An Acoustic Study on the Durational Correlates of Stress in Welsh English

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1. Introduction

The prosody of Welsh English, which is often described as ‘sing-song’, is noticeably different from that of Received Pronunciation (RP) or Standard Southern British English (SSBE). Its characteristics are considered to be transferred from Welsh, one of the Celtic languages widely spoken in Wales until two centuries ago (Wells 1982: 377). Despite the remarkable prosodic characteristics of Welsh and Welsh English, studies on the two to date have mostly concentrated on their segmental features; their prosodic features are in need of further research. The major works currently available on the prosody of Welsh are Williams (1986) and Rhys (1984), and those on Welsh English are Walters (2006) and Connolly (1981). Although other studies (e.g. Collins and Mees 1990; Connolly 1990) report several noticeable prosodic features in various accents of Welsh English, these studies mainly discuss segmental features.

In addition to the lack of works with which the whole picture of the prosody of Welsh and Welsh English can be grasped, one problem with the previous studies in this field is that there are few acoustic or experimental studies. Most of the previous papers are impressionistic and are not based on acoustic data. Recent progress in the field has been achieved by Webb (2011), who conducted a brief experiment and acoustic analysis of difference in the way of stress manifestation in Welsh, Welsh English, and SSBE. However, as her study deals with only two short vowels, there remains room for further investigation.
Among the previous studies on the prosodic features of Welsh and Welsh English, the topic which has gained the most attention from researchers is stress. The present study also focuses on this aspect of Welsh English and aims to show the peculiarities of stress-induced durational adjustment in Welsh English through acoustic and statistical analyses. The primary concern was to investigate the difference in segmental duration between stressed and unstressed syllables in Welsh English. To this end, a field recording was made in Neath, South Wales. In addition, two speakers of Southern British English (SBE) were also recorded to compare the durational features of the two accents and to demonstrate the peculiarities in stressed segments of Welsh English.

Section 2 will summarise how stress and other factors affect vowel duration in standard accents of English and Welsh, of which features have transferred into Welsh English. The present understanding of stress correlates in Welsh English will also be discussed in Section 2.3. Based on previous studies of both Welsh and Welsh English, an experiment was designed and conducted. The methodology will be outlined in Section 3, and the results of acoustic and statistical analyses will be presented in Section 4. Section 5 will briefly summarise the main findings.

2. Stress systems

2.1. Stress in standard accents of English

In standard accents of English, stressed syllables are set off from the surrounding environment by the acoustic nature of their components. They also serve as the rhythmic beat. Thus, stressed syllables are prominent acoustically as well as rhythmically.

Through acoustic analysis of speech and perceptual experiments, researchers have tried to identify which of the three acoustic correlates, fundamental frequency (F0), duration, or intensity, is the most important feature for the manifestation and perception of stress (e.g. Fry 1955). It is now generally understood that F0 is the primary cue, while the relative importance of duration and intensity is unclear. In
standard accents of English, stressed syllables usually have a higher Fx or carry Fx movement, and they often have greater (vowel) duration and intensity than unstressed syllables.

In regard to duration, which is of interest of this paper, Fry (1955) observed a major difference between stressed and unstressed vowels (p. 765). In his data, stressed vowels were longer by 50 ms\textsuperscript{1} on average than unstressed ones (p. 768). Another experiment found that stressed syllables were more than twice as long as unstressed ones (Fant, Kruckenberg, and Nord 1991: 359). The same trend, the greater duration of the stressed vowel, have also been observed in other languages such as French and Swedish (Fant, Kruckenberg, and Nord 1991).

It should be noted here that several other factors can affect segment duration. These factors include the number of phonemes in the syllable and foot, speech style, speech rate, and the nature of the following consonant. Above all, the nature of the following consonant, particularly the presence/absence of voicing, has a significant influence on the duration of the preceding vowel. When a vowel is followed by a fortis consonant, it becomes markedly shortened compared to when it is followed by a lenis consonant. Peterson and Lehiste (1960) report that short vowels were 60 ms shorter on average when they were followed by a fortis consonant than when they were followed by a lenis consonant. The difference was more conspicuous in long vowels (i.e. long monophthongs and diphthongs); pre-fortis clipping produced more than 100 ms difference on average (p. 702).

2.2. Stress in Welsh

Stress regularly falls on the penult in Welsh.\textsuperscript{2} Stressed syllables in Welsh, however, do not have the features described in Section 2.1. It has long been pointed out that stressed penults in Welsh serve primarily as a rhythmic beat, and it is unstressed final syllables which have a higher Fx and longer duration (Jones 1950: 63; Watkins 1954: 8). This observation was borne out in an acoustic study by Williams (1983; 1986). She investigated acoustic features associated with short monophthongs in phonologically stressed penultimate and unstressed ultimate syllables.
bles. Her data showed that vowels in a stressed syllable had little Fx movement and shorter duration, while vowels in an unstressed syllable had greater Fx movement and longer duration, though peak and mean amplitude may be greater in the stressed syllable than in the unstressed syllable (1983: 31–32, 34–36). Because of the dissociation of the physical cues of stress from the stressed syllable\(^3\), it has been reported that final syllables sound as if they are stressed to non-native speakers of Welsh (Watkins 1954: 8; Williams 1983: 31–2, 34–6). Table 1 summarises the features associated with stressed penults and unstressed final syllables in Welsh.

Table 1  Phonetic features of stressed penultimate and unstressed final syllables in Welsh

<table>
<thead>
<tr>
<th>Acoustic feature</th>
<th>Stressed penult</th>
<th>Unstressed final syllable</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fx (compared with neighbouring syllable)</td>
<td>lower</td>
<td>higher</td>
</tr>
<tr>
<td>Fx movement</td>
<td>little movement</td>
<td>greater movement</td>
</tr>
<tr>
<td>Duration</td>
<td>shorter</td>
<td>longer</td>
</tr>
<tr>
<td>Amplitude</td>
<td>greater</td>
<td>lower</td>
</tr>
</tbody>
</table>

Among the features associated with stress, Williams (1983) found that duration is the most reliable\(^4\). She then further investigated segmental durations and found that despite being the most consistent cue, the difference in vowel duration was statistically insignificant\(^5\) (p. 37–38).

2.3. Stress in Welsh English

It has been found that Welsh English reflects some prosodic characteristics of Welsh. Most studies on Welsh English to date report phonetic prominence on unstressed syllables following the stressed syllable rather than on the stressed syllable itself (Thomas 1997: 72; Walters 2006: Ch. 5). The durational feature discussed in Section 2.2 has also been observed in Welsh English. There are, however, a few differences. The major difference is that in Welsh English, lengthening as well as shortening occurs in stressed vowels (Walters 2003). One factor which Walters (2003) assumes to condition shortening and lengthening
is the syllable boundary. He writes as follows:

The indication in the data is that speakers have a measure of freedom how they syllabify. Words of similar phonetic composition and even identical words are found syllabified differently in the data, for example, *second* is found either as [sɛkˈænd] or [seˈkʌnd], and *chapel* either as [tʃæpˈl] or [tʃæˈpl]. (p. 219, italics in the original)

Walters (2003) further argues that not all vowels are subject to shortening and lengthening. According to his report, shortening was found in any short vowels, while lengthening was found only in the lower vowels /e, a, ə/ in open syllables. Likewise, shortened tokens were found with high long vowels, /iː, uː/, and lengthened tokens with other long vowels /eː, eː, aː, əː, ɔː, ɔː:/

Diphthongs were found to be shortened frequently (Walters, 2006: Appendix 17). Table 2 summarises the findings of this research.

In regard to vowel shortening, the difference between Welsh English and standard accents of English is that shortening is not caused, at least not solely, by a following fortis consonant. Walters (2003) observed remarkable shortening of stressed vowels followed by a lenis consonant (p. 218).

Table 2  Vowels subject to shortening and lengthening and consonantal environments

<table>
<thead>
<tr>
<th>Shortening</th>
<th>Lengthening</th>
</tr>
</thead>
<tbody>
<tr>
<td>Any short vowels: /ɪ, ɛ, a, ə, ʊ/</td>
<td>Before any single consonant and cluster</td>
</tr>
<tr>
<td>/iː, uː/</td>
<td>Before fortis consonants and clusters</td>
</tr>
<tr>
<td>Any Diphthongs</td>
<td>Before any consonant</td>
</tr>
</tbody>
</table>

When not followed by a consonant in the same syllable | In any context

Some of the earlier observations have been supported by Webb’s (2011) brief experimental study. She examined four disyllabic English words pronounced by five Welsh/English bilinguals and SSBE speakers. The stressed vowels and post-stress consonants chosen for her experiment
were /a/ and /ʊ/, and /n/ and /s/. Her data showed a statistically significant difference in the duration of post-stress consonants between the two groups: The mean duration was 81 ms in SSBE and 122 ms in Welsh English (p<.001). The average duration of stressed vowels was shorter in Welsh English than in SSBE. However, contrary to her expectations, the comparison between stressed and unstressed vowels in Welsh English revealed that the former was in fact longer than the latter (p. 2108). As the stressed vowels investigated in her study are short /a/ and /ʊ/, however, the results are not surprising; these vowels are subject to lengthening as well as shortening, as mentioned above.

3. Experiment

3.1. Experimental design

In order to examine the effect of stress on vowel duration in Welsh English, field recordings were made. Seven Welsh English speakers and two SBE speakers took part in the experiment. All the Welsh English speakers were born and brought up in Mid/West Glamorgan, South Wales. The SBE speakers were born and brought up in London. The SBE speakers were recorded as a reference group to facilitate an understanding of the way and the extent to which Welsh English speakers differ from speakers of the accent varieties of England.

The recordings were held in a hotel room, consultant’s house, or sound-proof room. Although the quality of the recordings varied depending on the environment in which the recording sessions took place, it was generally sufficient for acoustic analysis. All the consultants were recorded with computer software for phonetic research, SFS, at a sampling rate of 44100 Hz with a condenser microphone.

During the recording sessions, the consultants took part in a map task. They were shown maps of an imaginary country with the names of islands, towns, and streets. The descriptions of islands, etc. were read aloud by the experimenter, and the consultants were asked to answer with the names in the carrier sentence ‘You must mean [ ], then’ (placing a name from the map in the square brackets). As the sentence-final adverb ‘then’ was placed at the end of the sentence, the
names of the islands, etc. received no or only a minimal effect of intonation phrase (IP) final lengthening, which significantly lengthens syllables at an IP boundary.

The maps contained 38 names in total: 26 of them were disyllabic nonsense words, and 12 were distractor words consisted of existing disyllabic English street/place names. The consultants were asked the same 38 questions three times in a random order.

The syllable structures of the nonsense words were CVC, CVCC, VC, or CV. The constituent segments were chosen and arrayed so that they fulfilled the phonotactic constraints of English. Among the 20 vowel phonemes of southern Welsh English, 10 were chosen for the nonsense words. These consisted of four short monophthongs, /i, e, a, ɔ/, four long monophthongs, /iː, eː, aː, ɔː/, and two diphthongs, /ai, au/). For the consonants, fortis and lenis plosives, fricatives, and nasals were employed, and approximants were avoided for ease of segmentation.

All the nonsense words consisted of two identical syllables which differentiated solely by the presence/absence of stress (e.g. /'fit.fit/ and /'foi.fo:/). This enabled the investigation of differences in segmental duration caused solely by stress. In addition, as speakers are thought to be conscious about repetition of the same syllable, it was hoped that the nonsense words would automatically imply a syllable boundary and prevent unexpected syllabification.

3.2. Data

The total number of nonsense words annotated for analyses was 562: 451 instances from Welsh English speakers (hereafter, the WE data) and 111 from SBE speakers (hereafter, the SBE data).

Based on previous studies, the vowels were divided into seven groups as shown in Table 3 to facilitate the investigation of the difference in degree and frequency of shortening and lengthening. It must be noted that some of the constituent vowels are different, as the vowel systems of the two accents differ phonologically and phonetically.
Table 3  Vowel groups and their constituents in the WE data

<table>
<thead>
<tr>
<th>Vowel group</th>
<th>WE vowels</th>
<th>SBE vowels</th>
</tr>
</thead>
<tbody>
<tr>
<td>Short /i/</td>
<td>/i/</td>
<td>/i/</td>
</tr>
<tr>
<td>Short Vowels</td>
<td>/e, a, o/</td>
<td>/e, æ, o/</td>
</tr>
<tr>
<td>Checked /i:/</td>
<td>/i:/</td>
<td>/i:/</td>
</tr>
<tr>
<td>Checked Long vowels</td>
<td>/eː, æː, əː/</td>
<td>/æː, əː/</td>
</tr>
<tr>
<td>Free Long Vowels</td>
<td>/iː, aː, əː/</td>
<td>/iː, æː/</td>
</tr>
<tr>
<td>Checked Diphthongs</td>
<td>/ai, au/</td>
<td>/ai, ao, ei/</td>
</tr>
<tr>
<td>Free Diphthongs</td>
<td>/ai, au/</td>
<td>/ai, ao, ei/</td>
</tr>
</tbody>
</table>

4. Results and discussion

4.1. Stress-induced durational adjustment in the WE data

4.1.1. Difference between stressed and unstressed vowels

To begin with, absolute durations of stressed and unstressed vowels were obtained from the annotated data, and mean durations (M) for each vowel group were calculated. Differences between stressed and unstressed vowels in the same word were also identified, and the mean values were calculated. The results of these measurements are shown in Table 4. For stressed vowels, the shortest (S) and longest (L) durations found in the WE data are also tabulated. The column of mean difference has a negative value when the stressed vowels are shorter than the unstressed vowels and positive when vice versa.

The table shows negative values in four vowel groups. Among them, Free Long Vowels show the greatest degree of shortening (–16.0 ms), followed by Short /i/ (–9.6 ms) and Checked /iː/ (–3.8 ms). Although Short Vowels also show a negative value, the difference is only a minor one (–0.1 ms). The shorter mean durations of stressed vowels in Short /i/ and Checked /iː/ support previous studies which have reported frequent shortening of these vowels. However, the greatest negative value in Free Long Vowels is an unexpected result, as Walters (2003) argues that vowels become lengthened but not shortened in open syllables (p. 219).

In Checked Long Vowels, Checked Diphthongs, and Free Diphthongs, stressed vowels were longer on average than unstressed vowels.
by 0.9, 3.7, and 3.6 ms, respectively. The results for Checked Long Vowels and Free Diphthongs are consistent with those of previous studies. However, the differences between stressed and unstressed syllables were found to be quite small.

<table>
<thead>
<tr>
<th>Vowel category</th>
<th>No.</th>
<th>Stressed</th>
<th>Unstressed</th>
<th>Difference</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>M</td>
<td>S</td>
<td>L</td>
</tr>
<tr>
<td>Short /i/</td>
<td>44</td>
<td>72.5</td>
<td>41.4</td>
<td>110.1</td>
</tr>
<tr>
<td>Short Vowels</td>
<td>87</td>
<td>145.6</td>
<td>91.8</td>
<td>185.7</td>
</tr>
<tr>
<td>Checked /i:/</td>
<td>73</td>
<td>103.3</td>
<td>58.8</td>
<td>147.6</td>
</tr>
<tr>
<td>Checked Long Vowels</td>
<td>78</td>
<td>183.8</td>
<td>113.7</td>
<td>323.4</td>
</tr>
<tr>
<td>Free Long Vowels</td>
<td>42</td>
<td>155.4</td>
<td>78.5</td>
<td>257.0</td>
</tr>
<tr>
<td>Checked Diphthongs</td>
<td>89</td>
<td>180.0</td>
<td>88.9</td>
<td>326.8</td>
</tr>
<tr>
<td>Free Diphthongs</td>
<td>38</td>
<td>209.9</td>
<td>170</td>
<td>378.4</td>
</tr>
</tbody>
</table>

(Unit: ms)

4.1.2. Frequency of shortening and lengthening

Although the mean durations of stressed vowels were shorter than those of unstressed vowels in three vowel groups, this does not mean all the stressed vowels in these categories were shorter than the unstressed ones. Likewise, the longer mean durations of stressed vowels do not mean that all the stressed vowels were longer than the unstressed vowels in those vowel groups. The ratio of shorter stressed vowels, however, differed by vowel group, as illustrated in Figures 1 to 3 below.

In Figure 1, most of the data are plotted above the oblique line, suggesting frequent shortening. A similar, though less striking, graph was also obtained for Checked /i:/s. These results reinforce the observation that the two high vowels are frequently shortened in stressed syllables.

Section 4.1.1 mentioned that the greatest degree of shortening found in Free Long Vowels is an unexpected result. This result can be interpreted in two ways. The first interpretation is that shortening may occur in open syllables as well as in closed syllables. The second is that although the nonsense words were designed so that they would
automatically imply a syllable boundary, due to the relatively simple structure, CV.CV, in which free vowels were located, the consultants might have resyllabified them into CVC.V.

A closer investigation indicates that the latter explanation may be correct. Table 4 shows that the mean duration of stressed vowels in Free Long Vowels (155.4 ms) is much shorter than the equivalent in Checked Long Vowels (183.8 ms), even though shortening is not expected to occur in any long vowels except /i:/ (and /u:/) in any environment. In Figure 3 below, the three Free Long Vowels are distinguished with different markers: circles for /i:/, squares for /e:/, and triangles for /ɔ:/.

![Figure 1](image1.png)  
Figure 1  Duration of stressed and unstressed Short /i/ in the WE data

![Figure 2](image2.png)  
Figure 2  Duration of stressed and unstressed Free Long Vowels in the WE data
As can be seen in Figure 2, the front high vowel, /i:/, clusters around the shorter range of duration and is separated from the other two. Therefore, it can be inferred that the front high vowels which are frequently shortened in checked syllables are the contributing factor of the shorter mean duration of stressed Free Long Vowels in comparison to that of Checked Long Vowels. In fact, the mean durations of /e:/ and /ɔ:/ (200.8 and 169.5 ms, respectively) in this group are by no means shorter than those in the Checked Long Vowels (169.1 and 170.0 ms, respectively). It should also be pointed out here that the significant difference between stressed and unstressed vowels in /ɔ:/ (~20.4 ms) in the Free Long Vowels is caused by markedly lengthened unstressed vowels rather than shortened stressed vowels. As mentioned, the mean duration of this vowel in stressed syllables is almost the same as that of /ɔ:/ in Checked Long Vowels. The significant lengthening of unstressed /ɔ:/ is probably due to the syllable structure; vowels in free syllables can readily be lengthened in English, especially in word-final position. These observations suggest that the relatively short mean duration and difference between stressed and unstressed vowels are probably not due to shortening of the stressed free vowels but due partly to re-syllabification and to extra lengthening in unstressed vowels in the word-final open syllable.

Figure 3 is a scatter graph of the Short Vowel durations. In the graph, about half of the data are plotted above the line, and the others
are below. This indicates the equivalent frequency of shortening and lengthening and supports the previous observations. The graphs for the Checked Long Vowels, Checked Diphthongs, and Free Diphthongs show a similar pattern. Though Walters (2006) reports that Checked Diphthongs are frequently shortened, he does not deny the occurrence of lengthening.

However, the result for the Checked Long Vowels is somewhat surprising, given that previous studies have consistently shown vowels in this group are not subject to shortening. On this issue, Connolly (1989) probably gives the best description. Instead of denying the occurrence of shortening in this vowel group, he states that these vowels 'are never fully shortened' (p. 60). The data in the present study also support his description; Checked Long Vowels may be shortened, though the frequency and degree of shortening were not so great in most cases.

The scatter graph for Free Diphthongs also shows about the same amount of shortening and lengthening. Here again, shorter durations of stressed vowels cannot directly be interpreted to mean that shortening occurred in this group. As discussed earlier, given the measure of freedom in syllabification, the possibility remains that the relatively simple syllable structure, CV.CV, caused an unexpected syllabification in several tokens. It was also mentioned that vowels in the word-final open syllables are often lengthened. Considering that the mean duration of stressed Free Diphthongs (209.9 ms) is longer than that of Checked Diphthongs (180.0 ms) and that the mean duration of unstressed Free Diphthongs (206.3 ms) is also longer than that of Checked Diphthongs (179.1 ms), it seems that many of the stressed Free Diphthongs were in fact lengthened, though some of them were shorter than unstressed ones due to either of the abovementioned reasons.

4.1.3. Statistical results for the WE data

Paired sample t-tests were conducted to test the statistical significance of durational differences between stressed and unstressed vowels in the WE data. Significant differences were found for three vowel
groups, Short /i/, Checked Long /iː/, and Free Long Vowels. In Short /i/, in which stressed vowels were most consistently shortened, the difference was significant at the p<.001 level. In Checked Long /iː/, although the mean difference was small (−3.8 ms), it was statistically significant at the p<.05 level. In Free Long Vowels, although the cause for the observed difference may not be attributed to the presence/absence of stress as discussed above, the mean difference was found to be statistically significant at the p<.01 level.

In the other vowel groups, differences were not statistically significant. This may be because lengthening occurred as frequently as shortening did in these groups, cancelling out difference between the stressed and unstressed vowels when averaged.

4.2. Comparison of the WE and SBE data

So far, the focus has been on the difference between stressed and unstressed vowels in the WE data. In this section, measurements of the SBE data will be presented, and differences between the WE and SBE data will be discussed.

To begin with, the duration of stressed and unstressed vowels in the SBE data was measured, and the difference was calculated. Table 5 shows the mean durations of stressed and unstressed vowels, mean differences between stressed and unstressed vowels, and shortest (S) and longest (L) durations of stressed vowels for each vowel category.

Table 5: Results of measurements of the SBE data

<table>
<thead>
<tr>
<th>Vowel categories</th>
<th>No.</th>
<th>Stressed</th>
<th>Unstressed (Mean)</th>
<th>Difference (Mean)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>M</td>
<td>S</td>
<td>L</td>
</tr>
<tr>
<td>Short /i/</td>
<td>8</td>
<td>88.5</td>
<td>67.3</td>
<td>107.9</td>
</tr>
<tr>
<td>Short Vowels</td>
<td>16</td>
<td>146.5</td>
<td>110.9</td>
<td>186.0</td>
</tr>
<tr>
<td>Checked Long /iː/</td>
<td>19</td>
<td>161.4</td>
<td>126.1</td>
<td>237.5</td>
</tr>
<tr>
<td>Checked Long Vowels</td>
<td>14</td>
<td>187.3</td>
<td>137.1</td>
<td>253.3</td>
</tr>
<tr>
<td>Free Long Vowels</td>
<td>10</td>
<td>190.0</td>
<td>138.0</td>
<td>253.5</td>
</tr>
<tr>
<td>Checked Diphthongs</td>
<td>31</td>
<td>221.5</td>
<td>166.1</td>
<td>284.7</td>
</tr>
<tr>
<td>Free Diphthongs</td>
<td>13</td>
<td>243.0</td>
<td>215.8</td>
<td>284.7</td>
</tr>
</tbody>
</table>

(Unit: ms)
One obvious difference between the WE and SBE data is that all columns of mean difference have positive values, indicating that the stressed vowels were longer than the unstressed vowels in all vowel groups in the SBE data. Also, stressed vowels were rather consistently lengthened in the SBE data. This is clearly shown in the scatter graph in Figure 4. In the graph, the absolute duration of unstressed vowels is plotted against the duration of stressed vowel in the same nonsense word. The dots below the oblique line represent instances in which stressed vowels were longer than unstressed ones.

![Figure 4](image-url)

**Figure 4** Duration of stressed and unstressed short vowels, /ɪ, e, æ, ə/, in the SBE data

Figure 4 shows the scatter plots for short vowels /ɪ, e, æ, ə/ in the SBE data. In the graph, the majority is plotted below the oblique line, which indicates that most of the stressed vowels were longer than the unstressed vowels in the SBE data. These results are, on the whole, consistent with the general understanding that vowels are lengthened when they receive stress in most accents of English. Similar patterns were observed in the graphs for all vowel groups in the SBE data. Not a few, however, are plotted above the line, which means that stressed vowels were shorter than unstressed vowels in some instances. This is yet not surprising, given that duration is not the primary cue to the perception of stress in standard accents of English and, hence, it is by no means a reliable cue. In addition, long monophthongs and diph-
thongs in the second syllable may have been weakly stressed, though they never received primary or rhythmic stress in the data. If they had been weakly stressed, vowel reduction would have been prevented. In that case, duration of the ‘unstressed’ vowel may have become longer than expected. This, however, raises the question of whether or not the assignment of weak stress on the second syllable is the factor of shorter stressed vowels and longer unstressed vowels in the WE data. Although the influence of weak stress cannot be denied, further comparison of the WE and SBE data shows that stressed vowels in the WE data are, on the whole, shorter than those in the SBE data, which indicates that they were shortened indeed.

A comparison of the mean durations of stressed vowels in the WE and SBE data reveals the mean durations of stressed vowels are shorter in the former than in the latter. Table 6 shows the mean durations of stressed vowels in the WE and SBE data. Negative values in the bottom line of the table mean that the mean duration of a given vowel group was shorter in the WE data than in the SBE data.

<table>
<thead>
<tr>
<th>Table 6</th>
<th>Comparison of mean durations of stressed vowels in the WE and SBE data</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Short /i/</td>
</tr>
<tr>
<td></td>
<td>Checked</td>
</tr>
<tr>
<td>WE (mean)</td>
<td>72.5</td>
</tr>
<tr>
<td>SBE (mean)</td>
<td>88.5</td>
</tr>
<tr>
<td>WE-SBE</td>
<td>-16.0</td>
</tr>
</tbody>
</table>

(Unit: ms)

The table demonstrates that difference is particularly great in the vowel categories where frequent shortening was found in the previous sections. In Short /i/, Checked Long /i:/, and Checked Diphthongs, the differences in mean duration of stressed vowels are -16.0, -58.1, and -41.5 ms, respectively. Independent sample t-tests were carried out, and a high statistical significance was detected in Checked Long /i:/ (p<.001) and Checked Diphthongs (p<.001). The difference was also found to be statistically significant in Short /i/ at the p<.05 level. Inter-speaker-group difference is also remarkable and statistically sig-
significant in Free Long Vowels and Free Diphthongs. However, as has been argued, it is uncertain whether the vowels in these groups were treated as free vowels by the Welsh English speakers.

Meanwhile, the inter-speaker-group difference was quite small in Short Vowels and Checked Long Vowels, far from the level of significance. In the previous sections, it was revealed that the shortening of stressed vowels is not remarkable in these groups in the WE data.

4.3. Pre-fortis clipping

This section will show another inter-speaker-group difference which is not directly related to stress but is still of importance. As mentioned in Section 2.1, vowels are markedly shortened in standard accents of English when they are followed by a fortis consonant. As vowel duration serves as an important cue to distinguish phonological voicing of the following consonant in such accents of English, pre-fortis clipping occurs quite regularly. The SBE data show clear evidence of pre-fortis clipping, as illustrated in Figure 5. The figure shows that the range of duration of Checked Long Vowels in the SBE data was shorter (between 160 and 240 ms) when they were followed by a fortis consonant and longer (between 200 and 290 ms) than when they were followed by a lenis consonant. As can be seen in the figure, although there is some overlap, the clustering patterns are evident.

![Figure 5](image)

Figure 5 Histogram of the duration of Checked Long Vowels /iː, aː, ɒː/ in the SBE data
Such clustering patterns were not observed in the WE data. Figures 6 and 7 show the range of duration of Checked Long /iː/ and Checked Long Vowels in the WE data.

Figure 6  Histogram of the duration of Checked Long /iː/ in the WE data

Figure 7  Histogram of the duration of Checked Long Vowels in the WE data

In the graphs, vowels in both consonantal environments scatter across the wide range of duration, and the clustering pattern observed in the SBE data cannot be found in the WE data. This suggests that pre-fortis clipping does not occur in Welsh English, and therefore, vowel shortening in the WE data discussed above is independent of phonological voicing of the following consonants.
5. Conclusion

The present paper investigated the durational correlates of stress in Welsh English. The methodology included several important improvements over the methods used in previous studies. First, experimental recordings were made, and the data were acoustically analysed. Second, the present research investigated a wide range of segments by which differences were revealed in the frequency and degree of shortening and lengthening between vowel groups. Lastly and most importantly, the experiment was designed so that factors other than stress would not, or only minimally, affect segment duration. To this end, nonsense words which consisted of two identical syllables were invented, and they were pronounced in the non-final position of the carrier sentence. It should be admitted that due to the experimental environment of the recording sessions and use of nonsense words, the audio data were by no means natural speech. In addition, the amount of data was not large enough to draw a definite conclusion. The results of analyses, however, successfully demonstrated evidence of unique and complicated durational adjustment caused by stress in Welsh English.

In summary, among seven vowel groups of Welsh English, degree and frequency of stress-induced shortening were the greatest in Short /i/ and Checked Long /iː/. Statistically significant differences were also found between stressed and unstressed vowels and between the stressed vowels of Welsh English and SBE.

In Short Vowels, Checked Long Vowels, and Checked Diphthongs, some of the tokens were shortened while others were lengthened. Among these three groups, the degree and frequency of Checked Long Vowels were found not to be as great as the other two were. It should be noted that the results cast doubt on Walters’ assumption that the choice of shortening and lengthening is conditioned by syllabification of the post-stress consonant (see Section 2.3). In most of the nonsense words in these vowel groups, the segments were chosen and arrayed so that phonotactic constraints would be violated if syllabification changed. For example, in a nonsense word /das.das/, it is unlikely that Welsh English speakers would change the syllabification into /da.sdəs/
because the consonant cluster /sd/ in the onset is not allowed in the phonotactic rules of English.

Shortening was also found in Free Long Vowels and Free Diphthongs, in which only lengthening was expected. However, it was argued that because of the relatively simple syllable structure, uncertainty remains as to whether the vowels were treated as ‘free’ vowels by the Welsh English speakers, and it is also likely that the word-final unstressed vowels were considerably lengthened, making the relative duration of stressed vowels shorter than them.

The present study provided quantitative data which, on the whole, supports the results of previous studies. However, the question of whether or not the syllable boundary promotes and prevents stress-induced shortening and lengthening in Welsh English remains. Further experiments are needed to answer this question. Also, more studies are required to examine the effect of stress on segmental durations in more natural speech.

NOTES

Title
1) This paper is a revised version of my MA theses submitted to University College London and Tokyo University of Foreign Studies.

Section 2
1) Calculated by the author on the basis of data presented in Fry (1955: Appendix).
2) Some words have stress on the ultimate or antepenultimate syllable, but in such cases, they are mostly complex words or loan words.
3) Previous researchers considered that the unique stress system of Welsh was brought about by a historical change called the Old Welsh Accent Shift. Williams (1986) explains that though two elements of accent, ‘stress element’ and ‘pitch element’, had been on the same (ultimate) stressed syllable in Old Welsh, the Old Welsh Accent Shift which took place in the late eleventh century shifted the stress element from the ultimate to the penultimate syllable and left the pitch element on the final syllable (pp. 48–49). Thus, stressed penults in present-day Welsh tend to have greater amplitude, while unstressed final syllables often bear pitch prominence.
4) All stressed monophthongs in citation form and 76 percent of stressed monophthongs in continuous speech had a shorter duration than unstressed ones. The duration of long vowels was not measured because long vowels do not occur in unstressed syllables and, hence, are incomparable in Welsh (Williams, 1986: 37–42).
5) In Welsh, post-stress consonantal lengthening is also a noticeable feature. Williams (1986) found that the difference between the duration of consonants after a stressed vowel (94 ms) versus after an unstressed vowel (81 ms) is statistically significant at the level of $p < .05$ (p. 38–42).

6) Note that, as the vowel system in Welsh English is influenced by Welsh, some of the vowels listed are absent in the vowel inventory of standard accents of English. For example, /eː eː aː oː oː/ are FACE with monographic spelling (i.e. ‘a’ but not with digraphic spelling such as ‘ay’), SQUARE, START, NORTH/FORTH, GOAT with monographic spelling (i.e. ‘o’ but not ‘ou’), and NURTH, respectively (Standard lexical sets are from Wells (1982)). For the vowel system of Welsh English, see Penhallurick (2004) and Wells (1982: 377–393)).

Section 3

1) No high back vowels, /u, uː/, were used due to the wide range of realisation forms (Walters 2006: Ch. 1–3.6 and 3.14).

REFERENCES


Fry, D. B. 1955. Duration and intensity as physical correlates of linguistic stress. *The


