

Prosodic effects of focus and boundary on Mandarin lexical tones: A preliminary study of tongue kinematics

Hongmei Li¹, Sahyang Kim², Taehong Cho³

¹*Department of English, Yanbian University (China),* ²*Hongik University (Korea),*

³*Hanyang Institute for Phonetics & Cognitive Sciences of Language, Hanyang University (Korea)*

Mandarin lexical tones are defined by pitch targets, with traditional source-filter model assuming functional independence between glottal and supraglottal mechanisms [1]. While biomechanical accounts attribute tone-induced lingua variations to physiological linkage [2], recent research suggests that tonal realization reflects an integrated gestural system extending into the supralaryngeal domain [3-6]. This view implies that tone-segment interactions are internalized within language-specific phonetic grammar, which is further shaped by the higher-order linguistic influences such as phonological contrasts and prosodic structure [6,7]. Although acoustic effects of focus and prosodic boundary on Mandarin tones are well documented [8,9], and lexical tones are known to influence vowel productions spatially [10], it is still unclear to what extent the spatiotemporal dynamics of tone-related gestural implementation are shaped by lexical tones, and whether these patterns are further modulated by prosodic structure. Given that tongue gestures define vowel quality while simultaneously contributing to pitch production, this study examines how Mandarin lexical tones are implemented in tongue-lowering gestures for /a/ across temporal and spatial dimensions, and how these implementations are further modulated by prosodic factors such as focus-induced prominence and prosodic boundary.

Twelve native Mandarin speakers (6F, 6M) participated in an EMA experiment. The same set of stimuli as in [4] was used, which consisted of two CV sequences (/pa/, /ma/) across four lexical tones (T1, T2, T3, T4). Target words were embedded in carrier sentences that served as the response in a controlled mini-dialogue to manipulate Focus (UnFoc vs. Foc) and Boundary (IP-medial vs. IP-final). Using MVIEW, four kinematic measures were extracted for the tongue-dorsum lowering gesture for /a/ (in a /i/-C-/a/ context): (a) *Duration* (movement onset-release); (b) *Displacement* (onset-maximum lowering); (c) *Peak Velocity*; (d) *CV-Overlap* (the overlapping proportion between C and V gestures relative to the whole CV duration from C onset to V release). (c) and (d) were analyzed to assess whether articulatory movements and intergestural coordination are biomechanical or actively under speaker control.

Kinematic analysis revealed clear tonal modulation of tongue gestures, which is systematically regulated by focus and boundary. Relative to the high-level T1, the rising T2 showed temporal-spatial expansion accompanied by increased peak velocity and reduced CV-Overlap (Fig1.a1-d1), which was further enhanced by focus (Fig1.a2-d2) but remained stable across boundaries (Fig1.a3-d3), indicating an active recruitment of articulatory effort to accommodate tonal demands under prominence. Unlike T2, the dipping T3 and falling T4 were realized through temporal expansion without corresponding spatial or velocity adjustments (Fig1.a1-d1). This temporal expansion was further amplified by both focus and boundary (Fig1.a2-a3), while CV-Overlap was systematically reduced (Fig 1.d2-d3), suggesting articulatory gestures modified temporally to meet tonal maximization and prosodic marking.

Taken together, these results reveal that tongue gestures are dynamically regulated by tonal contrasts and further shaped by prosodic structure. T2 utilizes effort-driven hyper-articulation (temporal-spatial expansion and increased peak velocity) specifically under focus, whereas T3 and T4 employ timing-dependent enhancement across both focus and boundary conditions, suggesting that articulatory dimensions of tongue gestures are selectively recruited to signal phonological contrasts and prosodic marking. These findings underscore the joint role of tonal demands and prosodic cues in shaping the dynamical gestural organization of speech production, whereby prosodic structure refines language-specific phonetic grammar via tone-specific adjustments [6,7].

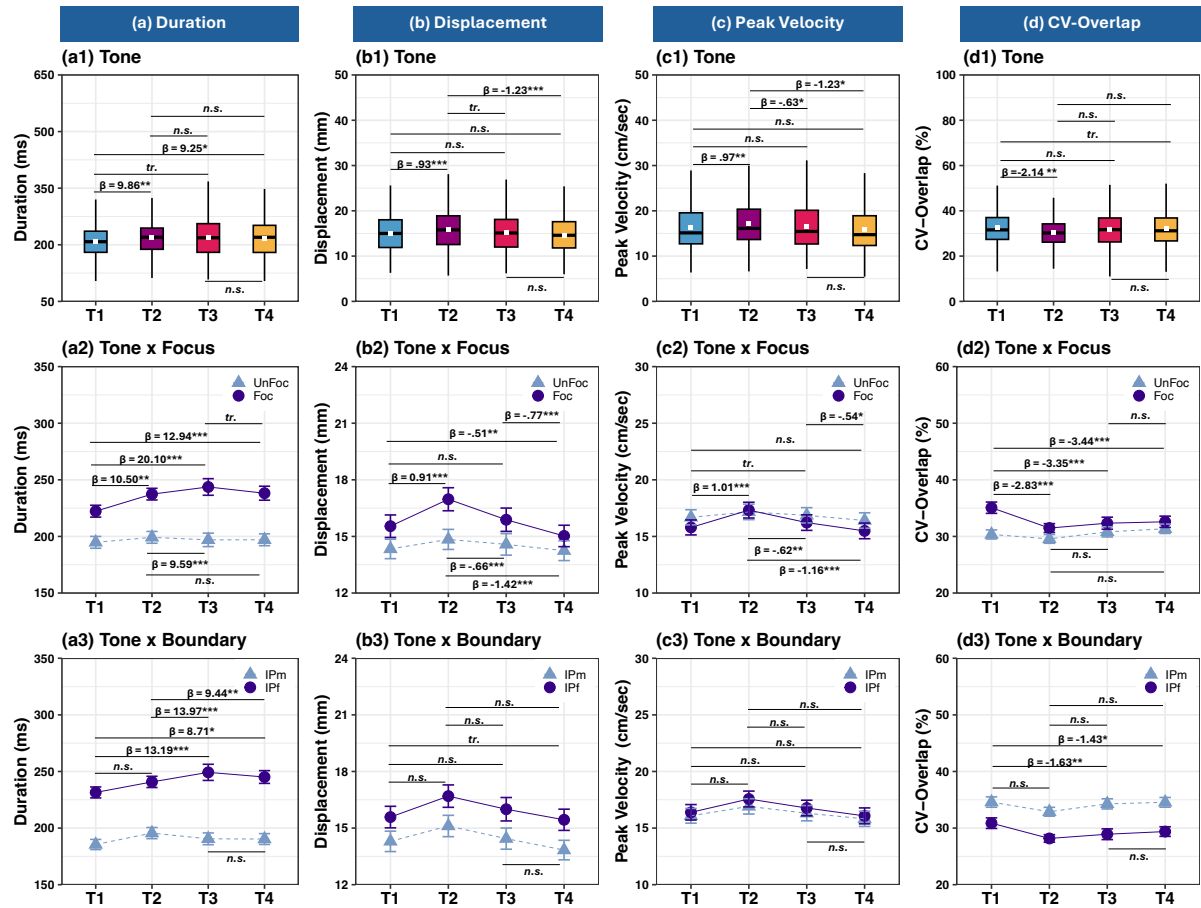


Fig 1. Effects of Tone, Tone×Focus, Tone×Boundary interactions for tongue lowering gestures. Error bars show standard errors. *** < 0.001, ** < 0.01, * < 0.05, 0.05 < tr. < 0.08, n.s. > 0.08.

References

- [1] Fant, G. (1960). *Acoustic theory of speech production*. The Hague: Mouton.
- [2] Honda, K. (1983). Relationship between pitch control and vowel articulation (Haskins Laboratories Status Report on Speech Research SR-73, pp. 269–282). New Haven, CT: Haskins Laboratories.
- [3] Gao, M. (2008). *Mandarin Tones: An Articulatory Phonology Account*. New haven, CT: Yale University. Thesis.
- [4] Li, H., Kim, S., Cho, T., Skarnitzl, R., & Volín, J. (2023). Preboundary lengthening and its kinematic characteristics in Mandarin Chinese in interaction with focus and lexical tone. In *Proceedings of the 20th International Congress of Phonetic Sciences* (pp. 2149-2153). Guarant International.
- [5] Burrioni, F., & Tilsen, S. (2025). Thai speakers time lexical tones to supralaryngeal articulatory events. *Journal of Phonetics*, 108, 101389.
- [6] Cho, T. (2025). Advancements of phonetics in the 21st century: Phonetic universals, language variation, and phonetic grammar. *Journal of Phonetics*, 111, 101426.
- [7] Cho, T., Kim, S., & Mitterer, H. (2026). Linguistic and cognitive functions of fine phonetic detail underlying sound systems and sound change. *Journal of Phonetics*, 114, 101470.
- [8] Xu, Y. (1999). Effects of tone and focus on the formation and alignment of f0contours. *Journal of phonetics*, 27(1), 55-105.
- [9] Chen, Y. (2006). Durational adjustment under corrective focus in Standard Chinese. *Journal of phonetics*, 34(2), 176-201.
- [10] Shaw, J. A., Chen, W. R., Proctor, M. I., & Derrick, D. (2016). Influences of tone on vowel articulation in Mandarin Chinese. *Journal of Speech, Language, and Hearing Research*, 59(6), S1566-S1574.