Temporal Effects on Vowel-to-Vowel Coarticulation in Cantonese and Thai

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Introduction

- The model of Target Undershoot [1] suggests that duration is the main determinant of vowel reduction.
- As vowels become shorter, the articulators have less time to reach their targets under ideal steady-state conditions (i.e. undershoot), thus resulting in vowel centralisation.
- Undershoot arises because the motor commands of successive vowels to articulators overlap more at a fast rate. More overlap leads to more coarticulation, e.g. an increased CV coarticulation at a fast rate [2]. A slowed rate also reduces v-to-v coarticulation [3].
- However, target undershoot is not an inevitable result. Vowel formant frequencies can be resistant to rate changes, e.g. [4, 5].
- Most studies mainly looked at formant frequency differences caused by stylistic temporal change (speech rate), but vowel durations can be affected by phonological differences too (vowel length).

Aim

To examine the validity of Target Undershoot with two different temporal effects on v-to-v coarticulation:

1. stylistic: normal versus fast speech rate in Cantonese.
2. phonological: long versus short vowels in Thai.

Hypothesis

If the model of Target Undershoot is correct, then there should be more v-to-v coarticulation for a faster speech rate in Cantonese and for short vowels in Thai.

Method

CANTONESE

- Vowels /i a u/ in all possible combinations in /pV$_1$pV$_2$pV$_3$/ nonsense trisyllables ($V_1 = V_3$) embedded in carrier phrases, e.g. /pipapi/
- 8 native speakers of Hong Kong Cantonese (4 male, 4 female) read 10 randomised lists at a self-paced normal rate and then a fast rate
- Measurements: a) Duration of V_2 b) normalised F1 and F2 frequencies of V_2 at onset, midpoint and offset
- 6 (2 formants x 3 locations) 3-way repeated measure ANOVA with Speech Rate (normal vs fast), Target Vowels (/i a u/) and Context Vowels (/i a u/)

THAI

- Long and short vowels /i æ a ə ɔ u/ in all possible combinations in /pV$_1$pV$_2$pa/ nonsense trisyllables embedded in carrier phrases, e.g. /pipupa/. Final syllable /pa/ is always stressed
- 6 native speakers of Bangkok Thai (3 male, 3 female) read 5 randomised lists at a normal rate
- Measurements: a) Duration of the target vowels (V1 or V2 depending on direction) b) normalised F1 and F2 frequencies of the target vowels at midpoint and vowel edge (offset for V1, onset for V2)
- 4 (2 formants x 2 locations) 4-way repeated measure ANOVA with Vowel Length (long vs short), Direction (anticipatory vs carryover), Target Vowels (/i æ a ə ɔ u/) and Context Vowels (/i æ a ə ɔ u/)

Results

CANTONESE

Table 1 Mean vowel durations (ms) in Cantonese averaged across all contexts, with proportions of fast rate relative to normal rate

Target vowels	normal rate	fast rate	fast/normal %
a	172	149	86.7
i	156	143	91.7
u	157	136	86.6

The duration differences of the two rates are significant (p<0.05) but small.

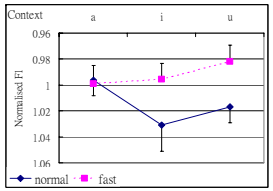
F2

Speech Rate does not significantly affect degree of v-to-v coarticulation (p>0.05).

F1

A significant Speech Rate x Context interaction at vowel midpoint (p=0.033).

Fig. 1 F1 Context effects for normal and fast rates at vowel midpoint



THAI

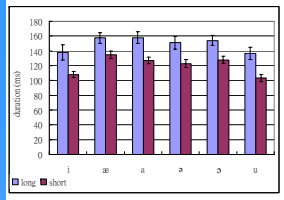


Fig. 2 Mean durations of long and short vowels in Thai averaged across contexts and directions

Vowel length differences are all significant (p<0.01). Long vowels are in general 24% longer than short vowels.

F2

Vowel length does not significantly affect degree of v-to-v coarticulation.

F1

Vowel Length only affects v-to-v coarticulation of /æ/ in the carryover direction. **LONG** /æ/ F1 lowered by Context /u/ more than short /æ/ at both vowel onset and midpoint.

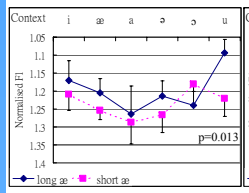


Fig 2A Effects of different context vowels on long and short /æ/ at vowel onset

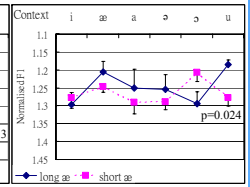


Fig 2B Effects of different context vowels on long and short /æ/ at vowel midpoint

Conclusion

- A faster speech rate does not increase degree of v-to-v coarticulation in Cantonese. Long /æ/ shows more v-to-v coarticulation than short /æ/ in Thai.
- In this study, temporal factor only has a small effect on v-to-v coarticulation which is in the *unexpected* direction.
- One possible reason is because of the small temporal differences, especially in Cantonese (~ 12%). Stronger temporal effects on v-to-v coarticulation in Cantonese may be found with an even faster speech rate.
- No minimum threshold of durational difference in the literature that would result in target undershoot, but more undershoot was reported with greater vowel shortening, e.g. > 30% [6].
- However, temporal effects on coarticulation cannot be accounted for by only one mechanism [7]. Speakers can use different strategies to cope with the temporal changes, e.g. by increasing articulator velocity to achieve the same targets [6, 8].
- Speakers' attempt to maintain clarity is crucial in preventing formant frequencies change with rate [6, 8].
- There is no simple one-to-one relationship between duration and degree of v-to-v coarticulation. Temporal effects are also dependent on other factors, e.g. articulatory velocity and clarity.

References

[1] Lindblom, B. (1963) Spectrographic study of vowel reduction. *Journal of the Acoustical Society of America, 35*, 1773-1781. [2] Gay, T., T. Ushijima, H. Hirose and F. S. Cooper. (1974) Effect of speaking rate on labial consonant-vowel articulation. *Journal of Phonetics, 2*, 47-63. [3] Hertrich, I. and H. Ackermann. (1995) Coarticulatioin in slow speech: durational and spectral analysis. *Language and Speech, 38*, 159-187. [4] Fourakis, M. (1991) Tempo, stress, and vowel reduction in American English. *Journal of the Acoustical Society of America, 90*, 1816-1827. [5] Van Son, R. J. and L.C. Pols. (1992) Formant movements of Dutch vowels in a text, read at normal and fast rate. *Journal of the Acoustical Society of America, 92*, 121-127. [6] Flege, J. E. (1988) Effects of speaking rate on tongue position and velocity of movements in vowel production. *Journal of the Acoustical Society of America, 84*, 901-916. [7] Gay, T. (1981) Mechanisms in the control of speech rate. *Phonetica, 38*, 148-158. [8] Matthies, M. L., P. Perrier, J. S. Perkell and M. Zandipour. (2001) Variation in anticipatory coarticulation with changes in clarity and rate. *Journal of Speech, Language and Hearing Research, 44*, 340-353.

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