

# HOW LISTENERS' L1 AFFECTS PERCEIVED SIMILARITY OF AMERICAN ENGLISH, JAPANESE AND KOREAN VOWELS

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## ABSTRACT

Native speakers of Japanese and Korean assessed perceived similarity between American English vowels and vowels of their L1, and native speakers of American English performed the same task. The results revealed no significant main effects of listener groups, but a significant interaction of vowels by listener groups was confirmed. The results indicate that listeners' L1 phonology as well as phonetic distance in the vowel space affects perceived similarity between L1 and non-native phones. The results also imply that what speakers of Japanese and Korean believe are close to their L1 phones are not necessarily perceived as similar by English speakers.

**Keywords:** perceived similarity, vowels, American English, Korean, Japanese

## 1. INTRODUCTION

A number of studies have indicated that linguistic experience influences how nonnative speech sounds are perceived. For instance, Rochet [4] points out that native speakers of Japanese perceive English /θ/ as an instance of /s/ whereas native speakers of Russian perceive it as an instance of /t/. This study attempts to investigate how listeners' L1 affects perceived similarity between American English and Japanese vowels, and between American English and Korean vowels.

The vowel inventories of these three languages differ in some ways. Japanese has only five spectrally different vowels /a, e, i, o, u/, but each of these has spectrally identical long geminate vowels /a:, e:, i:, o:, u:/. Korean vowel space is more partitioned with /a, e, i, o, u, ʌ, i/. American English vowel system is more complex with lax vowels /ɪ, ε, æ, ʌ, ʊ/, tense vowels /i, eɪ, aɪ, ə, aʊ, ɔ, ɔɪ, oʊ, u/ and reduced vowel /ə/. Of these, diphthongs /eɪ, aɪ, aʊ, ɔɪ, oʊ/, r-colored /ə/ and schwa /ə/ were excluded from this study. This study aims at investigating how the vowel inventory of one's L1 will affect the perceived

similarity of vowel pairs (these pairs are comprised of either a native and a nonnative vowel or of two nonnative vowels), and attempts to show that what is perceptually similar to speakers of one language is not necessarily perceptually similar to speakers of another language.

## 2. EXPERIMENT

### 2.1. Stimuli

A total of nine talkers—three female native speakers of American English, Korean and Japanese, respectively—participated as talkers. American English talkers produced /i, ɪ, ε, æ, ʌ, ʊ, u/ in /hVd/ frame. Korean talkers produced /ɪ, e, a, ʌ, o, i, u/ in /hVt/ frame and Japanese talkers produced /i, i:, e, a, o, u, u:/ in /hVdo/ frame. Their utterances were digitally recorded and edited to be used as stimuli, so that all the stimuli had either /hVd/ or /hVt/ structures. English diphthongs were not included because neither Korean nor Japanese has diphthongs like English (English diphthongs are usually transcribed as a combination of two vowels in Korean and Japanese.). American English vowels were matched with Korean and Japanese vowels as shown in Table 1. Thus, 13 English-Korean vowel pairs, and 13 English-Japanese vowel pairs were created.

**Table 1:** Matching of American English-Korean & American English-Japanese vowels.

AE vowels	K vowels	J vowels
/i/	/i/	/i/, /i:/
/ɪ/	/i/	/i/, /e/
/ε/	/e/	/e/
/æ/	/a/, /e/	/a/, /e/
/ʌ/	/a/, /ʌ/, /o/	/a/, /o/
/ʌ/	/a/, /ʌ/, /o/	/a/
/ʊ/	/i/	/u/
/u/	/u/, /i/	/u/, /u:/

### 2.2. Listeners

Fourteen native speakers of American English, Korean and Japanese participated as listeners.

American English listeners had not learned Korean or Japanese.

**2.3. Procedure**

Listeners heard two stimuli per trial. One of the stimuli was an American English stimulus, and the other was either a Korean or a Japanese stimulus. The order of the stimuli was reversed across trials. The perceived similarity of each vowel pair was assessed by 9 trials (3 AE talkers x 3 Japanese or Korean talkers).

Listeners rated the perceived similarity of the vowels of the two stimuli in each trial on a 7-point scale (1=very different, 7=very similar). They responded by moving the cursor to the box numbered 1 through 7 on the computer screen. They were allowed to hear the same trial as many times as they wanted. They were also instructed to disregard the difference of the consonants before and after the vowel.

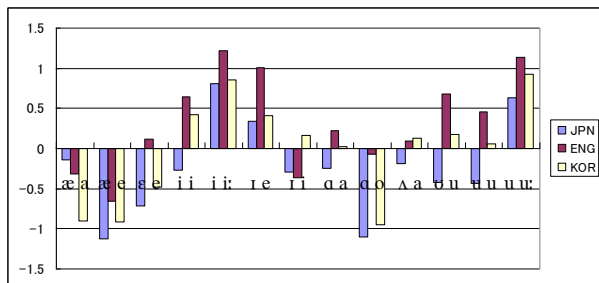
**2.4. Results**

The ratings by listeners were standardized for a statistical analysis. A two-way ANOVA (3 Listener Groups x 26 Vowel Pairs) yielded a significant main effect of Vowel Pairs [F(25,1050)=19.2, p<0.001], but a main effect of Listener Groups was not significant [F(2,42)=2.3, p=0.114 (n.s.)]. However, an interaction between Vowel Pairs and Listener Groups was significant [F(50, 1050) = 2.3 p<0.001].

*2.4.1. AE vowels-Japanese vowels ratings*

Mean similarity ratings are shown in Figure 1.

**Figure 1:** Similarity ratings of American English and Japanese vowels by 3 groups of listeners: Phonetic symbols of English vowel (left) and Japanese vowel (right) in each pair.



Bonferroni's pairwise comparisons revealed that Japanese listeners' similarity ratings of  $_{\text{E}}/i/$  and short  $_{\text{J}}/i/$  were significantly lower than those of the other two listener groups (p<0.05). Japanese listeners' similarity ratings of  $_{\text{E}}/a/$  and  $_{\text{J}}/o/$  and of

$_{\text{E}}/u/$  and  $_{\text{J}}/u/$  were significantly lower than were those of English listeners (p<0.05).

All the listener groups gave a high similarity rating to  $_{\text{E}}/i/-_{\text{J}}/i:/$  and  $_{\text{E}}/u/-_{\text{J}}/u:/$ , but only Japanese listeners rated Japanese one-mora  $_{\text{J}}/i/$  and  $_{\text{J}}/u/$  significantly less similar to  $_{\text{E}}/i/$  and  $_{\text{E}}/u/$  respectively than their geminate counterparts (See Table 2).

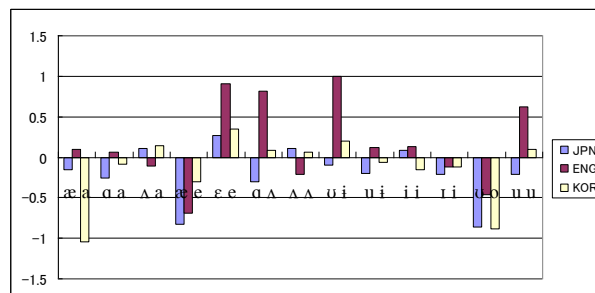
**Table 2:** English – Japanese vowel pairs each listener group gave a high similarity rating ('>') denotes a significantly higher rating at the p<0.05 level.

Japanese Listeners	
$_{\text{E}}/i/-_{\text{J}}/i:/$	> $_{\text{E}}/\text{æ}/-_{\text{J}}/e/$ , $_{\text{E}}/i/-_{\text{J}}/i/$ , $_{\text{E}}/a/-_{\text{J}}/o/$ , $_{\text{E}}/u/-_{\text{J}}/u/$ , $_{\text{E}}/u/-_{\text{J}}/u/$
$_{\text{E}}/u/-_{\text{J}}/u:/$	> $_{\text{E}}/\text{æ}/-_{\text{J}}/e/$ , $_{\text{E}}/a/-_{\text{J}}/o/$ , $_{\text{E}}/u/-_{\text{J}}/u/$ , $_{\text{E}}/u/-_{\text{J}}/u/$
English Listeners	
$_{\text{E}}/i/-_{\text{J}}/i:/$	> $_{\text{E}}/\text{æ}/-_{\text{J}}/a/$ , $_{\text{E}}/\text{æ}/-_{\text{J}}/e/$ , $_{\text{E}}/i/-_{\text{J}}/i/$
$_{\text{E}}/u/-_{\text{J}}/u:/$	> $_{\text{E}}/\text{æ}/-_{\text{J}}/a/$ , $_{\text{E}}/\text{æ}/-_{\text{J}}/e/$ , $_{\text{E}}/i/-_{\text{J}}/i/$
$_{\text{E}}/i/-_{\text{J}}/e/$	> $_{\text{E}}/\text{æ}/-_{\text{J}}/a/$ , $_{\text{E}}/\text{æ}/-_{\text{J}}/e/$ , $_{\text{E}}/i/-_{\text{J}}/i/$ , $_{\text{E}}/\text{ʌ}/-_{\text{J}}/a/$
Korean Listeners	
$_{\text{E}}/u/-_{\text{J}}/u:/$	> $_{\text{E}}/\text{æ}/-_{\text{J}}/a/$ , $_{\text{E}}/\text{æ}/-_{\text{J}}/e/$ , $_{\text{E}}/\text{ɛ}/-_{\text{J}}/e/$ , $_{\text{E}}/a/-_{\text{J}}/o/$
$_{\text{E}}/i/-_{\text{J}}/i:/$	> $_{\text{E}}/\text{æ}/-_{\text{J}}/a/$ , $_{\text{E}}/\text{æ}/-_{\text{J}}/e/$ , and $_{\text{E}}/a/-_{\text{J}}/o/$

*2.4.2. AE vowels-Korean vowels ratings*

Mean similarity ratings are shown in Figure 2.

**Figure 2:** Similarity ratings of American English and Korean vowels by 3 groups of listeners: Phonetic symbols of English vowel (left) and Korean vowel (right) in each pair.



Bonferroni's pairwise comparisons revealed that among similarity ratings between English and Korean vowels, Korean listeners' similarity ratings of  $_{\text{E}}/\text{æ}/$  and  $_{\text{K}}/a/$  were significantly lower than those of English and Japanese listeners (p<0.05). Japanese listeners rated  $_{\text{E}}/a/$  and  $_{\text{K}}/\text{ʌ}/$  significantly less similar than did English listeners (p<0.05). English listeners rated English  $/u/$  and Korean  $/i/$  significantly more similar than did the other two listener groups (p<0.05).

The results of within-group analysis (repeated measures) are shown in Table 3.

**Table 3:** English – Korean vowel pairs each listener group gave a high similarity rating (> denotes a significantly higher rating at the  $p < 0.05$ ).

<p><b>Japanese Listeners</b>  <math>_{E}/\Lambda/-_{K}/\Lambda/&gt;_{E}/\ae/-_{K}/e/</math></p> <p><b>English Listeners</b>  <math>_{E}/\upsilon/-_{K}/i/ &gt;_{E}/\ae/-_{K}/a/,_{E}/\alpha/-_{K}/a/,_{E}/\Lambda/-_{K}/a/,_{E}/\ae/-_{K}/e/,</math>  <math>_{E}/\Lambda/-_{K}/\Lambda/,_{E}/i/-_{K}/i/,_{E}/\upsilon/-_{K}/i/,_{E}/\upsilon/-_{K}/o/</math>  <math>_{E}/\epsilon/-_{K}/e/ &gt;_{E}/\Lambda/-_{K}/a/,_{E}/\ae/-_{K}/e/,_{E}/\upsilon/-_{K}/o/</math>  <math>_{E}/\alpha/-_{K}/\Lambda/ &gt;_{E}/\ae/-_{K}/e/,_{E}/\upsilon/-_{K}/o/</math></p> <p><b>Korean Listeners</b>  <math>_{E}/\ae/-_{K}/a/ &lt;_{E}/\alpha/-_{K}/a/,_{E}/\Lambda/-_{K}/a/,_{E}/\epsilon/-_{K}/e/,</math>  <math>_{E}/\alpha/-_{K}/\Lambda/,_{E}/\Lambda/-_{K}/\Lambda/,_{E}/\upsilon/-_{K}/i/,_{E}/\upsilon/-_{K}/i/,_{E}/i/-_{K}/i/</math>  <math>_{E}/\upsilon/-_{K}/u/</math></p>
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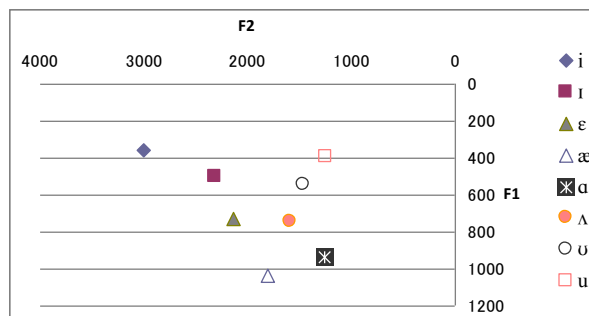
2.4.3. Acoustic analysis of stimuli

F1 and F2 frequencies of each stimulus were measured at the midpoint by using formant listing on Praat. Figures 3-5 show mean F1 and F2 frequencies (averaged across the three talkers) of each vowel of the three languages.

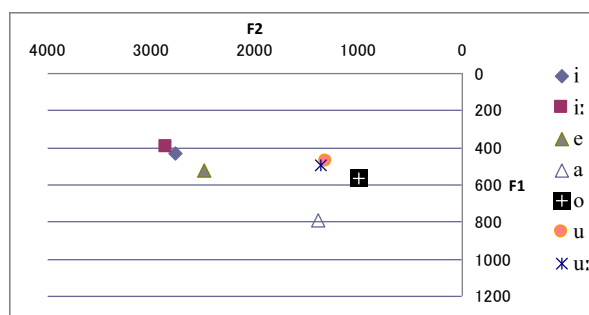
Of the high front vowels of the three languages,  $_{E}/i/$  is the highest and the most fronted and  $_{K}/i/$  is the lowest and the least fronted. This helps to explain Korean speakers' lower sensitivity to discriminate  $_{E}/i/$  and  $_{E}/i/$  than Japanese speakers as shown in Frieda & Nozawa [1], and English listeners' higher similarity rating between  $_{E}/i/$  and  $_{J}/i/$  than  $_{E}/i/$  and  $_{K}/i/$ . For Japanese listeners,  $_{E}/i/$  may have been perceived as a less ideal instance of  $_{J}/i/$ . All the three listener groups gave  $_{J}/i/$  a higher similarity rating to  $_{E}/i/$  than to  $_{J}/i/$ , but a significant difference was found only for Japanese listeners' ratings. This indicates that Japanese listeners depend on durational information to identify  $_{E}/i/$  as demonstrated by Morrison [3]. For them,  $_{J}/i/$  seems to be equally dissimilar to  $_{E}/i/$  (-0.27) as to  $_{E}/i/$  (-0.30).

Among mid front vowels,  $_{E}/\epsilon/$  and  $_{K}/e/$  are relatively close, and English listeners' similarity rating of these two vowels was especially high (0.91).  $_{J}/e/$ , on the other hand, is higher than  $_{E}/\epsilon/$  and  $_{K}/e/$ , and despite the fact that  $_{E}/\epsilon/$  is often perceptually assimilated to  $_{J}/e/$  as pointed out by such works as Frieda & Nozawa [1] and Ingram & Park [2], the similarity rating of these two vowels is relatively low. The closest English vowel to  $_{J}/e/$  is  $_{E}/i/$ , and English listeners gave a high rating to this vowel pair (1.01).

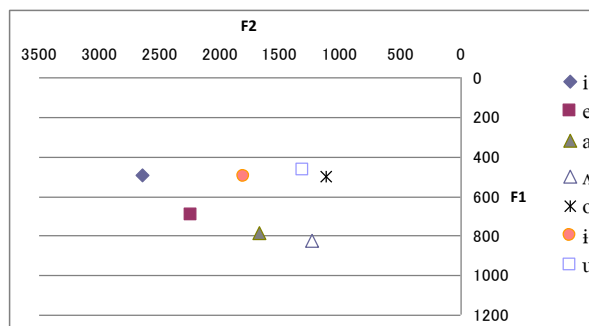
**Figure 3:** Mean F1 and F2 frequencies of English stimuli.



**Figure 4:** Mean F1 and F2 frequencies of Japanese stimuli.



**Figure 5:** Mean F1 and F2 frequencies of Korean stimuli.



In the low vowel region, English low vowels are lower than their Japanese and Korean counterparts.  $_{E}/\ae/$  is lower and located more anteriorly than  $_{J}/a/$  and  $_{K}/a/$ . Of these two vowels,  $_{K}/a/$  is located a little more anteriorly than  $_{J}/a/$ . In spite of this, Korean listeners' similarity rating between  $_{E}/\ae/$  and  $_{K}/a/$  was very low (-1.04). As mentioned in 2.4.2, a significant difference was yielded between Korean listeners and the other two groups of listeners at the  $p < 0.05$  level. For Korean listeners, the Korean vowel perceptually closest to  $_{E}/\ae/$  is  $_{K}/e/$ , while for Japanese and English listeners,  $_{K}/a/$  is more similar to  $_{E}/\ae/$ . Korean speakers perceptually assimilate  $_{E}/\ae/$  to  $_{K}/e/$  according to previous studies like Frieda & Nozawa [1] and Ingram & Park [2]. Korean

listeners also rated the similarity between  $\text{ɹ/a/}$  and  $\text{ɛ/æ/}$  higher than did Japanese and English listeners.  $\text{ɹ/a/}$  is roughly equally distant from  $\text{ɛ/æ/}$ ,  $\text{ɛ/ɑ/}$  and  $\text{ɛ/ʌ/}$ , and Japanese listeners' similarity ratings of  $\text{ɹ/a/}$  to these vowels are roughly equal. Frieda & Nozawa [1] demonstrated that Japanese speakers generally labeled these English vowels as  $\text{ɹ/a/}$ . According to Frieda & Nozawa [1], Korean speakers perceptually assimilated  $\text{ɛ/ɑ/}$  to  $\text{ɻ/a/}$ , but  $\text{ɛ/ɑ/}$  was spectrally closer to  $\text{ɻ/ʌ/}$  rather than  $\text{ɻ/a/}$ , and English listeners' similarity ratings (0.81) were significantly higher than that of Japanese (-0.30) and Korean listeners (0.08). Even though spectrally distant, English listeners discerned some similarity between  $\text{ɛ/ɑ/}$  and  $\text{ɹ/o/}$ . Their similarity ratings (-0.07) were significantly higher than those of Japanese (-1.1) and Korean (-0.95) listeners. English listeners did not find the two vowels very similar, but they did not find them very different either. This may be because in British English  $\text{ɛ/ɑ/}$  is produced as a higher back vowel like  $\text{ɹ/o/}$ . English listeners may have accepted  $\text{ɹ/o/}$  as a distant variation of  $\text{ɛ/ɑ/}$ .

In the high back vowel region, English and Korean have two spectrally different vowels whereas Japanese has one. English listeners rated  $\text{ɛ/ʊ/-ɻ/ɨ/}$  as highly similar (1.00) while Korean listeners did not (0.19). For English listeners,  $\text{ɻ/ɨ/}$  seems to be a good exemplar of  $\text{ɛ/ʊ/}$ , but for Korean listeners,  $\text{ɛ/ʊ/}$  seems to be rather distant from the  $\text{ɻ/ɨ/}$  category ideal. English listeners also gave  $\text{ɹ/ʊ/}$  higher similarity ratings to both  $\text{ɛ/ʊ/}$  (0.68) and  $\text{ɛ/u/}$  (0.45) than did Japanese and Korean listeners. This may be because  $\text{ɹ/ʊ/}$  (mean F1 475 Hz, F2 1312 Hz) is located between  $\text{ɛ/ʊ/}$  (mean F1 546 Hz, F2 1462 Hz) and  $\text{ɛ/u/}$  (mean F1 394 Hz, F2 1253 Hz). The listeners' similarity ratings are higher when  $\text{ɛ/u/}$  is compared with  $\text{ɹ/u/}$ , showing that the duration affects similarity rating. However, only Japanese listeners show a significant difference, depending on  $\text{ɛ/u/}$  as compared with  $\text{ɹ/u/}$  or  $\text{ɹ/u:/}$ . The result implies that durational difference plays a larger role for Japanese listeners than for English and Korean listeners.

### 3. CONCLUSION

The results show that the perceived similarity of interlingual vowel pairs is affected by listeners' L1 phonology as well as phonetic distance between the two vowels. That is, how the vowel space is partitioned affects the perceived similarity.

English listeners' similarity ratings (0.24) were slightly higher than those of Japanese (-0.22) and Korean (-0.07) listeners. English listeners had not learned Japanese or Korean, but Japanese and Korean listeners had at least some experience of learning English. Their linguistic experience may have made them a little more sensitive to interlingual dissimilarity of vowels. It is also possible that English listeners were more used to listening to nonnative speech than did Japanese and Korean listeners because English is widely spoken, and English listeners may have been exposed to foreign accented speech. Further research is necessary to see whether and how learning another language affects the interlingual perceived similarity by comparing Japanese and Korean speakers of different English proficiency.

To get a better picture of the perceived similarity of interlingual vowels, it would have been better to create all the possible vowel pairs, which include pairs between very distant vowels, and submit the results to a cluster analysis. However, for a practical reason this was not possible.

### 4. REFERENCES

- [1] Frieda, E.M., Nozawa, T. 2007. You are what you eat phonetically: The effect of linguistic experience on the perception of foreign vowels. In Bohn, O.-S., Munro, M. J. (eds.), *Language Experience in Second Language Speech Learning*. Amsterdam: John Benjamins, 79-86.
- [2] Ingram, J.C.L., Park, S.G. 1997. Cross-language vowel perception and production by Japanese and Korean learners of English. *Journal of Phonetics* 25, 343-370.
- [3] Morrison, G.S. 2002. *Effects of L1 Duration Experience on Japanese and Spanish Listeners' Perception of English High Front Vowels*. Unpublished master's thesis, Simon Fraser University, Burnaby, BC, Canada.
- [4] Rochet, B.L. 1995. Perception and production of second-language speech sounds of adults. In Strange, W. (ed.), *Speech Perception and Linguistic Experience: Theoretical and Methodological Issues in Cross-Language Speech Research*. Timonium, MD: York Press, 339-410.