

The phonology of inter- and intra-segmental coordination in Mandarin codas
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The goal of this study is to evaluate the tenets of Articulatory Phonology (henceforth AP; Browman & Goldstein, 1989; Goldstein et al., 2006) against data from Mandarin Chinese that are, by the nature of the segments involved, at once amenable to gestural representation, and challenging for the model. The data concern the licensing of multi-gestural segments - the rhotic suffix /ɿ/, the nasals /n/ or /ŋ/ - in coda position. Assuming a dynamical gestural theory of representation, the main issue raised concerns the formal treatment of intra-syllabic vs. intra-segmental coordination. So far, relatively few AP analyses (e.g., McMahan et al., 1994; Gafos 2002; Goldstein 2011) have engaged with the formalism in working out similarly complex data.

The Mandarin rhotic suffix is historically a diminutival suffix, which, through semantic bleaching, has become a stylistic marker of Northern Mandarin (Chao 1968, Cheng 1973, Zhang 2000, Lin 2007, Duanmu 2007). Its presence in a coda modifies the syllable rime. In standard non-rhotic Mandarin, a syllable rime contains a vowel or a diphthong, optionally followed by a coda nasal /n/ or /ŋ/. In a rhotic variety, as shown by Zhang (2000) in (1): both nasals are lost, but the vowel in /CVn+ɿ/ is oral, while in /CVŋ+ɿ/ it is nasalized. The asymmetry is confirmed by aerodynamic data from 3 native Beijing speakers (Lee 2005), and by our acoustic data from 13 North speakers, showing absence of anti-formants in /CVn+ɿ/, and their presence in /CVŋ+ɿ/ (2).

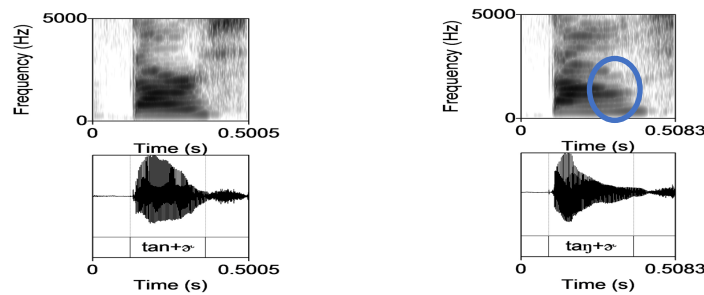
In AP, nasals involve an oral closure gesture (tongue tip TT or tongue body TB) and a velum lowering gesture (VEL). For Mandarin /ɿ/, we propose a dual gesture, on the basis of articulatory evidence for tongue root/body retraction and tongue tip raising (Gick et al., 2006; Chen et al., 2017; King & Liu 2017; Jiang et al., 2019). We thus propose that /ɿ/ consists of a TT narrow-palatal gesture and a TB narrow-pharyngeal gesture, coupled sequentially in anti-phase mode (3), such that TB precedes TT. Additional experimental results inform our analysis: Zhang (2000) finds significantly longer nasalization during the vowel in /CVŋ/ than in /CVn/. Our proposal crucially incorporates Zhang's findings in coupling graphs that differ for the two codas: the oral closure gesture of the nasal is coupled in-phase (synchronously) with VEL lowering in /CVn/ (4a), while in /CVŋ/ (4b), the two gestures are coupled in an eccentric mode, with VEL beginning earlier.

In non-rhotic Mandarin, the lexical contrast /CVn/ - /CVŋ/ is defined by the selected gestures (TT closure for /n/ vs. TB closure for /ŋ/). In the rhotic variety, the oral constriction gesture in coda is the same in both forms (/ɿ/). We propose that the lexical contrast is defined here on the vowel. The contrast /CVɿ/ vs. /CṼɿ/ is dependent on the presence vs. absence of VEL, and its coupling relation when present. If the longer nasalized vowel duration before /ŋ/ is interpreted as vowel nasalization, this may correspond to in-phase coupling of VEL with the vowel gesture. The same coupling relation is present in /CṼɿ/. This proposal is supported by Zhang's (2000) EMA study of the same speakers, which confirms the absence of dorsal raising for /ŋ/ in /CVŋ+ɿ/. The gestural re-analysis of vowel nasalization we propose is also consistent with the dialectal typology presented by Zhang (2000). Our analysis correctly predicts that no rhotic varieties of these dialects should exist, where /CṼɿ/ corresponds to non-rhotic /CVn/, and /CVɿ/ to /CV/. We conclude that the proposed dynamical account of the data highlights new, useful generalizations, and makes correct typological predictions.

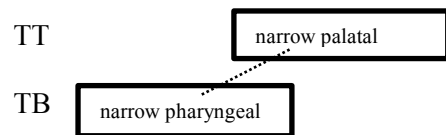
(1) The data to be accounted for, cf. Zhang (2000)

| Stem | Diminutive |
|---------------------------|-------------------|
| p ^h an 'plate' | p ^h aɿ |
| p ^h aŋ 'side' | p ^h ãɿ |

- (2) Illustrative waveforms and spectrograms of [tan+ɿ] (*left*) and [taɿ+ɿ] (*right*) showing the absence of zero formants in [tan] and their presence in [taɿ]

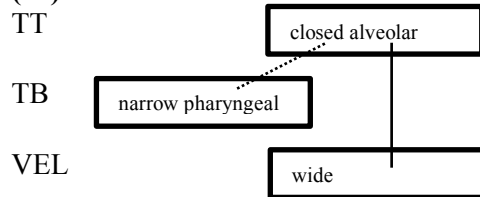


- (3) Proposed coupling graph for the rhotic suffix (..... anti-phase, ___ in-phase coupling)

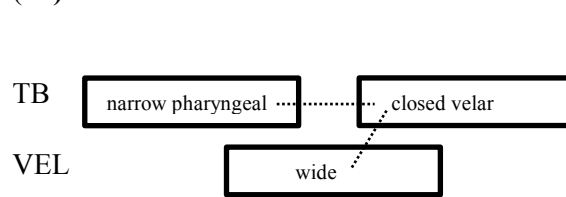


- (4) Proposed coupling graphs for: (a) syllable rime /an/ (b) syllable rime /aŋ/

(4a)



(4b)



References: Browman & Goldstein. 1989 Articulatory gestures as phonological units. *Phonology* 6. 201-251 / Chao. 1968 *A grammar of spoken Chinese*. Berkeley: University of California Press / Chen, Mok, Tiede, Chen, Whalen. 2017 Investigating the production of Mandarin rhotics using ultrasound imaging. *Ultrafest VIII*, Potsdam, 2017 / Cheng. 1973 *A synchronic phonology of Mandarin Chinese*. The Hague: Mouton / Duanmu. 2007 *The phonology of standard Chinese* (2nd ed). Oxford UP / Gafos. 2002 A grammar of gestural coordination. *NLLT* 20. 269-337 / Gick, Campbell, Oh, Tamburri-Watt. 2006 Toward universals in the gestural organization of syllables: A cross-linguistic study of liquids. *Journal of Phonetics* 34. 49-72 / Goldstein. 2011 Back to the past tense in English. In Gutierrez-Bravo, Mikkelsen, Potsdam (Eds.) *Representing language: Essays in honor of Judith Aissen*. Santa Cruz Linguistics Research Center, UCSC / Goldstein, Byrd, Saltzman. 2006 The role of vocal tract gestural action units in understanding the evolution of phonology. In Arbib (Ed.) *Action to language via the mirror neuron system*. Cambridge UP. 215-249 / Jiang, Chang, Hsieh. 2019 An EMA study of ER-suffixation in Northeastern Mandarin monophthongs. *ICPhS 19*, Melbourne, 2019 / King & Liu. 2017 An ultrasound and acoustic study of the rhotic suffix in Mandarin. *Ultrafest VIII*, Potsdam, 2017 / Lee. 2005 A phonetic study of the “er-hua” rimes in Beijing Mandarin. *Interspeech* 2005. 1093-1096 / Lin. 2007 *The Sounds of Chinese*. Cambridge UP / McMahon, Foulkes, Tollfree. 1994 Gestural representation and Lexical Phonology. *Phonology* 11. 277-316 / Zhang. 2000 Non-contrastive features and categorical patterning in Chinese diminutive suffixation – MAX[F] or IDENT[F]? *Phonology* 17. 427-478