

The Intelligibility and the Duration Time of Sounds

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要 旨

本論の目的は、少ない労力で日本人の英語発音の明瞭性を向上させる方法を提示することである。最初に、日本語音と英語音を比較対照し、日本人の英語発音を不明瞭なものにしている主な要因を確認する。そして、音の持続時間の調節は母語にない音を調音するよりも比較的容易なことに着目し、いくつかの英語母音・子音の持続時間を適切に調節することにより、日本人の英語発音の明瞭性を向上させる方法を考察していく。

1. Introduction

The aim of this paper is to consider the method that Japanese learners can improve the intelligibility of their English pronunciation with minimum effort. In order to attain the aim, we will firstly compare English sounds with Japanese sounds to see what the primary sounds in Japanese learners' improvement of their English pronunciation are, especially during the early learning stages. Then, we will seek to propose effective ways of distinguishing differences between English sounds focusing on the duration times of the sounds.

2. Differences in Vowels between English and Japanese

2.1 Differences in Number

As far as short vowels are concerned, English has six short vowels [ɪ, ɛ, æ, ʌ, ɒ, ʊ] and one schwa vowel [ə], while Japanese has five short vowels (ア = [a], イ = [i], ウ = [u], エ = [e], オ = [o]). It means that English has two extra short vowels, compared with Japanese.

In addition to the difference in the number of short vowels, there is one more crucial difference between the two languages: that is the way of distinguishing a short vowel from a long vowel. Both English and Japanese have five similar long vowels: [ɑ:, i:, u:, ɜ:, ɔ:] for English; and [a:, i:, u:, e:, o:] for Japanese. However, in the case of Japanese, there is no difference in the position and the shape of the tongue, and also in the shape of the lips, between each of the corresponding pairs of a short and a long vowel, such as the Japanese [i] and [i:]. Therefore, a Japanese long vowel is characterised as just being longer than a corresponding short vowel with no difference in the quality of sound. On the other hand, in the case of an English long vowel, the tongue position is different from the corresponding short vowel, and this leads to a change in the quality of sound, such as the English [ɪ] and [i:].

The above discussion suggests that, as far as short and long vowels are concerned, English has 12 different sound qualities (6 short vowels, 1 schwa vowel, and 5 long vowels) in its vowel system, and when Japanese vowels are substituted for them, these 12 kinds of sound qualities are covered by only 5 kinds of sound qualities of the Japanese vowels. The fact that one Japanese vowel tends to be substituted for more than two English vowels, such as the Japanese [a] for the English [ʌ], [æ], and [ə], means that the tolerance level over inaccuracies in pronunciation is low, when English native speakers listen to the pronunciation of Japanese learners. For example, in the case of ‘hung’ [hʌŋ] and ‘hang’ [hæŋ], as long as Japanese learners substitute the Japanese [a] for the English [ʌ] and [æ], their pronunciations are often difficult for English native listeners to judge whether they say ‘hung’ [hʌŋ] or ‘hang’ [hæŋ]. In striking contrast to this, when Japanese native speakers listen to the pronunciation of English learners of Japanese, the tolerance level is much higher, compared with the above case. For example, even when they pronounce 赤 (= [aka], meaning *red*) as [ʌkə] or [ækə], it is easily recognised as 赤 (= [aka]) by Japanese native speakers, because the Japanese vowel which is near the English [ʌ] and [æ] is only limited to the Japanese [a].

Based on the above discussion, one may say that the first step for Japanese learners to produce intelligible English vowels is to make distinctions between [ʌ] and [æ] and between short and long vowels in their English production. The following sections will

see how these English vowels are different from the corresponding Japanese vowels in the sound qualities and the duration times mainly based on acoustic analysis.

2.2 Comparison of the English [ʌ] and [æ] and the Japanese [a]

Usually, the shape and the position of the tongue when vowels are produced are simplified for purpose of description as follows: (1) the distance between the upper surface of the tongue and the palate; and (2) the part of the tongue which is raised the highest. In this paper, the former aspect is called the *vowel height dimension* (High-, Mid-, and Low-vowel), and the latter one is the *frontness-backness dimension* (Front-, Central-, and Back-vowel).

As Kawakami (1977) explains, the range of the distribution of the Japanese [a] is quite wide and could include the Cardinal Vowels [a] (No. 4) and [ɑ] (No. 5). The reason is strongly related to the fact that the Japanese [a] is the only one vowel which exists in the category of the low vowel in Japanese. However, there is a fairly general agreement that the norm of the Japanese [a] is classified in a low and central vowel.

A question is the area of distribution of the English [ʌ]. As far as the British accent is concerned, the English [ʌ] is often considered to be distributed quite near to the Japanese [a], and they are regarded as almost identical sounds. Therefore, Imai (1980) encourages Japanese learners to substitute the Japanese [a] for the English [ʌ]. However, as is clear from the fact that the English [ʌ] is often defined as an intermediate tone between the Japanese [a] and [o] in some textbooks (e.g., Igarashi, 1981; Ishiguro, Kousaka, and Yamauchi, 1992), the essence of the sound is more muffled than the Japanese [a], which means it should be classified as a more back vowel than the Japanese [a]. In the case of American accent, this tendency might become stronger.

The English [æ] is not grossly differentiated from either the English [ʌ] or the Japanese [a] in the vowel height dimension, but it is a much more front vowel than they are. The English [æ] is quite a unique sound from the viewpoint of natural languages, and not only Japanese but also some European languages such as French and German do not have such a sound. The English [æ] is also unique in the respect that it has comparatively a long duration time in spite of being classified into a short vowel. A more detailed description about the relationship between the English [ʌ], [æ] and the Japanese [a] will be presented in the next section based on acoustic analysis.

2.3 Acoustic Comparisons of the English [ʌ], [æ] and the Japanese [a]

The experiment was conducted to grasp the acoustic properties of the English [ʌ], [æ] and the Japanese [a] to fully understand the details of the discussion in the last section.

Speech productions were collected from both groups of English native speakers and Japanese native speakers. The English group consisted of 8 female adult speakers, and the Japanese group was made up of 10 female adult speakers. All of the Japanese subjects were born in the *Kantoh*² area, and lived there for quite a long time, so they were assumed to speak in the Tokyo-dialect. The participants in the English group were comprised of native speakers who had been teaching English in Essex, East Anglia, England. All of them had lived there for some considerable time, so they probably provided reasonable representations of British English. Needless to say, the number of the subjects was not sufficient enough to generalise the differences, but this comparison will be useful to recognise the rough differences in the acoustic properties of the vowels between the two languages, and to verify the discussion carried out in the previous section.

The English subjects were asked to produce three English words: *but*; *bat*; and *bet*, which contained the vowels [ʌ, æ, ɛ], in the carrier sentence ‘I say ____ again.’ The Japanese subjects were asked to produce two Japanese words: “バット” (*batto*); and “ベット” (*betto*), in the carrier sentence “私は ____ という。”. The first Japanese word “バット” corresponds to English *bat* and *but*, and in the same way, “ベット” = *bet*. In this experiment, the English [ɛ] and the Japanese [e] were also added so that we can grasp the distributions of the English [ʌ], [æ] and the Japanese [a] clearly in the distribution map which will be presented later.

Each target word was randomly shown at regular intervals to the subjects in both groups three times. Their speech productions were recorded using a digital recording machine. The mean value of the three repetitions for each word was regarded as the realisation of a subject’s production.

The vowel duration time and the frequencies of the first two formants (F1 and F2) were measured for each of the vowel productions by using the *SUGI Speech Analyzer* (produced by *ANIMO* Ltd.) which automatically estimates the frequencies of the first four formants at any given points. The cursor was placed by the researcher at the point where air pressure was the most stable. Although the *SUGI Speech Analyzer* automatically measures the formants’ frequencies, the final check to decide the frequencies was made by the author of this paper.

As outlined in the previous section, the sound quality of a vowel can be roughly characterised by the frontness-backness and vowel height dimensions. Basically, the frequency of F1 varies with the vowel height dimension, and the frequency of F2 is related to the frontness-backness dimension. More specifically, as the height of the whole raised shape of the tongue body becomes lower, the frequency of F1 becomes higher. Concerning the relationship between the frontness-backness dimension and

the frequency of F2, a front vowel is characterised by the high frequency of F2. On the other hand, the frequency of F2 in a back vowel is relatively low.

The distributions of the English [ʌ, æ, ε] and the Japanese [a, e] are described in the figure presented below.

Figure 1 Distributions of the English [ʌ, æ, ε] and the Japanese [a, e]

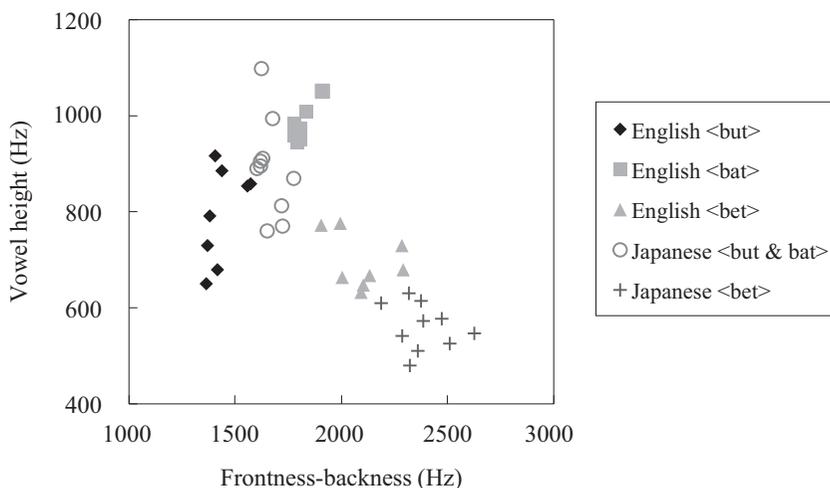


Table 1 Mean duration time and SDs of the vowels

	Eng [ʌ]	Eng [æ]	Eng [ε]	Jan [a]	Jan [e]
Duration (ms)	109.5	136.8	119.8	109.4	102.7
SD	24.2	31.9	28.1	19.9	19.3

The horizontal axis corresponds to the dimension of frontness-backness, the left-hand side represents the feature of a back vowel, and the right-hand side that of a front vowel. The vertical axis corresponds to the dimension of vowel height. A higher position indicates the feature of a lower vowel; on the other hand, a lower position indicates the feature of a higher vowel.

As Figure 1 shows, the Japanese [a], which tends to be substituted for both the English [ʌ] and [æ], has a wide distribution in the vowel height dimension, and the distribution overlaps with the distributions of both the English [æ] and [ʌ]. Concerning the frontness-backness dimension, the Japanese [a] lies almost midway between the English [ʌ] and [æ]. According to a series of Mann-Whitney *U*-tests, a significant difference was found between the English [ʌ] and the Japanese [a] in the dimension of frontness-backness: $U = 0, p < .001$; but not in the dimension of vowel height: U

= 20, $p > .05$. Similarly, in the case of the pair consisting of the English [æ] and the Japanese [a], although a significant difference was obtained for the frontness-backness dimension: $U = 0$, $p < .001$, it was not for the vowel height dimension: $U = 13$, $.05 > p > .01$.

The following three points are clarified in the above analysis. The first point is that the sound quality of the Japanese [a] is not identical to either that of the English [ʌ] or [æ]. The second point is that the Japanese [a] and the English [ʌ] or [æ] do not significantly differ in the dimension of vowel height. The third point is that the distribution of the Japanese [a] is almost midway between the English [ʌ] and [æ] in the dimension of frontness-backness. Summing the above three points up succinctly, as far as a sound quality is concerned, the Japanese [a] is distinguished from the English [ʌ] and [æ] mainly in the respect of the frontness-backness dimension, rather than the vowel height dimension.

Regarding the means of the absolute vowel duration times, the English [æ] (136.8 ms) was longer than the other four vowels which were the English [ʌ] (109.5 ms), the English [ɛ] (119.8 ms), the Japanese [a] (109.4 ms), and Japanese [e] (102.7 ms), but statistically these differences were not significant according to one-way ANOVA, $F(4, 39) = 2.48$, $.10 > p > .05$.

2.4 Comparison of the English [ɪ] and [i:] and the Japanese [i]

As mentioned earlier, the English [i:] is differentiated from the English [ɪ] in respect of not only the duration time, but also the sound quality. In the case of the Japanese [i], it has a sound quality very similar to the former, and they are almost identical, or the Japanese [i] is a slightly lower and more back vowel than the English [i:].

The productions of two English words: *bit* and *beat* and those of two Japanese words: “ビット” (*bitto*) and “ビート” (*bihto*), which contain the vowels [ɪ] and [i:], were elicited by using the same procedure as the previous experiment. The figure presented below shows the distributions of the English [ɪ, i:] and the Japanese [i, i:].

As Figure 2 shows, the distributions of the English [i:] and the Japanese [i, i:] overlap one another, but the English [ɪ] is isolated from them. A series of Mann-Whitney *U*-tests revealed that there were no significant differences between the English [i:] and the Japanese [i] in either the dimension of vowel height or frontness-backness: $U = 33$, $p > .10$; $U = 27$, $p > .10$, respectively, and between the English [i:] and the Japanese [i:] in either the dimension of vowel height or frontness-backness: $U = 36$, $p > .10$; $U = 40$, $p > .10$, respectively.

On the contrary, as is clear from the below figure, significant differences were found between the English [ɪ] and the Japanese [i] in both the dimensions of vowel height and

Figure 2 Distributions of the English [ɪ, i:] and the Japanese [i, i:]

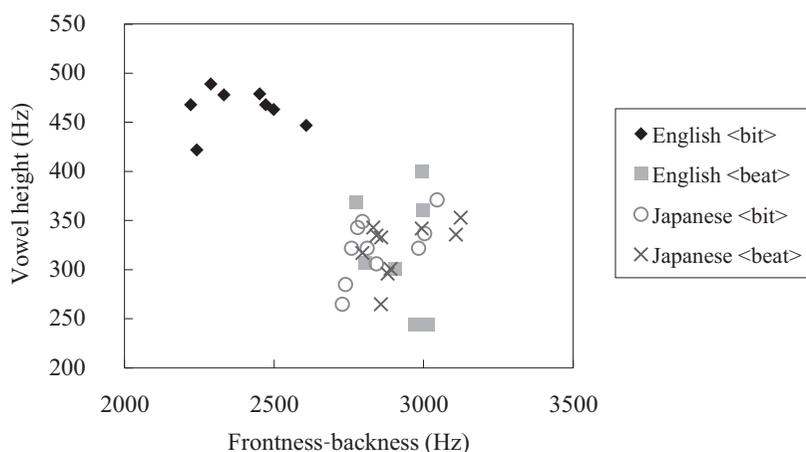


Table 2 Mean duration time and SDs of the vowels

	Eng [ɪ]	Eng [i:]	Jan [i]	Jan [i:]
Duration (ms)	92.9	133.0	97.7	194.7
SD	22.7	26.7	19.3	33.0

frontness-backness: $U = 0, p < .001$; $U = 0, p < .001$, respectively, and also between the English [ɪ] and the Japanese [i:] in both the dimensions of vowel height and frontness-backness: $U = 0, p < .001$; $U = 0, p < .001$, respectively. These statistical results suggest that there is no significant difference in the shapes of the tongue among the English [ɪ], the Japanese [i], and the Japanese [i:], but only the English [ɪ] is different from them in that respect. This is because, as Figure 2 indicates, the English [ɪ] is a lower and a more back vowel than the other three vowels.

As outlined in Table 2, the means of the duration times of the English [ɪ, i:] and the Japanese [i, i:] were as follows: the English [ɪ] (92.9 ms); the English [i:] (133.0 ms); the Japanese [i] (97.7 ms); and the Japanese [i:] (194.7 ms). The mean of [i:]-[ɪ] duration ratio was significantly longer in Japanese (2.0) than in English (1.4), $U = 4.0, p < .01$. This difference was mainly due to the longer duration of the Japanese [i:], compared with the English [i:]. The reason for this could be attributed to the fact that the duration is the only way to distinguish [ɪ] and [i:] in Japanese, although English has one more way to distinguish the difference in sound quality.

Taking into account the above basic differences, we will consider how Japanese learners, especially beginners, can differentiate the English [æ] and [ʌ], and the English [ɪ] and [i:] in their English production later.

3. Differences in Consonants between English and Japanese

3.1 Differences in Number

When we see the table which compares English consonants with Japanese consonants (e.g., Imai, 1980; 47), we can firstly notice that there is a difference in the total number of consonants. Similarly for vowels, there are a larger number of English consonants than of Japanese consonants. This means that Japanese learners sometimes tend to substitute one Japanese consonant for more than two English consonants. For example, the Japanese [b] is often substituted for both the English [b] and [v]. The same thing can be said for the relationships between the Japanese [s] and the English [s, θ], between the Japanese [z] and the English [z, ʒ, ð], and between the Japanese [r] and the English [l, r]. These problems have been often discussed as the typical problems of Japanese English since, as we have already discussed in the previous section dealing with the comparison of vowels, the fact that substituting one Japanese sound for more than two English sounds makes the tolerance level for inaccurate pronunciation lower when English native speakers listen to the pronunciation of Japanese learners.

3.2 Distinction between voiced and voiceless sounds

Although all vowels are voiced sounds, consonants consist of both voiced and voiceless sounds, and 16 English consonants out of 24 have voiced and voiceless contrasts as follows: [p]-[b]; [t]-[d]; [k]-[g]; [f]-[v]; [θ]-[ð]; [s]-[z]; [ʃ]-[ʒ]; [tʃ]-[dʒ]. In this sense, if Japanese learners can improve the voicing contrasts of English consonants up to the level of being intelligible to native speakers, the improvements will be a great help in making their English pronunciation clearer.

It might seem an easy task for Japanese learners to acquire the voicing contrasts of English consonants, because Japanese consonants also have the voicing contrasts. For example, English and Japanese plosives are similar in the sense that both have the same repertory which is classified as either voiced or voiceless.

Nevertheless, the pronunciation of English plosives by Japanese learners could be a problematic feature in their English pronunciation. The reason is that there are some differences in the phonetic basis for the criterion between voiced and voiceless plosives in English and Japanese. For example, when the English voiceless plosives [p], [t], and [k] are placed in an initial position of a stressed syllable, these voiceless plosives are attended with a large amount of aspiration. This existence of a strong aspiration is one of the main ways that English native speakers distinguish the voiceless plosives [p], [t], and [k] from the corresponding voiced plosives [b], [d], and [g]. Roach (1991) notes that if English native speakers hear a voiceless unaspirated plosive, they will

likely hear it as either [b], [d], or [g]. Japanese voiceless plosives are also attended with an aspiration to some degree, but, it is much weaker than that of the English voiceless plosives. Therefore, there is a good possibility that English voiceless plosives with a very weak aspiration produced by Japanese learners sound like English voiced plosives to English native speakers, which results in unintelligible English pronunciation of Japanese learners.

In the next section, we will consider how Japanese learners can improve the intelligibility of their English pronunciation by distinguishing the differences between the above-mentioned sounds in their production with minimum effort.

4. The Duration Time and the Intelligibility

The previous sections examined some sounds which would contribute to the improvement of English pronunciation of Japanese learners. This section sees how Japanese learners can improve the intelligibility of some of the sounds with minimum effort by focusing on the duration time of the sounds, which may be easily controlled compared with the sound quality.

4.1 The Duration Time of Vowels and the Intelligibility

Isono (2003) investigated the acquisition process of the English vowels [ʌ, æ, ɪ, i:, ɛ] produced by Japanese learners who were in various learning levels, and clarified that the experienced Japanese learners improved the intelligibility of their English vowel productions not by improving the sound qualities, but mainly by controlling the vowel duration times.

In addition, the fact that the duration time might strongly affect native English speakers' judgments was also clarified by Isono (2000a) who examined the criteria of native English listeners for distinguishing the English [ʌ] from the English [æ] and the English [ɪ] from the English [i:] when they perceived the sound qualities of the Japanese [a] and [i]. Concerning the English [ʌ] and the English [æ], a significant criterion was found between 150 ms and 160 ms. When the duration time of the Japanese [a] became longer than 150ms, it was constantly perceived as the English [æ] by the native listeners. There was one more criterion between 130 ms and 140 ms. When the duration time of the Japanese [a] was shorter than this criterion, it was frequently judged as the English [ʌ]. As Table 1 showed, the mean duration value of the Japanese [a] in “バット (= *batto*)” (= *but* & *bat*) was 109.4 ms. Therefore, the Japanese [a] is directly substitutable for the English [ʌ], but only when it is extremely prolonged is it perceived as the English [æ]. In other words, although the Japanese [a] is often said to be substitutable for the English

[ʌ] because they are believed to have similar sound qualities, the reason of the above fact is attributed to the similar duration time rather than to the sound qualities.

As for the English [ɪ] and the English [i:], one important criterion was observed between 110 ms and 120 ms, and if the duration time of the Japanese [i] became longer than this, it was constantly perceived as the English [i:]. As Table 2 showed, the mean duration value of the Japanese [i] was relatively close to this criterion. The other criterion was found between 80 ms and 90 ms. Only when the duration of the Japanese [i] was shorter than this criterion, it was often perceived as the English [ɪ]. This discussion suggests that we should give higher priority to shortening the duration time of the English [ɪ] rather than to prolonging that of the English [i:], although usually only the latter is emphasised in Japan.

4.2 Consonants and the Intelligibility

This section sees how Japanese learners can improve the intelligibility of some of the English consonants, which are problematic in their English pronunciation, by paying attention to the duration time.

It is true that Japanese learners need a certain period of learning to become able to produce English plosives accompanied by a sufficient amount of aspiration in word-initial position, as shown by Isono (2000b). On the other hand, it is relatively easy to improve the intelligibility of the voicing contrasts of English plosives in word-final position. As has been established, English native speakers' voiced plosives in word-final position normally have little voicing in casual speech style, and the difference in the duration of the preceding vowel might play a more important role for English native speakers to distinguish word-final voiced plosives from word-final voiceless plosives, than the degree of voicing of word-final plosives. Generally, as the below figures show, the vowel duration preceding a voiced plosive is noticeably longer than that preceding a voiceless plosive in English.

Figure 3 An example of 'pat' [pæt] in English

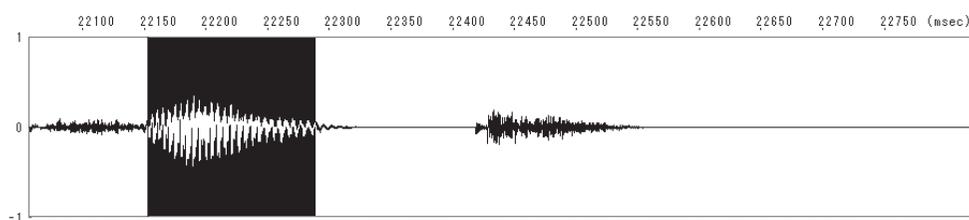
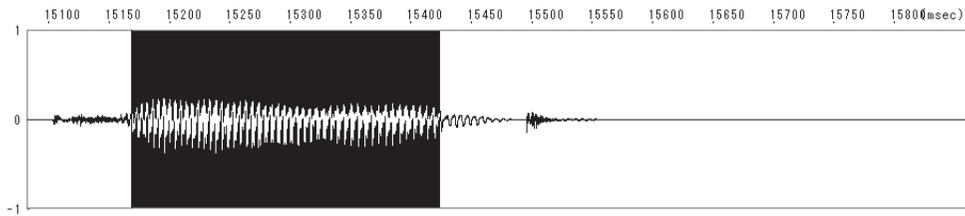
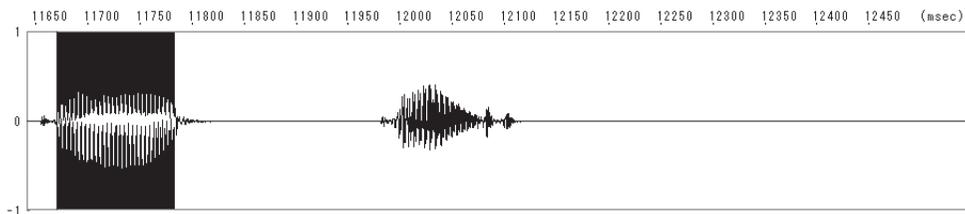
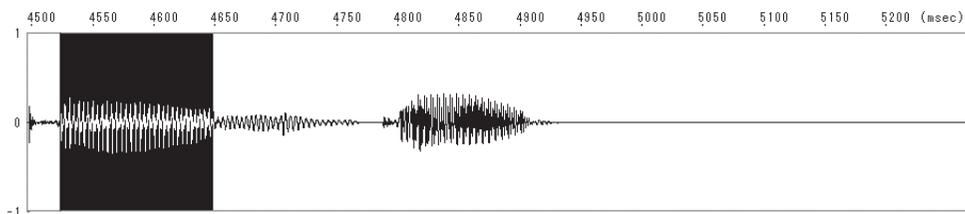


Figure 4 An example of 'pad' [pæd] in English



On the other hand, as Figure 5 and 6 suggest, the vowel duration time in Japanese is not affected by the following consonant as much as it is in English.

Figure 5 An example of 'パット' (= *patto*, corresponding to 'pat') in JapaneseFigure 6 An example of 'パッド' (= *paddo*, corresponding to 'pad') in Japanese

According to past studies, English children do not achieve the differences in preceding vowel duration between voiced and voiceless consonants at the very beginning stage, but they can do soon during early childhood (e.g., Higgs and Hodson, 1978; Smith, 1978; Raphael, Dorman, and Geffner, 1980). Therefore, Japanese learners should also be encouraged to distinguish between voiced and voiceless plosives in word-final position through the difference in the duration time of vowels preceding them from the beginning.

Another reason for this is that if learners' attention is focused too much on word-final plosives, especially word-final voiced plosives, it would lead to the occurrence of epenthesis, as we can see from the result of Isono (2004). An important suggestion for language teachers, when teaching the difference in vowel duration which systematically

varies according to a plosive following a vowel, would be to instruct Japanese learners to prolong the vowel duration preceding voiced plosives instead of shortening the vowel duration preceding voiceless plosives. This is suggested since, as shown in Isono (2003), the vowel duration time in the Japanese [CVC(V)] is relatively similar to that in the English [CVC] syllable when the word-final plosive in the English [CVC] syllable is voiceless.

The English [v] is a voiced sound of the English [f]. However, since the voiced sound of the Japanese [ϕ] which corresponds to the English [f] is alien to the Japanese sound systems, the Japanese [b] which is a bilabial plosive tends to be substituted for the English [v] because of the similarity in the place of articulation between the bilabial and the labiodental. Consequently, the Japanese [b] tends to be substituted for both the English [b] and [v]. In addition to the difference in the quality of noise between the English [v] and the Japanese (the English) [b]: namely, the former has the feature of [friction] but the latter has [plosion], they are also different in the duration times. The duration of the English [v] is longer than that of the Japanese [b]. This is due to the fact that fricatives are the consonants which have the feature of [continuant], which means, to borrow Roach's (1991: 47) phrase, that "you can continue making them without interruption as long as you have enough air in your lungs", yet plosives are not continuants. Therefore, when Japanese learners find a difficulty in distinguishing the sound qualities between the English [v] and [b], it would also be good to focus on the difference of the duration times.

When the Japanese [r] is pronounced, the tip of the tongue is raised toward the roof of the mouth which is approximately the border between the back part of the alveolar ridge and the front part of the hard plate. This process is very similar to the English [r]. However, when the tip of the tongue moves to the place which is mentioned above, a closure is made, like the English [l], but unlike the English [r]. In this respect, the Japanese [r] is similar to the English [l] rather than the English [r]. What is dissimilar from the English [l] is that the time of the contact between the tip of the tongue and the roof of the mouth is short, and very weak plosion is made by flicking the tip of the tongue against the roof. Therefore, it would be the first step for Japanese learners to keep the duration time of the above contact long when they intent to produce the English [l].

5. Conclusion

This paper considers how Japanese learners can improve the intelligibility of some English sounds by focusing on the duration time of the sounds. Controlling duration

time is considered easier than acquiring new sound quality, thus the methods proposed in this paper will be insightful especially for beginners. In addition, by reducing the effort of producing accurate L2 sounds in the sound qualities, we should be able to minimise any harmful effect on fluency such as decreasing fluency as a result of paying attention to segmental features.

Notes

- 1 This sound is often symbolised as [ɔ:] or [ə:].
- 2 The *Kantoh* area includes Tokyo, Kanagawa, and Saitama prefectures.

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