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# Consonant-vowel coarticulation patterns in Swedish and Mandarin

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Word initial consonant and its following vowel exhibit considerable overlap. This study compares C-V coarticulation between a lexical pitch accent language and a tone language using three different time lag measures. Results reveal an effect by speaker's **gender** and **language**, and by **tonal** patterns, but it depends on the articulatory measure.

## Background

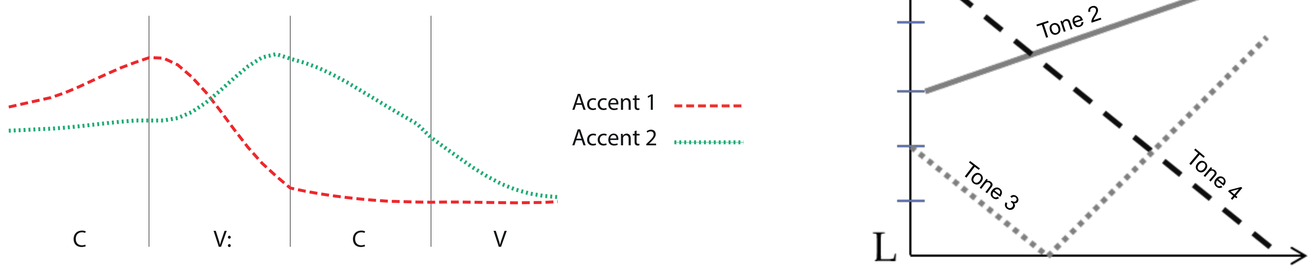


Fig 1. Schematic representation of tonal systems in South Swedish (left) and Mandarin (right)

**Mandarin** is a tone language with four lexical tones, and syllable is the tone-bearing unit (Fig 1)

**Swedish** is a lexical pitch accent language with two accents, which are morphophonological: they can have either lexical or morphological uses (Fig 1)

**C-V coarticulation** of consonant and its following vowel has been found using both 2D and 3D kinematic data: [1–6]

- ≈ synchronous tongue and lip onset in V1CV2 by American English speakers [1]
- 45 ms C-V lag between tongue and lip onset in Mandarin words [2]
- synchronous and temporal C-V lag dependent on articulatory measure in Swedish words [3]

Lack of standardized measurement in C-V coarticulation prompts continuous evaluations and development

Three measurement types on LA and TB onset are evaluated **in this study** (Fig 2):

- CV time lag 1: 20% threshold from zero-crossing to peak velocity of LA, and of TB lowering [2,3]
- CV time lag 2: peak acceleration of LA and the minimum tangential velocity of TB [1]
- CV time lag 3 (new): peak acceleration of LA and of TB

## Method

ElectroMagnetic Articulography (EMA) at Lund University Humanities Lab

- 4 Southern Swedish speakers (2F, 2M)
- 2 Mandarin speakers (1F, 1M)

Target words onsets /ma/, embedded in carrier sentences, with similar phonetic context in both languages

→No. of tokens: 46 (Mandarin) + 428 (Swedish)

Analyses were conducted in R [7].

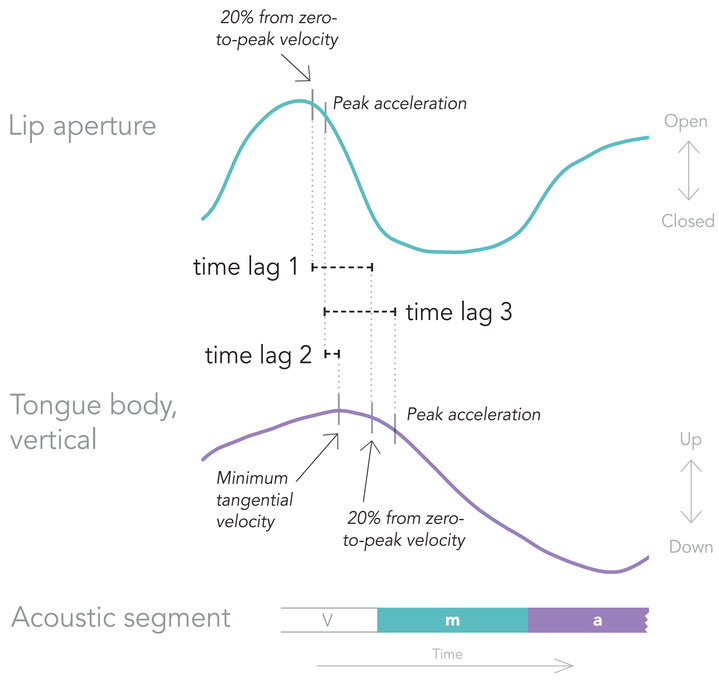


Fig 2. Lip aperture (LA) and tongue body (TB) landmarks used to calculate the CV time lags (Swedish word example).

| | Time lag 1 | Time lag 2 | Time lag 3 |
|---|---|---|---|
| **Language** | No diff.<br>Tendency of earlier TB in Mandarin | No diff.<br>Tendency of earlier TB in Mandarin | No diff. |
| **Tone** | No diff. | **Sign diff** between Swedish accents | **Sign diff** between Mandarin T1 and T3, and (marginally) between Swedish accents |
| **Gender** | **Sign diff** between both gender and languages (no interaction) | No diff.<br>Tendency of earlier TB in male | No diff.<br>Tendency of earlier TB in male |

Table. Summary of results

## Results

CV time lag measurements: **inter-language** differences were NOT significant; **intra-language** variations by tones/pitch accents were NOT significant for time lag 1, nor for time lag 2 in Mandarin speakers (Table)

Inter-language differences only found when dividing speaker by **gender** (Fig 3)

Female and male speakers display varied CV temporal lag, for **both languages** (in the same direction). Significant differences between gender and language in time lag 1

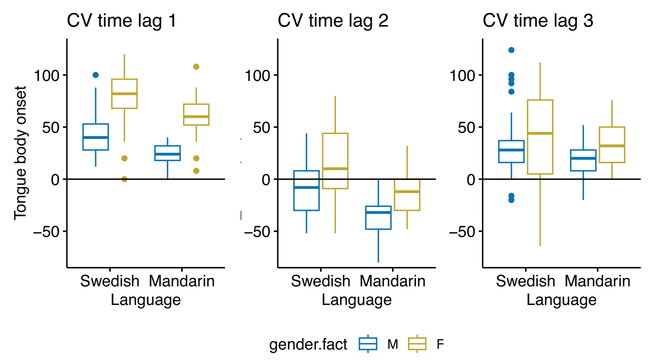


Fig 3. CV time lags 1-3 (in ms) divided according to gender and language. 0 marks LA onset, boxes marks TB onset.

## Discussions & Conclusions

Current results are consistent with findings from previous studies [1,2,3]

**Mandarin Chinese** and **Southern Swedish** exhibit similar coarticulation pattern between word-initial C and V.

Methodologically, only the measurements based on **acceleration –** time lag 2 and 3 – provided an effect of tones/pitch accents on CV coarticulation. Previously, acceleration has shown systematic tendencies with the acoustic segments across speakers [8]

Most unexpected finding is the effect of gender. Anatomical and physiological features may be a possible explanation:

**Male** speaker → bigger head and vocal tracts → higher tongue velocities[9] → shorter CV temporal lags.

In addition, compensatory articulation may contribute to gender-specific articulation [10,11]

Future work with bigger sample size is needed to validate the gender effect and the systematic tendencies in CV timing

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