ARTICULATORY MOVEMENT IN NON-NATIVE CONSONANT CLUSTERS

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ABSTRACT

We investigated articulatory movements of native Japanese speakers' productions of non-native consonant clusters, using the WAVE system (NDI Corp.). Four Japanese male speakers pronounced "blat", "bnat", "btat", and "pnat" 10 times each in a carrier sentence. Tongue tip displacement from the first to the second consonant varied greatly among the speakers. An ANOVA with two factors, Speaker and Cluster, was performed, and showed significant main effects of both Speakers ($p<0.0001$) and Clusters ($p<0.0001$), and significant interaction ($p<0.0001$). In addition, comparison with previous data of English speakers indicated that the tongue tip displacement in Japanese speakers was larger than that for English speakers. We suggest that the large displacement from the first to second consonant for Japanese speakers indicates that coarticulation is more difficult for them than it is for English speakers.

Keywords: consonant clusters, articulation, WAVE system, tongue tip height, displacement.

1. INTRODUCTION

Non-native consonant clusters are frequently difficult for second language learners to produce, even if their native language has consonant clusters. It is especially difficult for learners (e.g. Japanese) to produce consonant clusters when there are no consonant clusters in their native language. Production of consonant clusters often results in vowel epenthesis, consonant deletion, consonant change, and prosthesis. [1], [2]. Non-native consonant cluster productions were examined in a pilot study [3] using the electro-magnetic articulograph (EMA). EMA is a very good system for precise recording of the movement of articulator, but it can also be difficult for inexperienced investigators, especially calibration of sensors. In this study, we used the WAVE system (NDI Corp.) for no calibration was necessary [4]. Thus, we used this system to investigate the articulatory movements of native Japanese speakers' productions of non-native consonant clusters.

2. METHODS

2.1. Speakers and speech samples

The speakers were 4 male Japanese (A, B, C, D). Speech samples were 4 words, "blat", "bnat", "btat", and "pnat". Only "blat" is a possible cluster in English. The other 3 words have non-English consonant clusters. All the second consonants, /l/, /n/, /t/ are articulated with the tongue tip placed behind the alveolar ridge. These words (X) were embedded in an English sentence "Say X.". The 4 Japanese speakers pronounced these sentences 10 times in random order.

2.2. Wave recordings and data analyses

Articulatory movement and acoustic data were recorded simultaneously using the WAVE system (NDI Corp.). In the articulatory measurement, sensor coils were placed on the tongue tip, tongue middle, tongue back, incisors of the lower jaw, upper and lower lips on the mid-sagittal plane, as well as on the nasion (reference sensor) for head movement correction. The movements of each sensor were recorded separately for x and y axes. The x axis is the anterior-posterior axis, and the y axis, the superior-inferior axis. Both axes are on the mid-sagittal plane.

We used MVIEW (Haskins Laboratories) for the movement analyses of each sensor. We measured the tongue tip displacement (D) from the burst point of the first plosive consonants, /b/, /p/, to the place of articulation (the maximum value of tongue tip height during a consonant cluster) in the second consonants, /l/, /n/, /t/. We also calculated the relative tongue tip height (H_r) in the second consonant as follows,

(1) $H_r = H / (Y_{max} - Y_{min})$

H is the maximum value of tongue tip height in the second consonant, Y_{max}; the maximum value of tongue tip height in the sentence, Y_{min}; the minimum value of tongue tip height in the sentence.

The tongue tip displacement (D) was normalized by the method described in [3] in order to take into account of the size of speakers' articulators. Normalized D was represented by D_n.

3. RESULTS

Figure 1 shows displacement (D_n) of each cluster for each speaker. The amount of displacement varies greatly among the speakers. For speakers A and D, the displacements are relatively large, whereas those for B and C are relatively small. An ANOVA with two factors, Speaker and Cluster, was performed. The ANOVA showed significant main effects of Speakers ($F(2,108)=55.877$ ($p<0.0001$)) and Clusters ($F(3,108)=18.526$ ($p<0.0001$)), and also significant interaction ($F(6,108)=5.421$ ($p<0.0001$)). That is to say, the differences among speakers and that among clusters were very large. According to the study for three English speakers [5], the mean displacements for /bl/, /bn/ and /bt/ were 0.26, 0.36, 0.41, respectively. English speakers showed relatively small displacement, but similar to the Japanese speakers, the differences among speakers and among clusters were very large.

Figure 1: Tongue tip displacement from first consonant to second consonant.

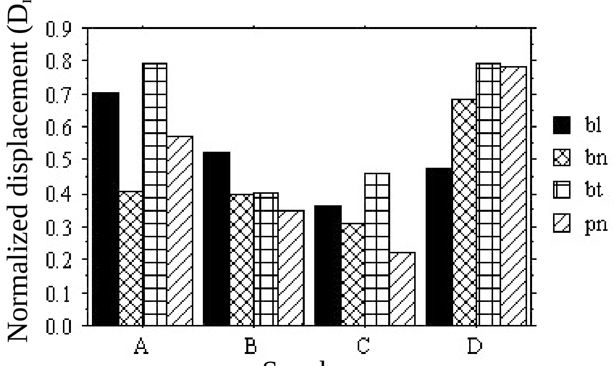


Figure 2 shows relative tongue tip height (H_r) of each cluster for each speaker. In this figure, H_r of /bl/ and /bt/ for speakers A and C are approximately 1, and of /bn/ and /pn/ are approximately 0.8. While for speakers B and D, H_r of /bn/, /bt/, and /pn/ are approximately 1, but that of /bl/ is approximately 0.65. Namely, their tongue tip heights were not as high as those of speakers A and C for the /l/ articulation. Figure 3 represents an utterance of “blat” (top) and “btat” (bottom) for speaker B. In this figure, the third window shows the spectrogram, the fourth, x displacement, and the fifth, y-displacement. This figure shows that tongue tip height for /l/ is lower than that for /t/.

Figure 2: Relative tongue tip height in second consonants.

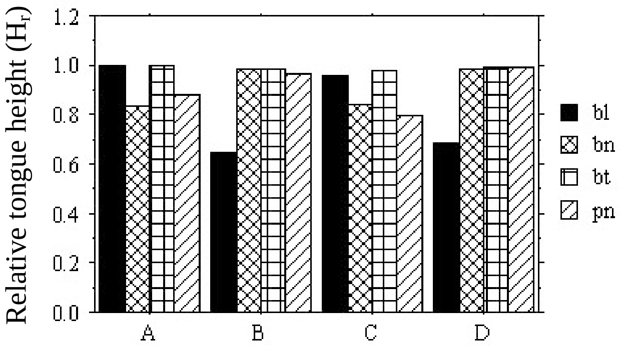
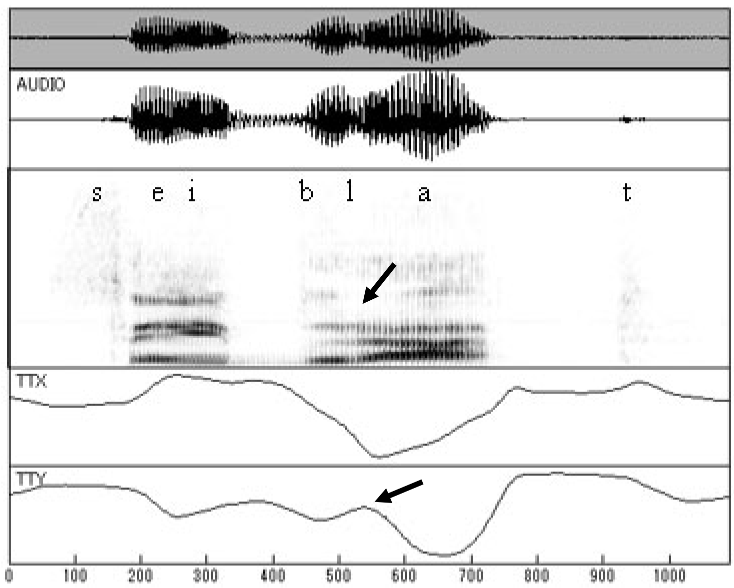


Figure 3: An utterance token of “blat” and “btat” for speaker B.
Top; “blat”, bottom; “btat”. The arrows point to the articulations for /l/ and /t/, respectively.



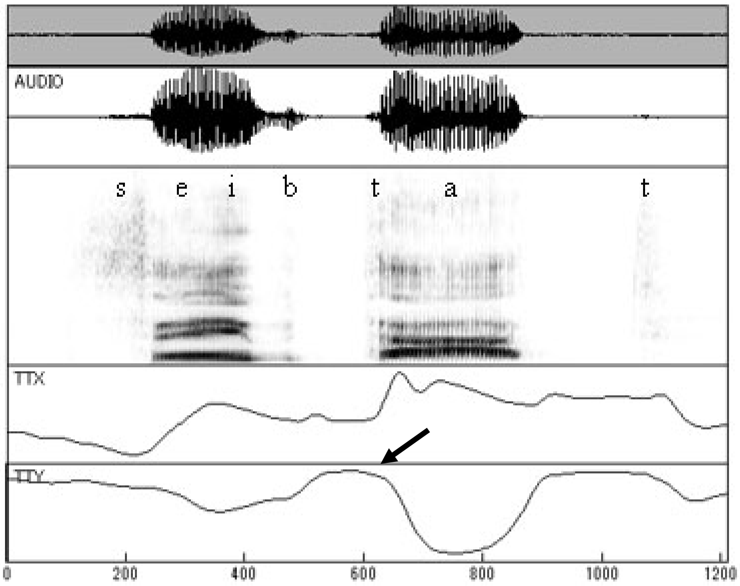
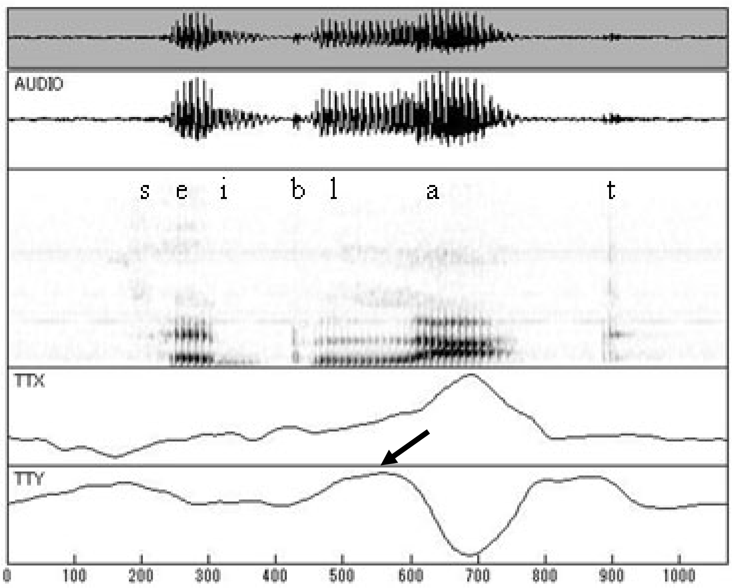


Figure 4: A token of “blat” and “btat” for speaker C.
Top; “blat”, bottom; “btat”. The arrows point to the articulations for /l/ and /t/, respectively.



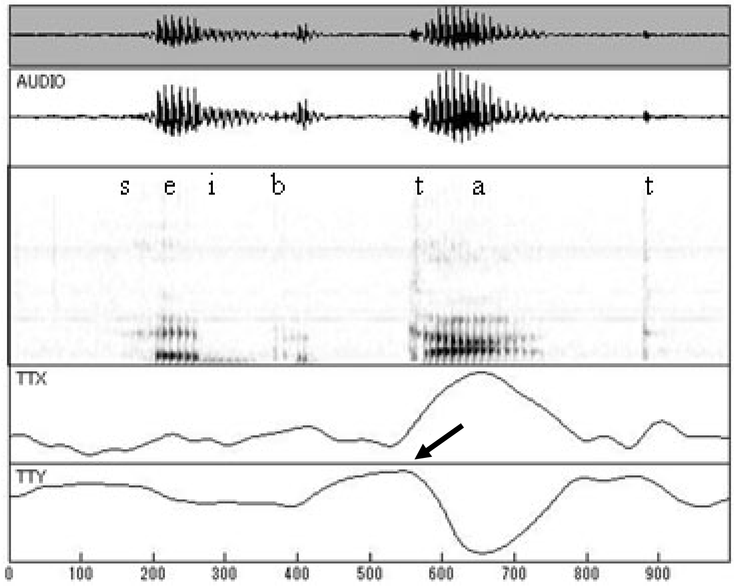


Figure 4 shows “blat” and “btat” for speaker C. Notice that the tongue tip is high for both consonants; however, for speaker B, the tongue tip for /l/ is not as high as that for /t/.

4. DISCUSSION

In non-native consonant clusters /bl/, /bn/, /bt/, /pn/, the displacements from the first consonant to second consonant showed very large differences among the Japanese speakers. The displacements for speaker C were relatively small, but those for speakers A and D were large. This displacement in Japanese speakers was larger than that in the previous experiment for three English speakers [5]. The displacement for Japanese speakers was larger than that for English speakers not only for the acceptable English consonant cluster /bl/, but also for the non-English consonant clusters, /bn/, /bt/. This might be because English speakers have more experience producing consonant clusters, and have developed efficient methods of coarticulation.

For speakers A and C, the relative height of the tongue tip in the second consonant is nearly the same for all the consonants. For speakers B and D, however, the relative tongue tip height for the /l/ is lower than that for the other consonants, and is also lower than the /l/ for speakers A and C. Moreover, the spectrogram for Speaker B (figure 3) shows a relatively high F2 for /l/ with a gradual (loose) closure (light-white, not black) spectrum) This, together with the lower tongue tip articulation, suggests that Speaker B is not producing a good English /l/, but rather something like a Japanese [ɾ] (Japanese *ra-gyo* sound). Therefore, it would appear that speaker B substituted Japanese [ɾ] for English /l/.

5. CONCLUDING REMARKS

From this study, we found that coarticulation between consonants for Japanese speakers was relatively weaker than that for English speakers. Also, it seems that some Japanese speakers substituted a native Japanese consonant for a non-native consonant (i. e. English /l/).

6. REFERENCES

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