - perhaps by not fully reducing vowels as a result of L1 transfer from the predictable stress system as suggested by other researchers (Zuraiq & Sereno, 2005; Altmann, 2006; Bouchhioua, 2008) - they *are* able to use this acoustic correlate more accurately as their language skills progress. Similarly, Chinese learners of English are able to overcome the negative transfer of their tonal system by producing pitch in a more native-like manner as they advance in their studies.

Furthermore, the present results do not support Ladefoged and Johnson's (2010) theory of tonic accent shift. Instead, the results actually suggest the opposite; that is, intensity and duration appear to be responsible for contrasts between primary and secondary stressed vowels. It will be interesting to observe whether these findings can be replicated, and whether the variables of token length (disyllabic vs. polysyllabic words) and/or token delivery method (read utterances vs. natural speech) have any effect.

Finally, with regards to pronunciation, this investigation provides convincing evidence for a possible revision of standard American English dictionary IPA transcriptions. At least for the words in this study, the suffixes <-ial>, <-ian>, and <-ious> were more commonly pronounced by native and nonnative speakers with the epenthetical insertion of a palatal glide, [j]. Thus, future studies should explore the presence or absence of this phenomenon in other dialects of English, both native and nonnative.

ABOUT THE AUTHOR

Paul Keyworth graduated from the MA TESL/Applied Linguistics program at SCSU in March, 2014. This paper is an abridged version of his Master's thesis project. Paul has spent the past 12 years teaching EFL/ESL to children and adults of all proficiencies in

South Korea, Singapore, the UK, and the US. He earned a B.Sc. degree from the University of Kent at Canterbury in Molecular and Cellular Biology in 2001 and attained the University of Cambridge Certificate in English Language Teaching to Adults (CELTA) in 2008. His area of research interest is the interface between laboratory phonology and the sociophonetic aspects of second language acquisition. He intends to pursue a Ph.D. in the field of acoustic phonetics and speech communication.
E-mail: keyworth.paul@gmail.com LinkedIn: www.linkedin.com/in/keyworth/

Thesis Committee: Dr. Ettien Koffi (Chair), Dr. Michael Schwartz, and Dr. Monica Devers.

Recommendation: This MA Thesis summary was recommended for publication by Professor Ettien Koffi, Ph.D., Linguistics Department, St. Cloud State University, St. Cloud, MN. Email: enkoffi@stcloudstate.edu

Acknowledgements
The study reported here was supported in part by the Student Research Fund - an internal grant awarded by the Office of Sponsored Programs at Saint Cloud State University.

References

Adams, C., & Munro, R. (1978). In search of the acoustic correlates of stress: fundamental frequency, amplitude, and duration in the connected utterance of some native and non-native speakers of English. *Phonetica, 35,* 125-156.

Altmann, H. (2006). The Perception and Production of Second Language Stress: A Cross-Linguistic Experimental Study. *Dissertation Abstracts International, Section A: The Humanities And Social Sciences*, *67*(6), 2133-2134. (2006753642)

Beckman, M. E., & Edwards, J. (1994). Articulatory evidence for differentiating stress categories. In P. Keating (Ed.), Phonological structure and phonetic form. Papers in Laboratory Phonology III (pp. 7-33). Cambridge: Cambridge University Press.

Boersma, P., & Weenink, D. (2013). Praat: Doing Phonetics by Computer (Version 5.3.32) [computer program], < http://www.fon.hum.uva.nl/praat/>. Amsterdam: University of Amsterdam.

Bouchhioua, N. (2008). Duration as a cue to stress and accent in Tunisian Arabic, native English, and L2 English. Proceedings from Speech Prosody 2008: *The Fourth International Conference on Speech Prosody*. (pp. 535-538). Campinas: Brazil.

Carroll, J.B., Davies, P., & Richman, B. (1971). *The American heritage word frequency book*. New York: Houghton Mifflin.

Celce-Murcia, M., Brinton, D., & Goodwin, J. M. (1996). *Teaching pronunciation: A reference for teachers of English to speakers of other languages*. Cambridge: Cambridge University Press.

Cowart, W. (1997). *Experimental syntax.* Thousand Oaks, Sage.

de Jong, K., & Zawaydeh, B. A. (1999). Stress, duration, and intonation in Arabic word-level prosody. *Journal of Phonetics, 27,* 3-22.

Flege, J. E., & Bohn, O. S. (1989). An instrumental study of vowel reduction and stress placement in Spanish-accented English. *Studies in Second Language Acquisition, 11*, 35-62.

Fry, D. B. (1955). Duration and intensity as physical correlates of linguistic stress. *Journal of the Acoustical Society of America,* 27, 765-768.

Fry, D. B. (1958). Experiments in the perception of stress. *Language & Speech*, *1:2,* 126-152.

Halle, M., & Kenstowicz, M. (1991). The free element condition and cyclic versus noncyclic stress. *Linguistic Inquiry, 22,* 457-501.

Keating, P., & Kuo, G. (2012). Comparison of speaking fundamental frequency in English and Mandarin. *Journal of the Acoustical Society of America, 132,* 1050-1060.

Kiparsky, P. (1982). From cyclic phonology to lexical phonology. In H. van der Hulst & N. Smith (eds.), *The Structure of Phonological Representations* I, pp. 131-175. Dordrecht: Foris.

Kreidler, C. W. (2004). *The pronunciation of English: A course book, 2nd edition.* Malden, MA: Blackwell.

Ladefoged, P. (2001). *A course in phonetics*, 4th edition. New York: Thomson-Wadsworth.

Ladefoged, P. (2003). *Phonetic data analysis: An introduction to fieldwork and instrumental techniques*. Malden, MA: Blackwell.

Ladefoged, P., & Johnson, K. (2010). *A course in phonetics*, 6th edition. New York: Thomson-Wadsworth.

Lee, S., & Cho, M. (2011). An acoustic analysis of stressed and unstressed vowels in English nouns: A cross-language case study. *Korean Journal of English Language and Linguistics* 17, 61-88.

Li, B., & Shuai, L. (2011). Suprasegmental features of Chinese-accented English. *Journal of the Acoustical Society of America, 129,* 2453.

Lieberman, P. (1960). Some acoustic correlates of word stress in American English. *Journal of the Acoustical Society of America, 32,* 451-454.

Maeda, S. (1976): A characterization of American English intonation. (Doctoral dissertation). MIT: Cambridge, MA. Retrieved from: http://hdl.handle.net/1721.1/29189. (edsoai.654895205)

Post, B., & Nolan, F. (2012). Data collection for prosodic analysis of continuous speech and dialectal varaiation. In A. C. Cohn, C. Fougeron, and M.K. Huffman (Eds.), *The Oxford handbook of laboratory phonology* (pp. 538-547). NY: Oxford University Press.

Ryan, K. (2005). Grid-maker.praat [Praat script]. Available from http://www.linguistics.ucla.edu/faciliti/facilities/acoustic/praat.html

Yoon, T. (2008). Stress analysis script [Praat script]. Available from http://web.uvic.ca/~tyoon/resource/vq.praat

Zhang, Y., Nissen. S.L., & Francis, A.L. (2008). Acoustic characteristics of English lexical stress produced by Mandarin speakers. *Journal of the Acoustical Society of America, 123:6,* 4498-4513.

Zuraiq, W. (2006). The Production of Lexical Stress by Native Speakers of Arabic and English and by Arab Learners of English. *Dissertation Abstracts International, Section A: The Humanities and Social Sciences*, *66*(12), 4375. (2006751445)