Phonetic Characteristics of Unstressed Vowels in Fast Speech

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Introduction

Among English vowels, a mid-central [ə] is often articulated in reduced form: the duration of the vowel is very short, and thus the acoustic characteristics of the vowel change drastically. It is commonly known that the vowel [ə], which is usually called the neutral vowel or "schwa", occurs only in weak (unstressed) syllables. Unstressed vowels are those for which there is difficulty in determining characteristics of duration and formant frequency(Klatt et al 1976). This is because unstressed vowels are greatly influenced by a variety of conditions, such as speech rate, consonantal environment, stress pattern, morphological structure, word class and so on in comparison with stressed vowels. There have been a number of studies carried out on the characteristics of the reduced vowel [ə], that is, under what circumstances this reduction occurs. These studies have been carried out mostly for normal tempo speech, but there have been a few studies of fast tempo speech.

Peterson and Barney (1952) give average values for the F1 and F2 frequency of vowels in monosyllabic American English CVC words pronounced at a normal tempo. In their data, it can be said that the F1 of schwas is from 400 to 600 Hz and from 1350 to 1800 Hz for F2.

In Misono's study using polysyllabic words with a schwa appearing in either of three positions (initial, medial and final), it was found that schwa is articulated with a larger variability than that found by Peterson and Barney, depending upon the subject and the position of schwa in words.

However, their study is also restricted to normal tempo speech. How the formant frequency of schwa changes due to an increase in the speech rate has not been studied. When the speech rate becomes faster, it is expected that the formant frequency for schwa will show greater variability. In this paper, the characteristics of the frequency of F1 and F2 for schwas in fast tempo speech were examined, mainly focusing on the relationship between schwas and their adjacent consonants.

Linguistic materials

Our materials consisted of the recorded tapes from the CNN and ABC broadcast news. The former scripts were found in the monthly magazine of English Express with CNN, the latter ones were found in the monthly magazine The Study of Current English.

The news announcers were six native speakers of English, who were all veteran broadcast newscasters in America. They were all male. The total duration of the materials was about 60 minutes. In order to estimate how fast the announcers' speeches was, we adopted Pimsleur's et al (1977) 5-degree speech-rate classification. The details of this 5-degree speech rate classification are shown below.

speech rate	word per min.	word per sec.
fast	220 or above	3.6 or above
moderately fast	190 ~ 220	3.1 ~ 3.6
average	160 ~ 190	2.6 ~ 3.1
moderately slow	130 ~ 160	2.1 ~ 2.6
slow	130 or below	2.1 or below

Pimsleur's et al (1977) 5-degree speech-rate classification

The average number of words per second uttered by the announcers in our materials was 3.4. In terms of the number of syllables Carroll (1964:60) has pointed out that the normal rate of speech spoken in English is 265 syllables per minute, which is about 4.4 syllables per second. The speech rate spoken in our materials was about 5 syllables per second. According to these measurements, the materials we used belong to a moderately fast rate.

Procedure

From the present speech materials, only content words and proper nouns containing schwas were selected for analysis. There were about 900 words containing schwas. By listening to the recorded speech, 101 words were selected in which the schwas were greatly reduced and perceptually perceived as almost deleted. These 101 words were their computer-analyzed on a High-Speed Speech Analysis System (Imagawa 1989). In order to measure the frequency of F1 and F2 for the schwas, the boundaries of each schwa and the adjecent consonants were decided both by a visual observation of the speech wave form displayed on a graphic screen and also by listening to the segmented sounds through a D/A converter.

Results

Figure 1 shows the frequency of F1 and F2 for the schwas analyzed in this study. The range for each vowel reported by Peterson and Barney (1952) is also shown for

reference. In their study, the vowels of the male subjects were analyzed as in the present study, and the typical area of the formant frequency for schwas was from 400 to 600Hz for F1 and from 1400 to 1800Hz for F2. However, schwas uttered in as fast a speech tempo as in the present study never appeared in Peterson and Barney's analysis. In the present study, the frequency of F1 and F2 for the schwas was from 300 to 450Hz for F1, and from 900 to 1800Hz for F2 in fast speech; In Figure 1, the difference between schwas in isolated words and those uttered in continuous speech at a fast tempo can be clearly observed.

Due to the increases in speech tempo, the frequency of F1 and F2 for the schwas changed considerably. Figure 2 shows that the variation in speech tempo affects the formant frequencies of stressed vowels. The stressed vowels [u] and [i] uttered by one of the announcers were examined. The words observed here were "wounded" and "police". Figure 2 shows the frequency of F1 and F2 for stressed vowels [i] and [u]. It can been seen in this figure that even in fast speech, stressed vowels are nearly the same as in normal tempo speech.

In Figure 1, the overall frequency range of F1 and F2 for schwas is shown. In order to further examine the pattern of the formant frequency change in the schwas due to utterance speed, the relationships between the formant frequency of the schwas and the adjacent consonants was examined. Table 1 (a) shows a list of words containing schwas which appeared in the area of [i]. The schwas' F1 and F2 were about from 200 to 450Hz and 1700 to 2000Hz, respectively. Table 1 (b) shows a list of words containing schwas which appeared in the area of [u] and [u:]. The formant frequency of the schwas were about from 200 to 550Hz for F1 and 800 to 1200Hz for F2. Table 1 reveals that the schwas in the area of [i] appeared when the adjacent consonants were [t],[z],[d],[ʃ],[p] and [b]. On the other hand, the schwas in the area of [u] and [u:] appeared when the adjacent consonants were [l],[r][k] and [v].

Gimson (1980:126) has pointed out that when schwa is articulated with adjacent consonants [k],[g] and [ŋ],the tongue may be slightly more raised and retracted. In this study, it was shown that [l],[r] have similar effects. Furthermore, the dental consonants [t],[z] and [d] also affect schwas. Formant frequencies move into the frequency of the [i] region, which is probably due to the fronting and raising of the tongue associated with these consonants. It should be noted here that the labial consonants [p] and [b] also have effects similar to these of the dental consonants.

These changes in formant frequencies are naturally expected due to the undershoot of the articulatory movements associated with the shortening of schwas in fast speech. The problem remaining to be examined is whether there is a difference between schwas and stressed vowels in the patterns of duration shortening associated with changes in the speaking rate.

References

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The list of recorded tapes

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World News in Brief, Home News in Brief and Voices in the Head News Highlight). The Study of Current English. August. 1989. Tokyo:Kenkyusha.

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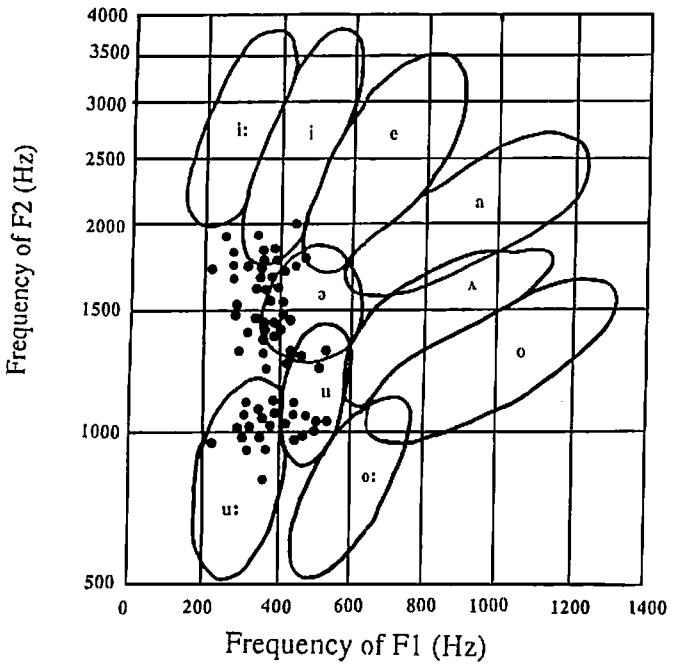

Fig.1 Diagram of F1-F2 plots for the unstressed American vowel [ɚ] in fast tempo speech

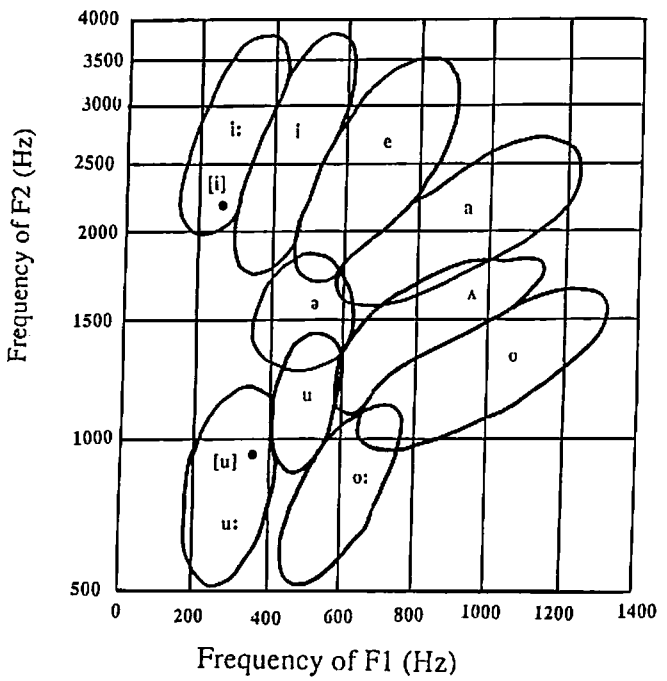

Fig.2 Diagram of F1-F2 plots for the stressed vowels [i] and [u] in fast tempo speech

Words	Consonants
investigation	/t/,/g/
together	/t/,/g/
secretary	/r/,/t/
machine	/m/,/ʃ/
opposition	/p/,/z/
departure	/d/,/p/
because	/b/,/k/
second	/k/,/n/
antagonizing	/g/,/n/

Table 1 (a) List of words containing schwas whose formant frequency are appeared in the area of [i]

Words	Consonants
cooperation	/p/,/r/
liberal	/r/,/l/
political	/k/,/l/
collided	/k/,/l/
dissaproval	/v/,/l/
festival	/v/,/l/
revival	/v/,/l/
alcoholic	/k/,/l/

Table 1 (b) List of words containing schwas whose formant frequency are appeared in the area of [u]