



Problems encountered by Japanese EL2 with English short vowels as illustrated on a 3D Vowel Chart

Toshiko Isei-Jaakkola^{1,2}, Takatoshi Naka³, Keikichi Hirose⁴

¹Department of English Language and Culture, Chubu University, Japan

²Department of Speech Sciences, University of Helsinki, Finland

³School of Information Science and Technology, Chukyo University, Japan

⁴Graduate School of Information Science and Technology, The University of Tokyo, Japan

¹tiseij@isc.chubu.ac.jp, ²toshiko.jaakkola@helsinki.fi, ³t-naka@sist.chukyo-u.ac.jp, ⁴hirose@gavo.t.u-tokyo.ac.jp

Abstract

In this study we attempted to illustrate to what extent Japanese university students who study English immediately after their enrolment have acquired English short vowels using graphs and a three-dimensional (= 3D) vowel chart, and thus to clarify what their problems are while simultaneously producing American English short vowels. There was a prediction that Japanese learners of English (JEL2) have weakness in lip-rounding and protrusion since there are no such articulatory movements in Japanese vowels. This was clarified while observing F2 and F3. JEL2 have problems with simultaneous in lip movements, the jaw movements in general in this case. Also we found that there was a difference between female and male JEL2. As far as this experiment is concerned, female JEL2's tongue and jaw movement (F2) is less stable than males'. Moreover, it may be confirmed that the 3D Vowel Chart may be more useful for EL2 than the graph.

Index Terms: JEL2, General American English (=GA) short vowels, vowel acquisition, graphs, 3D Vowel Chart

impressionistic plotting and is widely used for research and educational purposes. ([1]) All these vowels are concerned with maximum lip-spreading, for example, [i], maximum lip protrusion, [u], maximum jaw opening, that is, mouth openness, [a ɒ], maximum tongue height, [i u], and so forth. Then, a two-dimensional formant vowel chart with circles was invented. Figure 2 ([2]) shows a Vowel formant chart for Japanese ([3]) and Finnish short vowels ([4]) utilising Iivonen's program. ([5])

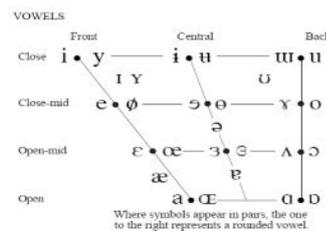


Figure 1: IPA Vowel Chart.

1. Introduction

English is widely taught all over Japan from elementary school to university. Yet, the Japanese have difficulty in acquiring its proper pronunciation. Phonemes, particularly vowels, are most essential and important for acquiring correct pronunciation when studying a foreign language. English vowels are very different from those of Japanese which has only five vowels. In English the number, quality and types of the vowels largely differ from Japanese. In English there are monophthongs, which constitute short and long vowels, diphthongs and triphthongs. In Japanese there are linguistically (semantically) distinctive short and long vowels but their quality is quite similar.

In English vowels, monophthongs, diphthongs and triphthongs are mostly combinations of short vowels when analytically observed. Firstly, and above all, short vowels are the basic phonemes that must be acquired by all Japanese learners of English (= JEL2). In our research we attempted to illustrate to what extent Japanese university students who study English immediately after their enrolment have acquired English short vowels using a three-dimensional (= 3D) vowel chart, and thus to clarify what their problems are while simultaneously producing English short vowels.

1.1. Review of vowel charts

Here we need to review the history of vowel charts. Figure 1 shows the IPA Vowel Chart which was created by

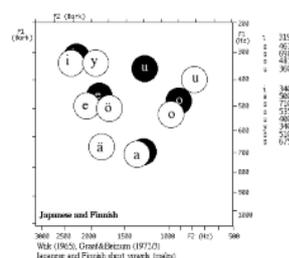


Figure 2: Vowel formant chart for Japanese and Finnish short vowels.

Thirdly, Isei-Jaakkola, et. al., have invented such a program (3D Vowel Chart), which can be used by learners to locate vowels in a three-dimensional environment. A teacher or learner can compare his/her own monophthongal locations with model monophthongs from the target language, simply by typing in formant values. Further, the user can change the background colours and symbols, move the angles of the whole chart, compare with the monophthongs in other languages or change the formant values freely. Thus, it is expected that this visualisation system will motivate the language learner to learn more while having a pleasurable experience. Recently the program was updated to allow any of the formants 1-4 to be displayed in three dimensions. This program was originally designed to meet the needs of learners of the most widely-spoken languages. ([6], [7]) We shall exemplify this in 1.2.

1.2. English and Japanese short vowels

Utilizing the above 3D Vowel Chart, let us compare the five Japanese short vowels /i e a o u/ and General American English (=GA) short vowels /ɪ ɛ æ ʌ ʊ/. It should be noted that all five short vowels are different from each other in the quality, that is, lip-spreading, lip roundness, lip openness, and also that there is no equivalent in GA for Japanese /o/.

Figure 3 (front view) shows a comparison of F1 (y axis) and F2 (x axis) and figure 4 (side view) shows that of F1, F2 and F3 (z axis) (male data quoted from [8]).

It is clear from figure 3 that F1 and F2 are generally higher in Japanese than in GA, and from figure 4, F3, particularly /i/, much higher in Japanese than GA. This means that Japanese vowels require more lip spreading for /i/ and this makes it difficult not only for JEL2 to pronounce the phoneme but also in listening. In addition, there is little lip protrusion in Japanese vowels.

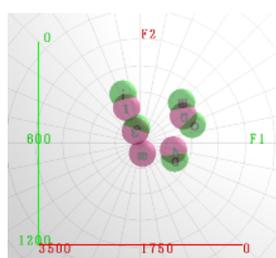


Figure 3: Front view of five Japanese (green) and five American vowels (red) utilising only two axes (F2=x and F1=y) on a 3D Vowel Chart.

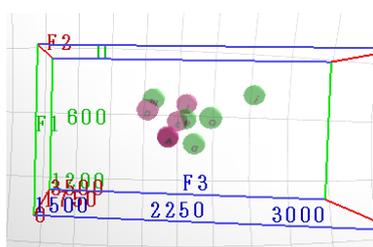


Figure 4: Side view of five Japanese (green) and five American English vowels (red) utilising three axes (F2=x, F1=y and F3=z) on a 3D Vowel Chart.

1.3. Research questions

In this research, we shall consider the following questions:

- (1) To what degree did the JEL2 acquire GA short vowels?
- (2) Are there any differences between males and females in this regard?
- (3) Are there differences between graphical and 3D visualisation in illustrating such differences?

2. Experiment

2.1. Materials and subjects

Since there are five short vowels in General American (GA), we decided to use five words containing these phonemes. The five test words were taken from [9]. (See table 1) The underlined part in each test word is transcribed in the same list as the target phoneme which was used for the experimental analysis.

The subjects (=JEL2) were male and female university freshmen whose ages were 18–19, and who were majoring in English. They had studied English for six years. The recordings were made immediately after their enrolment in April in a laboratory at Chubu University. They uttered each test word only once after short practice.

The number of subjects (see table 1) was 31 for males and 22 females. However, some pronounced the phonemes very differently to the respective target phoneme, and consequently these mistakes (23) were eliminated from the data for analysis. There was no significant error between males (9%) and females (8%).

Thus, the experimental data consisted of 265, although there were a total of 242 for analysis.

Table 1: Test word list and number of subjects.

Test words	Target phoneme	No. of male subjects	No. of female subjects
<u>b</u> id	ɪ	31 (100%)	19 (86%)
<u>b</u> ed	ɛ	27 (87%)	21 (95%)
<u>b</u> ad	æ	29 (94%)	21 (95%)
<u>b</u> ud	ʌ	27 (87%)	20 (91%)
<u>b</u> udd(hist)	ʊ	27 (87%)	20 (91%)
Total	—	141 (91%)	101 (92%)

(% = correct ratio)

2.2. Analytical method

The duration of each vowel varies. We selected a segment of approximately 40–60ms in duration from the whole duration depending on the phoneme and acquired a mean and SD value for each vowel formant of each phoneme.

3. Results

3.1. Comparison between JEL2 and GA using graph

Figures 5 and 6 show the mean vowel formant values of F1~F3 of five JEL2's short vowels for males (Fig. 5) and females (Fig. 6) respectively and GA's ([8]) in common to both figures.

In terms of figure 5, F1 of JEL2's and GA's s were very similar regardless the phonemes. All F3 of JEL2's had higher values than those of GAs. On the other hand, F2 of JEL2's and GAs showed a different pattern from F1 and F2, that is, the difference between the two were not parallel.

Regarding figure 6, the patterns of F1~F3 appeared to be relatively similar, although F2 and F3 appeared slightly different from those in figure 6.

For JEL2 males and females, above all their /u/ showed a significant difference from the GA counterpart in both F2 and F3.

Figures 7 and 8 show the standard deviation (= SD) of the vowel formant values of F1~F3 for five JEL2's short vowels for males (Fig. 7) and females (Fig.8) respectively.

The female JEL2 had much higher ratios in comparisons of F1~F3 (if F1=100%, then F2=240%, F3=280%) than the male (if F1=100%, then F2=390%, F3=430%). The contours appear to be very different in both F2 and F3, and particularly in F2 for females, as SD shows.

It may be natural for SD to be higher for females than males because the original formant values for females (a denominator) are generally higher than those for males. However, it should be noted that the female JEL2 had much

higher ratios of F2 and F3 compared to that of L1 than male JEL2.

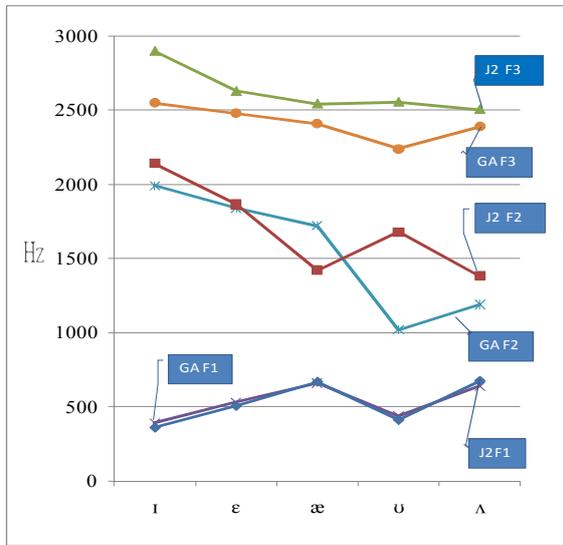


Figure 5: Comparison of mean F1~F3 between JEL2 (J2 in the figure)'s and GA's short vowels for males.

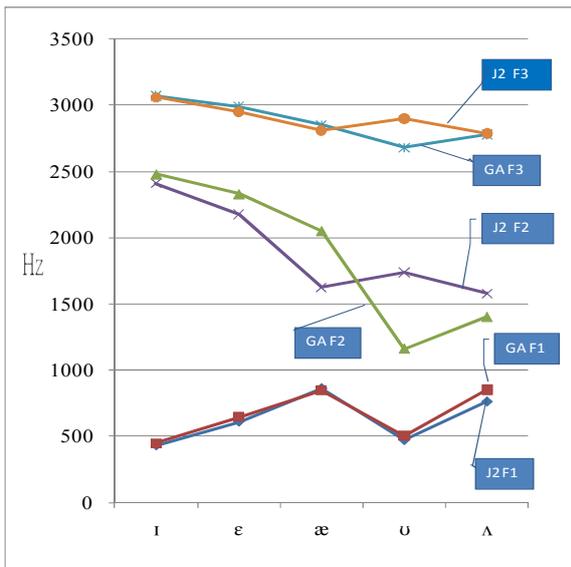


Figure 6: Comparison of the mean F1~F3 between JEL2's (J2 in the figure) and GA's short vowels for females.

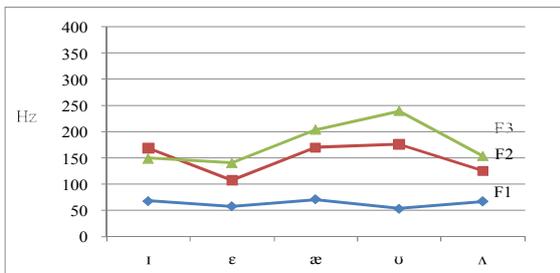


Figure 7: SD of vowel formant values of F1~F3 for five JEL2's GA short vowels for males.

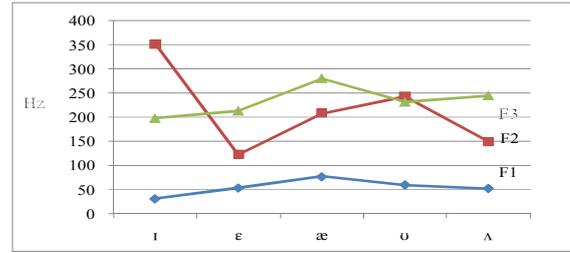


Figure 8: SD of vowel formant values of F1~F3 for five JEL2's GA short vowels for female.

3.2. Comparison between JEL2 and GA using 3D Vowel Chart

Here, the data used are the same as in 3.1 but the representation is in 3D Vowel Chart. Figures 9 and 11 show a comparison of the mean F1~F2 between JEL2's and GA's short vowels for males and females viewed from the front with x (F2) and y (F1) on a 3D Vowel Chart. Figures 10 and 12 are the same but with x (F2), y (F1) and z (F3) viewed from side.

As expected the vowel formants are more widely spread for females than males for both JEL2 and GA because of gender differences. However, it appears that JEL2 females had in general a higher F2 and JEL2 males a higher F3.

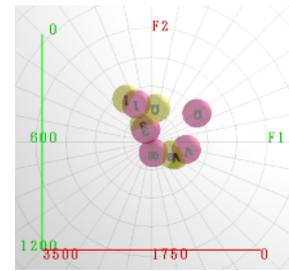


Figure 9: Comparison of mean F1~F2 between JEL2's (yellow) for males and GA's (red) short vowels for males on the 3D Vowel Chart viewed from the front showing x (F2) and y (F1) axes.

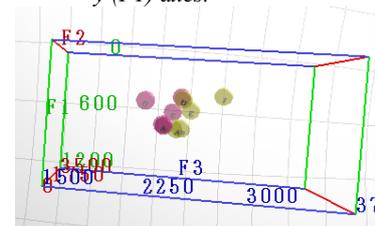


Figure 10: Comparison of mean F1~F3 between JEL2's (yellow) for males and GA's (red) short vowels for males on the 3D Vowel Chart viewed from the side showing x (F2), y (F1) and z (F3) axes.

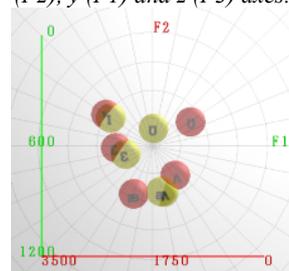


Figure 11: Comparison of mean F1~F2 between JEL2's (yellow) for females and GA's (red) short vowels for females on the 3D Vowel Chart viewed from the front showing x (F2) and y (F1) axes.

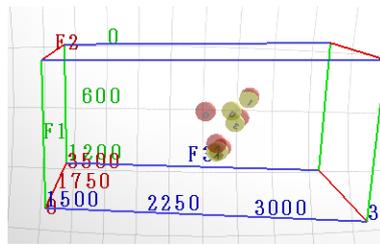


Figure 12: Comparison of mean F1~F3 between JEL2's (yellow) for females and GA's (red) short vowels for females on the 3D Vowel Chart viewed from the side with x (F2), y (F1) and z (F3) axes.

4. Discussion

[10] (p. 98) states that the first formant (F1) is most responsive to changes in mouth opening. Speech sounds requiring small mouth openings have low frequency first formant. Conversely, open mouth sounds are characterised by relatively high frequency first formants—the second formant is most responsive to changes within the oral cavity...Tongue backing or lip activity might lower the frequency of this formant, as these constrictions would occur in areas of high velocity, but any tongue or jaw activity that would narrow the region in the oral cavity where the pressure is relatively high would result in raising the frequency of the second formant. The third formant is responsive to front versus back constriction.

Based on this definition, there was no problem for JEL2 (see, figures 5 and 6) regarding F1, that is, mouth opening (viz, the vertical width between lips). However, as clarified in the above section, JEL2 had problems or difficulty in F2 and F3. We cannot separate tongue movement from lip movement. Yet, it may be predictable that there was a problem inside the mouth, namely the position of the tongue (backness/frontness). In particularly JEL2 males had this problem in all F3s. This implies that they may have had problems with the tongue position, quite probably lacking frontness (e.g., /æ/) and backness (e.g., /ʌ/) a little, and constriction in the mouth, namely, regarding the opening of the jaw.

For example, comparing the Japanese uttering of /u/ to the GA /u/, the JEL2 had to slightly lower the jaw without opening the lip/mouth further, and with a slight lip rounding, for which the lips should be slightly narrowed. Further, the back of the tongue will be slightly raised and simultaneously the tongue position towards the back. In addition, there was a problem with lip spreading. In GA /æ/ requires more spreading than the Japanese /a/.

Consequently, JEL2 should have more lip roundness (e.g., /u/) and more or less lip spreading (e.g., /æ/, /ʌ/, /ɪ/) because it is not easy to control the jaw opening.

As to whether nor there be differences between graphical and 3D visualisation in illustrating the vowel formants, the graph can show more clearly the numerical values, whereas the 3D Vowel Chart tells the location of each vowel, and thus the interval between vowels at a glance, as shown in the above figures. For research purpose, both are useful. On the other hand, the 3D Vowel Chart may be much more useful for EL2.

5. Conclusion

In this study we attempted to illustrate to what extent Japanese university students who study English immediately after their enrolment have acquired English short vowels using 3D Vowel Chart, and thus to clarify what their problems are while simultaneously producing American English short vowels.

There was a prediction that JEL2 have weakness in lip-rounding and protrusion since there are no such articulatory movements in Japanese vowels. This was clarified while observing F2 and F3. JEL2 have problems with simultaneous in lip movements, the jaw movements in general in this case.

Also we found that there was a difference between female and male JEL2. As far as this experiment is concerned, female JEL2's tongue and jaw movement (F2) is less stable than males'.

Moreover, it may be confirmed that the 3D Vowel Chart may be more useful for EL2 than the graph.

For future studies, we need to compare the present result and the same subjects' development of the acquisition of the same GA vowels used for this experiment. Also, it would be expected that we can use this system for CALL system in many other language than the language used for this study.

6. Acknowledgements

This work was supported by the Japan Society for the Promotion of Science (JSPS) Grant-in-Aid for Challenging Exploratory Research (21652058).

7. References

- [1] IPA vowel chart: <http://www.arts.gla.ac.uk/ipa/vowels.html>.
- [2] Isei-Jaakkola, T., *Lexical Quantity in Japanese and Finnish*, Publication (48) of the Department of Phonetics, University of Helsinki, Hakapaino Oy., Helsinki, 2004.
- [3] Fujisaki H., and Sugitou, M., "Onsei no Butsuriteki Seishitsu", Iwanami Kouza Japanese Vol.5 ed. by Ohno and Shibata, Tokyo: Iwanami, pp.63-98, 1977.
- [4] Wiik, K., *Finnish and English Vowels*, Publications of University of Turku, B: 94, 1965.
- [5] Iivonen, A., <http://www.helsinki.fi/puhetieteeetprojektit/vokaalikartat/>, 2005.
- [6] Isei-Jaakkola, T., Naka, T., and Hirose, K., "A multilingual 3D vowel chart for monophthongs based on formants", *Nordic Prosody Proc. of the Xth Conf.*, Helsinki 2008, Peter Lang, Frankfurt am Main, Germany, 117-126, 2009.
- [7] Isei-Jaakkola, T., Naka, T., and Hirose, K., "A basic study for four-dimensional visualisation of a three-dimensional vowel chart", *ITE Technical Report Vol.34, No.11, 43-46, HI2010-62, 3DIT2010-14*, 2010.
- [8] Peterson, G. E. and Barney, H. L., "Control methods used in a study of the vowels", *Journal of Acoustic Society of America* 24, 175-184, 1952.
- [9] Ladefoged, P., "The vowels of American English", <http://www.ladefogeds.com/vowels/chapter3/amengvowels.html>, 2008.
- [10] Gloria, J. B., Harris, K. S. and Raphael, L. J., *Speech Science Primer 3rd ed.*, Maryland: Williams and Wilkins, 1994.