

# A Preliminary Study of Lexical Stress in Taiwan English Homographs

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## Abstract

In this study lexical stress of homographs uttered by speakers with three different levels of English, namely native Americans, Taiwanese students specializing in English and students with basic knowledge of English, is investigated. The acoustic properties of duration, fundamental frequency and intensity are studied. A new measure is proposed based on the ratio of successive vowels that is insensitive to speaker and speed variations. The results show that the degree to which duration and fundamental frequencies are varied in successive vowels is related to the English level of the speaker. Intensity was not found to be a significant cue.

## 1. Introduction

Research into the acquisition of second language phonology has primarily focused on the level of segments [1, 2, 10, 11, 17]. An increasing number of studies have investigated the suprasegmental features of second language phonology [5, 18]. Stress, in particular, has attracted considerable attention. According to Wijk [20], there are two types of stress which can be realized in English phonology, namely lexical stress and sentence stress. Lexical stress is realized at the word level emphasizing individual syllables in words, while sentence stress is realized at the sentence level emphasizing individual words in sentences. Chen, Robb, Gilbert, and Lerman [3] examined Mandarin speakers' sentence stress realization of English. In their study, they measured the fundamental frequency (F0), vowel duration, and vowel intensity in the sentence stress produced by 40 Mandarin speakers, and compared the results to those produced by 40 American speakers. They found that the sentence stress realization in Mandarin speaker's English production was not identical to that of American speakers. The subjects in their study showed a significantly higher F0 and shorter duration compared to American speakers when producing stressed words.

The present study focuses on lexical stress. The realization of lexical stress in English speech production by Mandarin speakers is examined and compared to that of native American speakers. F0, vowel duration, and vowel intensity of both stressed and unstressed syllables are measured. The rest of this paper is organized as follows. In section 2, the literature related to lexical stress and second language learners' realization of lexical stress in English is reviewed. Section 3 states the specific research questions in the present study. The methodology, including subjects, materials, and the process of analysis, is introduced in section 4. Section 5 presents our results and a discussion of the findings. Finally, the paper is concluded in section 6.

## 2. Background

### 2.1. Stress

According to Ladefoged [7], stressed syllables are "those on which the speaker expands more muscular energy...and usually involves pushing out more air from the lungs" (p. 231). Physically, stressed syllables carry greater respiratory energy than unstressed syllables. However, what are the universal acoustic properties stressed syllables carry in comparison with unstressed ones? There does not seem to be a definite answer to this question in the literature. As Ladefoged noted, "stress can always be correlated with something a speaker does rather than with some particular acoustic attribute of the sounds" (p. 93). However, according to Ladefoged, by spending more muscular energy and pushing more air out from the lungs, stressed syllables are usually, but not always, higher in pitch, which can be measured with the fundamental frequency (F0) of the sounds, louder, which can be measured with the acoustic intensity of the sounds, and longer in duration. Furthermore, spectral features such as formant frequencies were also considered to be valid cues to signal stress [16]. Spectral features are not addressed in this study. Therefore, F0, vowel intensity, vowel duration, and spectral features can be acoustic characteristics that signal stress.

Although F0, vowel intensity, and vowel duration can be used by speakers to signal stress, there seems to be no universal pattern. Results from experimental studies in the literature shows that different languages realize stress differently in the acoustic domain. Silipo and Greenberg [15] examined the role of duration, intensity, and F0 in signaling stress in spontaneous American English discourse. They found that duration and intensity were the more important parameters, while F0 only played a minor role in distinguishing stressed syllables from unstressed ones. Potisuk, Gandour, and Harper [13] investigated the acoustic parameters in Thai. The results of their experiments revealed that duration was the most dominant parameter in distinguishing stressed syllables from unstressed syllables, and that intensity had no significant roles, while the importance of F0 was somewhere in between.

### 2.2. Second language learners' realization of stress

Wijk [20] stated that one of the major difficulties in second language learners' pronunciation of English was the realization of stress. Differences in the realization of lexical stress between second language learners with different language backgrounds and American native speakers are found in the literature. Shibuya [14] examined the stress realization of native speakers of Japanese in terms of the F0 and duration of the stressed syllables, and compared the results with that of American speakers. Their experimental results demonstrated that Japanese speakers realized stress

differently from American speakers. In terms of duration, the Japanese speakers in their study showed an increase when producing stressed syllables as American speakers did, but the differences among stressed syllables and unstressed ones were much smaller than those produced by American speakers. On the contrary, in terms of F0, the opposite direction was found. Both the Japanese speakers and the American speakers produced stressed syllables with higher pitch, but the production by Japanese speakers revealed greater differences than that by the American speakers. Pickering and Wiltshire [12] examined the acoustic properties of stress in Indian English and American English. One of the major findings in their study was that speakers of American English realized stress with a higher pitch, while speakers of Indian English realized stress with a lower pitch.

### 2.3. Objectives and Research Questions

The aim of the present study is to first examine how native Mandarin speakers realize lexical stress in their production of English. Then, the results will be compared with American speakers to see how Mandarin speakers realize stress in English differently from American speakers. As mentioned earlier, F0, vowel duration, and vowel intensity are the three acoustic parameters signaling stress. These three parameters will be the acoustic measurements in the present study.

## 3. Method

### 3.1. Subjects and materials

There are a total of 24 participants, divided into three groups. Group A consisted of eight Americans ranging from 19 to 33 years of age, Group B included eight native Mandarin speakers who were English majors ranging from 19 to 24 years of age, and Group C comprising eight native Mandarin speakers who were non-English majors ranging from 21 to 29 years of age. The English-major participants were all undergraduate students at National Cheng Kung University in Taiwan. The Non-English-major participants include graduate students and undergraduate students at National Cheng Kung University. All the English-major subjects had an extensive exposure to English, at least two years more than the non-English-major subjects.

Most previous studies on the acoustic realization of stress compares stressed syllables with unstressed syllables within the same word [20]. However, differences in pitch, vowel duration, and vowel intensity between stressed and unstressed syllables may be caused by the differences in the nature of their vowel qualities. Therefore, in the present study, a different method is proposed to minimize the effect of the differences between the vowel qualities.

Ten pairs of disyllabic homographs identical in their segmental features, but different in their stress placement, were selected as the test items in the present study. In each pair, the first member is a trochaic noun whose stress falls on the first syllable, and the second member is an iambic verb whose stress falls on the second syllable. Since each pair of the test items are identical in spelling, an indication of the target word's grammatical category were provided in the beginning for each item, and a priming sentence in which the target word was underlined was also provided prior to the test item. Both devices were employed to ensure subjects' correct

stress placement in the target words. The reading material is provided in the Appendix.

### 3.2. Data collection

Each subject met with the experimenter individually in a quiet room in National Cheng Kung University. They were first asked to familiarize themselves with the reading list. Then, subjects were asked to read the reading material provided by the experimenter. Before they started to read, they were told that they would not be interrupted during their reading and that they could repeat without informing the experimenter if they made any mistake. When subjects misread words and did not correct the mistake, the experimenter noted down those mistakes and asked the subjects to re-read those items upon completing the set reading task. Their readings were recorded using Praat through a microphone connected to a Compaq Presario laptop computer.

### 3.3. Analysis

Praat was used to extract subjects' production of the disyllabic target words. Each vowel of the target word was marked at its onset and offset. All the extracted vowels were acoustically measured in terms of their duration, mean F0, F0 at the onset position, F0 at the offset position, peak intensity, valley intensity, and mean intensity.

## 4. Results and discussion

### 4.1. Duration

In order to examine whether duration is used by subjects to realize stress, a parameter  $D$  is proposed (pair-wise vowel ratio).  $D$  is defined as the ratio of duration of the first vowel to that of the second vowel in a target word, and can be derived from the following equation.

$$D = \frac{\text{duration of the first vowel}}{\text{duration of the second vowel}} \quad (1)$$

For each pair of words, two  $D$  values can be derived,  $D[N]$  and  $D[V]$ .  $D[N]$  is defined as the  $D$  value of the noun in each pair of target words, and  $D[V]$  is defined as the  $D$  value of the verb in each pair of the target words. For example, for the target pair *conduct[N]/conduct[V]*,  $D[N]$  would be the ratio of the duration of the first vowel to that of the second vowel in 'conduct' when it is pronounced as a noun, that is, when the stress falls on the first syllable, and  $D[V]$  would be the ratio of the duration of the first vowel to that of the second vowel in 'conduct' when it is pronounced as a verb, that is, when the stress falls on the second syllable. Given these two parameters, if we are to see whether subjects realize stress by lengthening the vowel duration, we would expect to find that for each pair of target words,  $D[N]$  is greater than  $D[V]$  since the stress falls on the first syllable in the noun of each pair of the target words, and on the second syllable in the verb counterpart.

Given that the only difference of the two words in each pair is their stress placement, we would expect to find  $D[N]/D[V]$  to be greater than 1 if the stressed vowels are lengthened. Table 1 list the mean values of  $D[N]/D[V]$  for the three groups.

Table 1: Prosodic features extracted from homographs.

Subject group	duration	intensity	f0
US Native	1.88	1.16	1.80
TW English-major	1.58	1.10	1.34
TW Non-English-major	1.25	1.10	1.59

Table 1 shows that for US native English speakers the value of  $D[N]/D[V]$  is the largest and hence indicates a larger difference in duration for the noun and the verb forms of the homographs. The second largest value is displayed by the Taiwanese speakers who are majoring in English and hence should be relatively trained in English pronunciation. As expected, the smallest value is measured among the Taiwanese speakers who are not majoring in English. These subjects have received limited English pronunciation training and hence are less likely to differentiate the pronunciation of the verb and the noun forms of the homographs. These differences are statistically significant ( $F(2,21)=10.9;p<0.001$ ). The statistical test was conducted using a one-way analysis of variance with subject type as factor and eight subjects as replications. This suggests that although stressed vowels are not always lengthened, duration seems to be also used by non-English-major subjects to realize stress, but not as much as American speakers do.

The  $D$  value is approximately insensitive to variations in speech speed. We can assume that the speed remains approximately constant across two consecutive vowels. Therefore imagine that the actual duration is related to the speech rate as follows  $d_i = f_i d_{mean}(s)$ , where  $d_i$  is the duration of vowel  $i$ ,  $f_i$  is the stress factor for vowel  $i$  and  $d_{mean}(s)$  is the mean syllable duration for speaker  $s$ . When computing a ratio of consecutive vowels, the speaker-dependent mean syllable duration therefore cancels.

#### 4.2. Intensity

Peak intensity  $I_p$  is used to represent vowel intensity.  $I_p$  is defined as the ratio of the peak value of the intensity of the first vowel to that of the second vowel, namely:

$$I_p = \frac{\text{Peak Intensity of the first Vowel}}{\text{Peak Intensity of the second vowel}} \quad (2)$$

If we are to see whether intensity, in terms of peak value, is used by speakers to signal stress, we would expect to find for each word pair, the  $I_p$  value of the noun,  $I_p [N]$ , will be greater than the  $I_p$  value of the verb counterpart,  $I_p [V]$ , since the stress falls on the first syllable in the noun of each pair of the target words, and on the second syllable in its verb counterpart. In other words, we would expect to find  $I_p [N]/I_p [V]$  to be greater than 1. The mean values for the three groups are plotted in Figure 1.

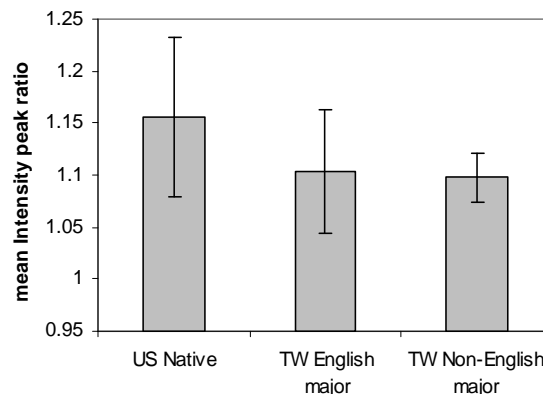


Figure 1: Mean intensity peak rate.

Although Figure 1 shows that native US speakers have a larger difference between stressed and non-stressed vowels than Taiwanese speakers; the results are not statistically significant ( $F(2,21)=2.5;p>0.1$ ). There is therefore no evidence to suggest that the different groups use intensity differently to signal stress.

#### 4.3. Pitch

We will look at the mean vowel pitch  $P_m$  in order to examine whether pitch is used by subjects to realize stress.  $P_m$  is defined as the ratio of the mean value of the pitch of the first vowel to that of the second vowel, namely

$$P_m = \frac{\text{Mean Pitch of the first Vowel}}{\text{Mean Pitch of the second vowel}} \quad (3)$$

If we are to see whether vowel pitch, in terms of its mean value, is raised in stressed vowels, we would expect to find for each word pair, the  $P_m$  value of the noun,  $P_m [N]$ , will be greater than the  $P_m$  value of its verb counterpart,  $P_m [V]$ , since the stress falls on the first syllable in the noun of each pair of the target words, and on the second syllable in its verb counterpart. In other words, we would expect to find  $P_m [N]/P_m [V]$  to be greater than 1.

Table 1 confirms that there is a difference between the three groups, where native US subjects use pitch to a greater degree to signal stress than the Taiwanese subjects. This difference is statistically significant ( $F(2,21)=7.7;p<0.004$ ).

The results show that in both of the two varieties of English, the pitch of the stressed vowel is raised at both the onset and offset positions, and the overall mean pitch of the stressed vowel is also raised compared to its unstressed counterpart. This suggests that pitch is a device used by both American English speakers and Taiwan English speakers to realize stress.

## 5. Conclusion

In this study, acoustic realization of lexical stress in Taiwan English and American English are examined. The results suggest that in both Taiwan English and American English, stress syllables are realized by lengthening the duration, enhancing the intensity, and raising the pitch of the vowels. Although both varieties of English realize stress with duration,

intensity, and pitch quality of the vowels, some differences were also observed. In terms of duration, our results illustrated that American English speakers lengthen stressed vowels to a greater extent than Taiwan English speakers do. This echoes with Jian's [6] finding that while American English is a stress-timed language, Taiwan English tends to be more syllable-timed. Similar pattern was also found in our analysis for intensity and pitch. Our results demonstrated that American English enhances the intensity and raises the pitch of stressed vowels to a greater extent than Taiwan English does.

## 6. References

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## Appendix

Abstract (N).	You should submit an abstract of your paper.
Abstract (V).	You should abstract the most important points from your paper.
Discount (N).	Those stores offer a discount of three percent on cash purchases.
Discount (V).	Those stores discount three percent for cash payment.
Impact (N).	His father has a strong impact on him.
Impact (V).	The new policy will strongly impact the stock market.
Import (N).	The import of diseased animals was forbidden.
Import (V).	We export rice but import wheat.
Insult (N).	She can't forgive any insult to her pride.
Insult (V).	I never meant to insult you.
Misprint (N).	There is a misprint in this paper.
Misprint (V).	Don't misprint any part of the paper.
Prefix (N).	"Non-" is a prefix with negative meaning.
Prefix (V).	We prefix "Mr." to a man's name.
Refill (N).	Please give me a refill of the drink.
Refill (V).	Please refill my drink.
Transport (N).	The machines will be ready for transport tomorrow.
Transport (V).	They will transport the machines to Taipei tomorrow.
Upset (N).	I had a stomach upset last night.
Upset (V).	The rain has upset our plans for a picnic.