Reexamining the role of duration in English vowel perception by Taiwanese L2 learners: A pilot study

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Abstract

This study investigated how Taiwanese EFL learners' perception of English vowels is affected by duration. Previous studies have suggested that non-native speakers relied on vowel length rather than vowel quality (i.e. formant frequency) to distinguish tense/ lax vowels (Chen, 1999; Luo 2002; Kondaurova & Francis, 2008). Due to the fact that several factors can affect the duration of English vowel, such as intrinsic properties (i.e. referring to vowel length differences of tense/lax properties), coda types (i.e. voicing feature of final consonants) and rhythm, there is a need to reexamine the role of duration in L2 learners' perception of English vowels. An identification experiment was carried out by using four words /🎄🌲🌸/, /🎄🌲🕯/, /🎄🍲🌸/ and /🎄🍲🕯/. In order to investigate the effect of duration on Mandarin listeners' perception, four stimuli were manipulated in terms of their individual duration. That is, each stimulus had four versions of the length with the vowel quality unchanged: the original length version and three other versions with the length of other stimuli. The result showed that Taiwanese EFL learners relied primarily on duration to identify the tense/lax vowels (i.e. /🌲/-/🍲/) even in the context of different code types. In other words, when the vowel /🌲/ was manipulated to be longer, its perception was better; when the vowel /🍲/ was manipulated to be shorter, its perception was better as well.

Keywords: duration, formant frequency, tense/ lax vowel

1. Introduction

In English, tense and lax vowel are mainly differentiated according to two acoustic features: one is vowel quality (related to the formant frequencies: F1, F2 and F3) and the other is duration (i.e. vowel length). Studies have shown that native speakers rely primarily on the formants and they also take vowel duration as a secondary cue (Ainsworth, 1972; Hillenbrand et al., 2000). However, many studies have demonstrated that, unlike English native speakers, Mandarin EFL learners rely predominantly on vowel duration to identify the tense/ lax vowel contrast.

The length variation of English vowels is widely reported to produce an effect on the non-native speakers' perception and production. According to Chen (1999), Luo (2002) and Lai (2010), the contrasts of tense /lax vowels are difficult to be produced and perceived by Mandarin L2 learners because the differences do not present in Mandarin vowel inventory. That is, because tenseness is not used to distinguish phonemes in Mandarin L1, and it is speculated that Mandarin speakers would encounter difficulty in perceiving and producing especially lax vowels (i.e. /ɪ/, /ʊ/, /[illegible]/). Luo (2002) conducted an experimental study of English vowel pairs /i/-/ɪ/ and /u/-/ʊ/ produced and perceived by Mandarin adult learners. The purpose of this study was to examine whether L2 learners could produce and perceive English *similar* and *new* vowels in terms of the first language (i.e., Mandarin). In other words, L2 vowels which are similar to L1 vowels are recognized as *similar* sounds while L2 vowels which are absent in L1 vowel system are considered *new* sounds (Flege, 1987). In the perceptual task, Mandarin speakers had to identify the four vowels. It was showed that they were able to identify them correctly. As for the task of production, three dimensions (i.e. duration, F1 and F2) were considered to examine native speakers' production and the L2 speakers' utterance. It was urged that in terms of their first language which was Mandarin, 'familiar' (i.e., tense) vowels were produced better than 'new' (i.e., lax) vowels with distinct

F1 and F2 frequencies by Mandarin EFL learners. That is, they might produce English /i/ and /u/ sounds more accurately than the sounds /ɪ/ and /ʊ/ that were not permissible in L1. In fact, according to the findings, the L2 learners' production did not contrast English /i/-/ɪ/ by F1 rather than by F2, and their production did not contrast English /u/-/ʊ/ neither by F1 nor F2. Even though these vowels were differentiated inconsistently using formant cues, it was found that they were able to contrast the tense/lax pairs mainly by duration. In the case, it was suggested that the subjects distinguished tense and lax vowels by duration because they were incapable of using spectral cues like native speakers.

The study of Spanish listeners, consistent with the study of Mandarin L2 speakers in the above, suggested that duration were weighted more heavily than formant properties on the identification of non-native vowel pairs (Flege & Bohn, 1989; Kondaurova & Francis, 2008). In Spanish, only vowel /i/ is permissible while the contrast of /i/ and /ɪ/ are not. In this case, the native phonetic experience seemed to share with Mandarin second language learners. Nevertheless, the tendency both Spanish and Mandarin speakers' reliance on duration cues cannot be explained by the use of L1 phonological and phonetic experiences since neither Spanish nor Mandarin speakers use duration to contrast vowels in their sound inventories. Bohn (1995) has further explained this phenomenon according to his 'desensitization hypothesis' which stated that the lack of spectral differences in native linguistic experience makes listeners less sensitize to the spectrum and use duration to distinguish non-native contrast instead. Based on these studies, EFL learners tend to use duration as a parameter to distinguish English vowels rather than other parameters (e.g. formant frequencies) used by native speakers.

Evidence on the role of duration in vowel identification comes from several perception experiments using synthetic speech. For instance, Ainsworth (1972) synthesized two-formant vowels (F1 and F2) with durations ranging from 120 to 600 ms in a perceptual experiment designed for English native speakers. It was found that the duration affected the listeners' perception of vowels, particularly when the formant space of one vowel is near another vowel sound. For example, signals with similar F1 and F2 values to the vowel /[illegible]/ and /[illegible]/ are likely to be perceived as /[illegible]/ if the duration is long, and perceived as /[illegible]/ if the duration is short. In a related study, Hillenbrand *et al*. (2000) recorded 12 vowels embodied in /[illegible]/ syllable under a variety conditions differing by four duration sets: original duration, neutral duration (i.e., controlled to be 272ms), short duration (i.e., controlled to be 144ms) and long duration (i.e., controlled to be 400ms). The result showed that English listeners gave more weight to spectral signals than to duration because they were able to identify the original vowels correctly even the sounds were manipulated into four different categories. Despite of the relatively small effect of duration, some vowels (e.g. /[illegible]/-/□/-/□/, /[illegible]/-/[illegible]/) were significantly influenced by duration rather than other vowels (e.g. /[illegible]/-/[illegible]/, /[illegible]/-/[illegible]/, /[illegible]/-/[illegible]/-/[illegible]/). Therefore, it was concluded that native speakers relied more on spectrum than duration, but they used both features to different extent.

While native listeners used primarily on spectral properties to identify vowel contrasts, Spanish second language learners employed duration alone. According to Kondaurova and Francis' (2008) study, the vowels of *beat*/ *bit* were synthesized as nine duration/ spectrum steps (1 to 9 step) within a continuum from 275 to 35ms. The subjects, including Spanish L2 learners and English native speakers, were asked to identify whether *beat* or *bit* they heard in the perceptual experiment. The analysis results demonstrated that English native speakers showed a significant difference between the proportion of responses at step 1 and step 9 in both the spectral and duration continuum, but Spanish listeners only had a significant difference at step 1 and step 9 in the duration continuum. Thus, for native listeners, both spectrum and duration were applied when classifying stimuli like *beat* and *bit* while stronger reliance on duration than spectral properties occurred in Spanish L2 listeners' perception.

As can be seen, duration has been considered a contrastive feature in the analysis of English vowels, especially in the study of second language perception of tense and lax vowels

(Chen, 1999; Luo, 2002; Teng, 2002; Kondaurova & Francis, 2008; Lai, 2010). In other words, vowel length did influence L2 learners' perception of English tense and lax vowels but primarily in terms of the intrinsic properties of vowels. Specifically, previous studies only examined the duration differences which were due to the property of vowels (e.g. English tense vowels with longer length than English lax vowels); yet, there are other factors (e.g. coda type, rhythm) also affecting the duration of English vowels. For example, the phenomenon that the duration of English vowels is influenced by the type of coda has been extensively studied (Raphael, 1972; Krause, 1982; Chang, 1994; Hsieh & Kuo, 1999) and the preceding vowel duration is often considered a cue to the voicing features of word-final consonants. Specially, a vowel is longer when followed by a voiced consonant while it is shorter when followed by a voiceless consonant (e.g. /☦/ is longer in *mad* than in *mat*) (Ladefoged, 2006). Therefore, in this study, not only intrinsic properties of vowel but also voicing characteristics of coda consonants were considered to examine the role of duration on perception of English tense and lax vowels. The purpose of this investigation is to identify whether the duration boundary play a role during the process of distinguishing English tense and lax vowels by Taiwanese L2 speakers. That is, how will they perceive /🌲/-/🥯/ that were varied with different length. According to previous studies, it is hypothesized that when a vowel is lengthened, it's more possible to be perceived as tense vowel (i.e., /🌲/); when a vowel is shortened, it's more possible to be perceived as lax vowel (i.e., /🥯/).

2. Method

2.1 Participants

Participants were twenty Mandarin EFL learners who were undergraduate English major students, with the ages ranging from nineteen to twenty-one and 10 years of average learning experience of English. There were 5 males and 15 females who all have been taught to recognize IPA symbols in an introductory to language class so they did not have problem identifying the symbols of vowel in the following task.

2.2 Stimuli

Stimuli focused on a vowel pair /[IPA]/-/[IPA]/ in the syllables which were carried in the context of [IPA]_[IPA] and [IPA]_[IPA]. A 26-year-old male British native speaker produced the stimulus words (4 in total: /[IPA]/, /[IPA]/, /[IPA]/ and /[IPA]/) situated in a sentence: *I say* _____ *now* in order to get natural unreleased final obstruents as in normal speech. The sounds were recorded by the software PRAAT. Two tokens of the CVC syllables were then extracted from the sentences using PRAAT, and the durations (Figure 1 & Table 1), F1 and F2 (Table 2) were measured individually. According to the original duration of the four vowels in [[IPA]], [[IPA]], [[IPA]] and [[IPA]], the duration of each vowel was later manipulated with the durations corresponding to other three vowels. For instance, in the first token, the duration of stimulus [[IPA]] was measured to be 260ms and then it was manipulated to have the duration of 170ms, 161ms and 133ms, and the stimulus [[IPA]], with the duration of 170ms was manipulated to have the duration of 260ms, 161ms and 133ms. Similar procedure was also done on the stimuli [[IPA]] and [[IPA]]: the duration of stimulus [[IPA]] was 161ms and it was manipulated to have the duration of 260ms, 170ms and 133ms, and the stimulus [[IPA]], with the duration of 131ms was manipulated to have the duration of 260ms, 170ms and 161ms. The same manipulation procedure was also applied the stimuli in the second token. Consequently, 16 stimuli were generated in each token. The design purpose was to know the subjects were able to identify the vowels /[IPA]/-/[IPA]/ with variance length.

Table 1. Vowel duration of /[IPA]/, /[IPA]/, /[IPA]/and /[IPA]/

	/hid/	/hit/	/hɪd/	/hɪt/
Vowel duration (1st token)	260 ms	170 ms	161 ms	133 ms
Vowel duration (2nd token)	254 ms	169 ms	160 ms	136 ms

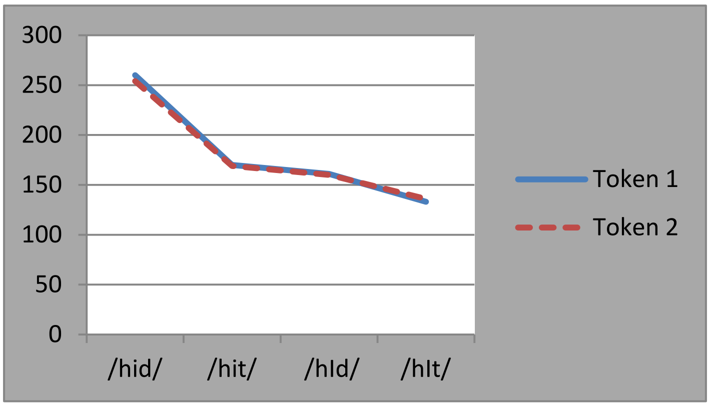

Figure 1. Vowel duration of /hid/, /hɪd/, /hit/ and /hɪt/

Table 2. Formant Frequency of [hid], [hɪd], [hit] and [hɪt]

	[hid]		[hit]		[hɪd]		[hɪt]	
Formant (1st token)	F1	F2	F1	F2	F1	F2	F1	F2
	275	2472	290	2480	368	2109	459	2285
Formant (2nd token)	F1	F2	F1	F2	F1	F2	F1	F2
	284	2462	291	2554	379	2127	442	2192

2.3 Procedure

The listening experiment was compiled using E-PRIME and run in a sound-proof booth with a PC and high-quality headphones. There were two blocks, and each block contained 16 manipulated words which were doubled to get 32 stimulus, and 8 distractors were included (bell/ mess, eleven/ seven, cheap/ shoot, eight/ nine). The procedure was (i) to hear one sound, and (ii) to see two phonetic transcriptions (i.e. /i/ and /ɪ/) on the screen, and (iii) to decide which sound they just heard.

3. Result

The number of responses (correct= one point, incorrect= zero point) were calculated and the correct responses in the two blocks were added. For example, **/[illegible]/** sound had two different length in the first and second block (i.e. 1st block: 260ms; 2nd block: 254ms), but the correct number of responses in the 1st block (i.e. 36) and in the 2nd block (i.e. 36) were added together to get 72 points. The number of 72 was divided by 80 which were the total responses by 20 subjects so as to get the ratio of 90%. The same procedure was used to calculate other stimuli as Table 3 showed. The highlighted parts indicated the original length of each stimulus.

Table 3. The percentage of correct responses on the vowel perception

/[illegible]/		/[illegible]/	
/[illegible]/ (260ms/254ms)	90%	/[illegible]/ (260ms/254ms)	83%
/[illegible]/ (170ms/169ms)	75%	/[illegible]/ (170ms/169ms)	73%
/[illegible]/ (161ms/160ms)	56%	/[illegible]/ (161ms/160ms)	53%
/[illegible]/ (133ms/136ms)	70%	/[illegible]/ (133ms/136ms)	59%
/[illegible]/		/[illegible]/	
/[illegible]/	86%	/[illegible]/ (260ms/254ms)	55%

(260ms/254ms)			
/[illegible]/ (170ms/169ms)	54%	/[illegible]/ (170ms/169ms)	18%
/[illegible]/ (161ms/160ms)	49%	/[illegible]/ (161ms/160ms)	81%
/[illegible]/ (133ms/136ms)	74%	/[illegible]/ (133ms/136ms)	90%

The statistic report shows that the length plays a role for the perception of the tense vowel /[illegible]/ and the lax vowel /[illegible]/. In the perception of the tense vowel, it is found that the longer the duration it has, the more accurately it is identified. The argument is based on two pieces of evidence. First, when **/[illegible]/** takes its original duration (i.e., 260ms/254ms), the accuracy rate is 90%. When it is shortened and takes the duration of 170ms/169ms, the accuracy rate drops by 15% and becomes 75%. Chi-square test shows that the difference is very significant ($\chi^2(1) = 6.79$, $p < 0.005$). When it is further shortened to be 161ms/160ms, the accuracy rate drops even more (i.e. 56%), which is very significant ($\chi^2(1) = 27.63$, $p < 0.001$). Similar tendency is found when it takes the shortest duration of 133ms/136ms (i.e., accuracy = 70%), which is also statistically significant ($\chi^2(1) = 11.28$, $p = 0.0004$). Secondly, when **/[illegible]/** (original accuracy: 73%) is shortened and takes the duration of 161ms/160ms, the accuracy rate drops 20% to the accuracy of 53%, which is very significant as can be seen from Chi-square test ($\chi^2(1) = 7.74$, $p = 0.002$). When it is further shortened to 133ms/136ms (i.e., accuracy = 59%), which is also significant ($\chi^2(1) = 3.77$, $p = 0.026$). Interestingly, when it is lengthened and takes the duration of 260ms/254ms, the accuracy rate rises up to 83%, which is marginally significant ($\chi^2(1) = 2.36$, $p = 0.06$). Consequently, we can see the findings are consistent with our assumption.

It seems that the length also plays a role for the perception of the lax vowel /ɪ/ based on two pieces of evidence. First of all, when /bɪt/ takes its original duration of 133ms/136ms, the accuracy rate is 90%. When its length is lengthened and takes the duration of 161ms/160ms, the accuracy rate drops by 9% and becomes 81%. Chi-square test shows that the difference is marginally significant ($\chi^2(1) = 2.59$, $p = 0.05$). As it is further lengthened to be 170ms/169ms, the accuracy rate drops even more (i.e., 18%), which is very significant ($\chi^2(1) = 101.47$, $p < 0.0001$). Similar tendency is found when it takes the longest duration of 260ms/254ms (i.e., accuracy = 55%), which is also statistically significant ($\chi^2(1) = 28.99$, $p < 0.001$). Furthermore, when /bɪd/ is shortened from 161ms/160ms to 133ms/136ms, the accuracy rate rises up to 74% which is 25% more than the original accuracy rate. The statistical result shows that the difference is very significant ($\chi^2(1) = 12.16$, $p = 0.0002$). However, as it is lengthened to be 170ms/169ms, the accuracy rate rises up to 54% and when it is lengthened to be the longest duration (i.e., 260ms/254ms), the accuracy rate rises even more (i.e., 85%). The report is not expected in our hypothesis that when the lax vowel becomes shorter, it is identified better. The phenomenon is discussed in the next section.

The correct rate of individual vowel perception can be drawn from Table 3. As can be seen, the measured durations of /bit/, /bɪd/ and /bɪt/ are close but at the same time more distant with the duration of /bid/. In this case, if the statistic result was made according to each duration set, we might neglect the similarity among these duration boundaries due to the fact that about 10-20ms differences among duration /bit/, /bɪd/ and /bɪt/ are actually considered little distinction in terms of acoustic measurement. In order to see the relation between the longest duration and the other three kinds of duration, the correct response numbers of /bit/, /bɪd/ and /bɪt/ under four sets of real vowels are averaged and the mean is used to examine the duration effect compared with the correct responses in the longest duration /bid/ (See Table 4). As the accuracy rate of /bid/ is compared with the accuracy rate of other three stimuli (i.e., 67%), Chi-square test shows that the difference is very significant ($\chi^2(1) = 14.34$, $p < 0.001$). Similar report is found on the accuracy rate of /🌲🌲🌶/, which is also significant. As expected, the tense vowel is perceived better when it becomes longer. On the other hand, when /🌲🐦🌶/ is lengthened and takes the longest duration (i.e., 260ms/254ms), the accuracy rate drops 15%. The report shows the difference is statistically significant ($\chi^2(1) = 4.18$, $p = 0.02$). As /🌲🐦🌸/ becomes longer, the accuracy rate does not drop but it rises up to 86%. The result is unexpected as we have seen in the above analysis. The situation is also discussed in the following section.

Table 4. The percentage of correct responses on vowel perception

/🌲🌲🌸/		/🌲🌲🌶/	
/🌲🌲🌸/ (260ms/254ms)	90%	/🌲🌲🌶/ (260ms/254ms)	83%
/🌲🌲🌸/ (170ms/169ms), /🌲🌲🌸/ (161ms/160ms) & /🌲🌲🌸/ (133ms/136ms)	67%	/🌲🌲🌶/ (170ms/169ms), /🌲🌲🌶/ (161ms/160ms) & /🌲🌲🌶/ (133ms/136ms)	58%
/🌲🐦🌸/		/🌲🐦🌶/	
/🌲🐦🌸/ (260ms/254ms)	86%	/🌲🐦🌶/ (260ms/254ms)	55%
/🌲🐦🌸/ (170ms/169ms), /🌲🐦🌸/ (161ms/160ms) & /🌲🐦🌸/ (133ms/136ms)	59%	/🌲🐦🌶/ (170ms/169ms), /🌲🐦🌶/ (161ms/160ms) & /🌲🐦🌶/ (133ms/136ms)	70%

4. Discussion

The significance of the effect of duration occurs on the tense vowel perception and the lax vowel perception as can be seen from the result which is in consistent with Spanish listeners who employed vowel duration significantly on the perception of both tense and lax vowel (Kondaurova & Francis, 2008). In other words, the current investigation reveals that the Taiwanese EFL subjects are able to perceive the tense vowel /🌲/ more accurately as its duration becomes longer duration while they are able to perceive the lax vowel /🐚/ when its duration becomes shorter.

Previous studies have been discussed the duration properties of vowel (Ainsworth, 1972; Hillenbrand et al., 2000), which only covers the “long” or “short” contrast of vowel itself in the same environment (e.g. vowels embodied in /🎄_🕷/). In other words, the definition of duration they refer to is more about intrinsic properties. To understand how other factors affect the duration, this study, different from the previous studies, includes the factors of final consonant types (i.e., voice or voiceless). For example, the duration differences between /🎄🐚🕷/ and /🎄🐚⌡/ are due to the coda types. Specifically, /🎄🐚🕷/ has longer duration (i.e., 160ms/161ms) than /🎄🐚⌡/ (i.e., 133ms/136ms) because /🎄🐚🕷/ has a voiced word-final consonant while /🎄🐚⌡/ has a voiceless word-final consonant. The result shows that for these two stimuli, whenever the length of /🐚/ becomes shorter, it is perceived better; yet, as it is lengthened, it becomes harder to be identified. However, the similar tendency cannot be seen as the duration of /🎄🐚🕷/ is lengthened and takes the duration of 170ms/169ms and 260ms/254ms, the accuracy rate rises up by 5% and 37% independently. So far in this experiment, we may not able to explain this situation in terms of our hypothesis and the previous studies. Thus, it needs to be examined in further study.

On the other hand, for the stimuli /🎄🌲🕷/ and /🎄🌲⌡/, as the length of /🌲/ becomes longer, it is perceived better. In contrast, when it is shortened, the identification becomes worse. The tendency implies that these L2 learners rely heavily on the duration in English vowel perception, especially the tense and lax vowel as discussed here. The result also shows that the different coda types do influence the subjects' perception to some extent. To conclude, it is urged that Mandarin L2 learners mainly contrast English tense and lax vowels by duration (Luo, 2000) and the present study seems to agree with the tendency that the L2 listeners depend on duration to identify the vowels. However, in the experiment, it is limited in accounting for 1) the rising accuracy rate as the duration of /[illegible]/ lengthened, 2) how L2 Taiwanese speakers perceive vowels controlled with other duration factors (e.g. rhythm) and 3) to what extent they use duration to perceive other tense/ lax pairs of English vowels (e.g., /[illegible]/-/[illegible]/). In sum, the present findings support many former studies that duration factors are preferred by Taiwanese L2 learners on the perception of vowels.

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檢視母音長度對台籍英語學生感知能力的影響

摘要

本研究主要探討母音長度對台籍英語學生在英語鬆緊母音上的感知能力。先前的研究指出非英語母語人士主要依據母音音長來辨別鬆緊母音的差異，但因為有許多影響母音音長的因素未考慮，像是字尾子音清濁和音韻學裡韻律的概念等等，所以此實驗將考慮字尾子音清濁的要素，來重新檢視母音長度對非英語母語人士的影響。此感知實驗使用四個包含英語前高鬆緊母音的字(/[illegible]/, /[illegible]/, /[illegible]/ and /[illegible]/)，然後逐一將其原有長度拉至和其餘三個字相同長度，因此每字會各擁有四種長度之態樣。實驗結果顯示，台籍英語學生在鬆緊母音的感知能力會受到母音音長之影響，亦即當前高緊母音(/[illegible]/)愈長，其辨別度愈高；反之，當前高鬆母音(/[illegible]/)愈短，其辨識度愈高。

關鍵字：(母音)音長、音頻、鬆緊母音

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