COMPARISON OF CROSS-LANGUAGE COARTICULATION: ENGLISH, JAPANESE AND JAPANESE-ACCENTED ENGLISH

Kimiko Tsukada

Speech, Hearing and Language Research Centre (SHLRC)
School of English, Linguistics and Media
Macquarie University
e-mail: kimiko@srsuna.shlrc.mq.edu.au

ABSTRACT

This study investigates the cross-language coarticulation patterns in Australian English and Japanese. F2 trajectories between the vowel target and vowel onset/offset in the context of /d/ were plotted and locus equations were fitted to the datapoints to capture the degree of coarticulation.

Three talker groups were considered: native talkers of Australian English (AE), L2 English talkers (L1 Japanese, hence, JE) and native Japanese talkers (J). Two native groups AE and J clearly showed different coarticulation patterns between the alveolar stop and the adjacent vowels. There was some suggestion that /d/ is most resistant to coarticulation in AE, least in J, while JE talkers produced intermediate coarticulation values. The deviation of JE talkers' F2 trajectories from the AE group appeared more pronounced at the vowel offset than at the onset.

1. INTRODUCTION

While coarticulation is a universal phenomenon, various factors such as rate of articulation, style of speech, stress and so forth are known to affect coarticulation in a language-specific manner (Sussman, 1995, Bakran, 1995, Keating and Huffman, 1984, Krull, 1989). This study investigates coarticulation patterns in English and Japanese by examining formant transitions between the vowel target and vowel onset/offset. From the previous studies, a prediction can be made that more coarticulation might be observed in Japanese than in English (Manuel and Krakow, 1984, Manuel, 1990). The aims of this study are to test if this prediction could be borne out by examining comparable phonetic contexts produced by each talker group and to explore the extent to which the JE group has intermediate values in an acoustic space between the native AE and J groups. For V-to-V coarticulation in Japanese and British English, Kondo (1995, 1997) observed intermediate values in English produced by Japanese learners.

2. EXPERIMENT

2.1. Talkers and Speech Materials for CV Syllables

Table 1 shows details of the corpora for the CV syllables. All talkers in this study are females. A large number of JE talkers in the present study are holders of postgraduate degree from English-speaking countries or working towards one and thus could be classified as experienced learners of English.

	material	context vowels	talkers	condition	N
J1	VdVdV	eao	ABCDE	isolated	5
J2	dV(V) dV(V)	eao	AFG	isolated	5
AE1	dVd@	i:Ia:	abcd	continous	12
AE2	dVd	IEAOVi:(Ua:o:u:@:)	efghi	isolated	2
JE1	dVd@	i:Ia:u:	FG	Dr. _____	5
JE2	dVd	IEAOVi:	FG FG	isolated continuous	5 5

Table 1: Talkers and speech materials for CV syllables

In the J-corpora which consist of multi-syllabic words, the vowel type was kept constant within each word. The underlined are the vowels analyzed. The AE1-corpus was originally collected by Harrington et al. (1998) for their kinematic study. The target words were immediately preceded by 'Dr' and were further embedded in a dialogue script read by each talker. Only accented vowels were analyzed for the present study. The JE1-corpus was an approximation to the AE1-corpus. However, only target words, i.e., 'Dr. ____' were produced. The AE2-corpus is a small subset of the ANDOSL (Australian National Database of Spoken Language). /IEAOVi:/ were kept separate from the other vowels (/Ua:o:u:@:/) in order to isolate the words that are identical to those in JE2. The target words in the JE2-corpus were produced 5 times in isolation and another 5 times in the sentence final position. In the sentence condition, each word was preceded by segments such as 'a', 'the', 'my' and 'is' which would facilitate segmentation. Each talker is denoted by alphabet: Japanese (J and JE) by upper case and Australians by lower case, respectively. Machine readable phonetic alphabet (MRPA) is used throughout this paper (see Appendix).

2.2 Talkers and Speech Materials for VC Syllables

Table 2 gives details for the VC syllables. In the J1-corpus, i.e.,

/VdVdV/, high vowels /iu/ were added to combine with a low vowel /a/ (e.g., /idada/) as it is possible for them to occur before (but not after) /d/ without palatalizing and further affricating it (see Charbonneau and Jacques (1972) cited in Dart (1998) for a similar phenomenon in Canadian French).

	material	context vowels	talkers	condition	N
J1	VdVdV	(i)eao(u)	ABCDE	isolated	5
J2	dV(V) dV(V)	eao	AFG	isolated	5
J3	CV(V) do	ieaou	BDHIJKL MNOPQR	isolated	7
AE1	dVd@	i:Ia:	abcd	continous	12
AE2	dVd	IEAOVi:(Ua: o:u:@:)	efghi	isolated	2
AE3	CVd	IEAOUV i:a:o:u:@:	jklmno	isolated	7
JE1	dVd@	i:Ia:u:	FG	Dr. _____	5
JE2	dVd	IEAOVi:	FG	isolated continuous	5
JE3	CVd	IEAOUV i:a:o:u:@:	BDHIJKL MNOPQR	isolated	7

Table 2: Talkers and speech materials for VC syllables.

2.3. Procedure

The speech data were recorded in a sound-treated studio and digitized on SUN workstations at 20kHz. Each group read the test materials in 2 to 12 randomized orders (see Tables 1 and 2). The speech signal processing package waves+ was used for segmentation and labelling. Speech samples were phonetically labelled by hand using a combination of waveform and spectrographic cues. The EMU speech database interrogation system was used for acoustic analyses and graphic displays of the data.

3. RESULTS

In the locus equations, the extent of coarticulatory overlap of /d/ with pre- and post-vocalic vowels was estimated using locus equations by plotting F2-onset/offset frequencies against F2-midpoint frequencies. Least-squares regression lines were then fitted to the datapoints. It is generally considered that the slope values are indicative of the degree of coarticulation (Krull, 1988). The results are summarized in Tables 3 and 4.

3.1. CV Syllables

Slope values were higher for the J-corpora than for the AE-corpora and all the languages examined in Sussman et al. (1993). This suggests that there is more anticipatory vowel coarticulation in Japanese than in Australian English. In the latter, /d/ is not as much influenced by the following vowels as in Japanese, hence more precise locus is implied. A somewhat higher slope value for AE1 (0.43) may be due to the fact that the speech was continuous. Also, it is possible that the transducer coils attached to the talkers' articulators have in some way affected their articulation of /d/. (Recall AE1 was extracted from a corpus designed for a kinematic study.)

	slope	locus (Hz)	R-squared
J1	0.62	2371	.87
J2	0.51	2055	.91
AE1	0.43	2127	.77
AE2	0.34 (0.32)	2156 (2136)	.67 (.66)
JE1	0.38	2161	.83
JE2	0.38 0.42	2149 2286	.81 .86

Table 3: Locus for /d/ and the slope values for regression lines.

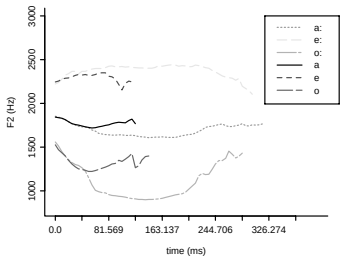

Figure 1a: F2 trajectories of Japanese vowels following /d/ averaged after time alignment at the vowel onset (J2).

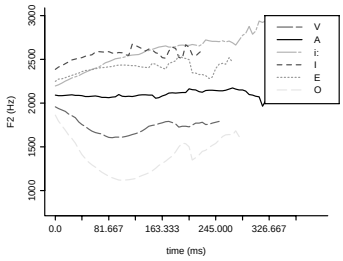

Figure 1b: F2 trajectories of Australian English vowels following /d/ averaged after time alignment at the vowel onset (AE2).

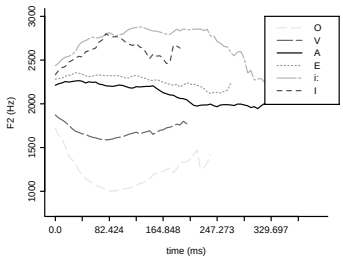

Figure 1c: F2 trajectories of Japanese English vowels following /d/ averaged after time alignment at the vowel onset (JE2 - isolated).

Figures 1a, 1b and 1c show representative plots from the J-, AE- and JE-corpus, respectively. F2 frequencies (Hz) are plotted on the y-axis as a function of time. Two native talker groups, AE and J, were clearly distinct in the extent to which F2 trajectories of vowels point towards the locus for /d/. Some differences between AE and JE can be pointed out. It appears that the non-front vowel /V/ shows more movement in AE than in JE productions. At the vowel onset, AE /i:/ is visibly lower than the JE counterpart. In fact, the onset F2 value for AE /i:/ is marginally lower than that for AE /E/. In the JE data, /E/ and /A/ are fairly close together throughout their trajectories while in the AE group, the two vowels are clearly differentiated. In spite of the differences in trajectory patterns, the two datasets (AE2, JE2) did not differ significantly on any of the vowel types in their mean duration ($F(1, 118) = 0.71$, $p > 0.1$). The interaction between the two main factors, i.e., vowel type and talker group was non-significant.

Figures 2a, 2b, and 2c below are scatterplots of F2 values at the vowel onset (y-axis) with F2 values at the vowel target (x-axis) for the same data visualized in Figures 1a, 1b, and 1c. The figures also show locus equations fitted to the datapoints. From these figures and Table 3, it can be seen that the JE slope and locus values are closer to the AE than to J values. This suggests that JE talkers are successfully assimilating to the production of English /d/.

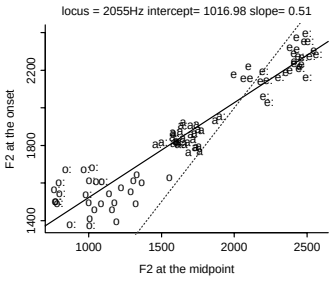

Figure 2a: Locus equation for /d/ in Japanese (J2). The estimated locus, assuming straight line transitions, is at the intersection of the dotted line y = x and the solid regression line through the scatter. The labels represent the following vowel context for each stop token.

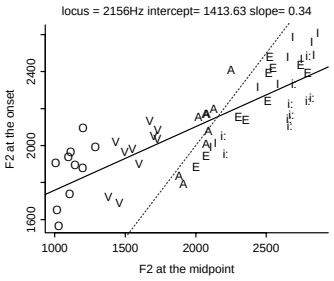

Figure 2b: Locus equation for /d/ in Australian English (AE2). The estimated locus, assuming straight line transitions, is at the intersection of the dotted line y = x and the solid regression line through the scatter. The labels represent the following vowel context for each stop token.

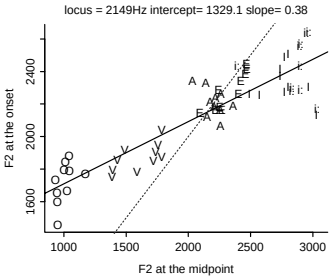

Figure 2c: Locus equation for /d/ in Japanese English (JE2 - isolated). The estimated locus, assuming straight line transitions, is at the intersection of the dotted line y = x and the solid regression line through the scatter. The labels represent the following vowel context for each stop token.

3.2. VC syllables

	slope	locus (Hz)	R-squared
J1	0.6	2356	.86
J2	0.6	2038	.89
J3	0.65	2072	.88
AE1	0.66	1847	.92
AE2	0.55 (0.48)	2117 (2137)	.87 (.81)
AE3	0.43	2101	.70
JE1	0.57	2070	.77
JE2	0.54 0.57	1915 2010	.81 .88
JE3	0.59	2300	.84

Table 4: Locus for /d/ and the slope values for regression lines.

When /d/ is preceded by a vowel in VC syllables, its articulation appears to be more variable than when it is in the syllable-initial position as is indicated by higher slope values. Because there is a syllable boundary between V and C in the three J-corpora (J1, J2, J3), AE1 and JE1, coarticulation patterns may not be directly comparable across different corpora. While the lowest slope value can still be found in the AE-corpus (0.43), except for the comparison between AE3 and JE3, the slope values do not vary much from one talker group to another. The highest slope value (0.66) was obtained in the AE1-corpus which was of continuous speech data: the same pattern of results had been observed in the CV context.

Figure 3 shows the mean F2 ranges at the 'margins', i.e., vowel onset/offset in each corpus. Roughly speaking, small values indicate that the F2 trajectories for different vowel types converge closely, suggesting a relatively precise locus, hence little coarticulation between the vowel and the neighbouring consonant. In CV syllables, this would mean that there is not much anticipatory vowel coarticulation for /d/, and in VC syllables, on the other hand, little carryover vowel coarticulation is implied. Mean F2 ranges in JE2 and JE3 are quite dissimilar to the corresponding AE-corpora. This trend appears more pronounced in the vowel offset position (AE3 vs JE3). This

figure suggests that /d/ is most resistant to vowel-coarticulatory influences in the AE-corpora, least in the J-corpora, and intermediate in the JE-corpora.

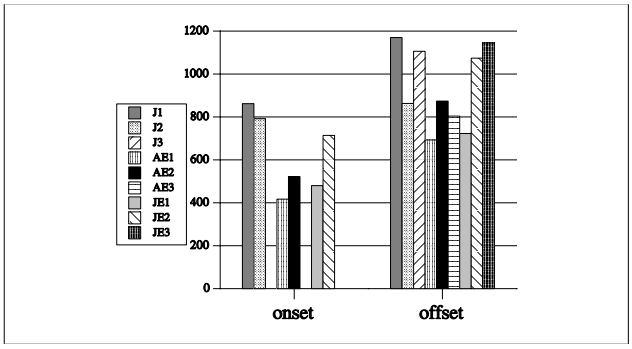

Figure 3: Mean F2 ranges at the 'margins' in each corpus (see Tables 1 and 2).

4. DISCUSSION

The present study demonstrated cross-language differences in the acoustic features of the alveolar stop /d/ in Japanese and English. The findings presented are possibly a reflection of the slightly different places of articulation used in the two languages. It is conceivable that they differ in the articulatory settings, as well (Honikman, 1964). Quite expectedly, JE talkers' productions revealed intermediate values between J and AE groups. However, there appears to be an effect of the position of /d/ in the syllable. As can be seen in Figure 3, JE talkers' F2 trajectories deviated from the AE group more at the vowel offset (syllable-finally) than at the vowel onset (syllable-initially). This difference could be attributed to the fact that in Japanese, /d/ (or oral stops in general) is not permissible syllable-finally and poses production difficulties to the learners. JE talkers may produce the formant frequency values that fall within the range of the AE group at the vowel target, but they may still articulate /d/ in a non-native manner, yielding F2 offset values that are quite different from the AE values. It will be interesting to investigate the differences between AE and JE talkers in the articulatory domain to determine if the same place of articulation is involved in the production of /d/ by the two talker groups. If a difference is found in addition to the acoustic differences reported in this paper, then its perceptual relevance needs to be tested.

5. CONCLUSION

Japanese and English showed a different extent of coarticulatory overlap between the vowel and the neighbouring consonants. There was some suggestion that /d/ is most resistant to coarticulation in Australian English, least resistant in Japanese, while Japanese talkers learning English tend to have intermediate coarticulation values. This was visible in the extent to which F2 trajectories of the vowels in the three talker groups point towards the locus for /d/ (Figures 1a, b, c and Figure 3). These results are consistent with previous research (Manual and Krakow, 1984, Manuel, 1990) that has established a relationship between the magnitude of coarticulation and the number of phonemic vowels in the language.

Cross-language differences in coarticulation observed in two native talker groups, AE and J, together with the intermediate nature of interlanguage data suggest that L2 learners are aware of the possibly subtle differences between the target language and their L1 and that the acquisition of coarticulation is an important aspect of learning a second language. The finding that Japanese talkers of English have coarticulatory patterns that are different from those of native talkers may contribute to the perception of 'foreign (Japanese) accent' in the JE production.

6. REFERENCES

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APPENDIX

Machine Readable Phonetic Alphabet (MRPA)

/I/	HID	/U/	HOOD	/o:/	HOARD
/E/	HEAD	/V/	HUD	/u:/	WHO'D
/A/	HAD	/i:/	HEED	/@:/	HERD
/O/	HOD	/a:/	HARD		