Effects of focus and lexical tones on preboundary lengthening and its kinematic characteristics in Mandarin Chinese: A preliminary report

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Preboundary lengthening (henceforth PBL) is a temporal expansion of domain-final phonological units before a prosodic boundary [1,2]. As a cross-linguistic phonetic phenomenon, PBL is known to be modulated by the π-gesture [3,4,5], a non-tract variable prosodic gesture that locally slows down the constriction gestures. Although PBL is considered to be physiologically and biomechanically driven, the detailed articulatory implementation of PBL and its scope are acknowledged to be fine-tuned by higher-order linguistic structures [6,7,8,9,10], such as the prominence system of a language. For example, in English, PBL was not only realized on the phrase-final syllable regardless of stress, but its scope also extended to a non-final stressed syllable [6]. PBL was further regulated by phrase-level prominence in English, being modulated by the degree of prominence [7]. The interaction between PBL and language-specific prominence was also found with Japanese and Korean [8,9,10], but no further interaction between PBL and phrase-level prominence was detected in either language. The current study extends this cross-linguistic evidence for PBL to Mandarin Chinese by exploring articulatory variations of the lip aperture conditioned by boundary, focus-induced prominence, and lexical tones.

We investigate the kinematic characteristics and the scope of PBL of monosyllabic CV words in Mandarin by examining the lip closing and opening gestures at the IP-final and the IP-medial positions. In order to further understand the fine-grained phonetic details of PBL and its interaction with language-specific prominence system, we explore how phrase-level prominence and lexical tone system in Mandarin interact to influence the articulatory realization of PBL. Mandarin has four lexical tones that are specified with different tonal targets: a high-level tone (T1), a rising tone (T2), a low-dipping tone (T3), and a falling tone (T4). Considering that each lexical tone has distinctive tonal targets and intrinsic temporal structure [11], a specific question that arises as to how PBL may be modulated by lexical tones in Mandarin and whether and how the presumed interaction between lexical tones and PBL may be further conditioned by prominence.

Two CV sequences (/pa/, /ma/) across four lexical tones were produced by 12 speakers (6F,6M) in an EMA (Electromagnetic Articulograph) experiment. Each target word was embedded in a carrier sentence that was an answer to a question in a mini dialogue in which Boundary (IP-medial vs. IP-final) and Focus (UnFoc vs. Foc) conditions varied, as shown in Table 1. Five kinematic measures for lip closing and opening gestures of CV were taken in MATLAB, including: (a) *movement duration* (onset-target); (b) *formation duration* (onset-release); (c) *time-to-peak velocity* (onset-pkvel); (d) *movement displacement* (onset-target); (e) *peak velocity*.

The results showed that no sign of PBL was found for the lip closing gesture of CV words, although its movement was *slower* in velocity and *smaller* in displacement phrase-finally than phrase-medially. As for the lip opening gesture, the movement was *longer*, *larger* and *slower* phrase-finally, which could be accounted for the π-gesture [3,4,5], however, *Time-To-Peak velocity* was not necessarily longer associated with PBL. PBL interacted with focus-induced prominence (Fig.1). Under focus, PBL came with slower velocity with no spatial expansion, however, under no focus, PBL came with spatial expansion but no slowing-down. This suggests that in the absence of focus-induced hyperarticulation, PBL generates both temporal and spatial expansion, possibly counteracting a slowing-down effect. PBL also interacted with lexical tones (Fig.2). Compared to simplex Tone1, spatiotemporal realization of PBL was much more robust for Tone3 (low-dipping) and Tone4 (falling) with further augmented PBL for Tone 3 under focus, probably to make sufficient room for realizing their tonal complexity. These results indicate that although PBL in Mandarin follows the cross-linguistically applicable patterns, it is modulated by the phonetically-

driven phonological requirements for maximizing tonal contrast when it is licensed by prosodic structure.

Table 1: Examples of CV in carrier sentences. Target words are underlined and italicized. Focused words are in bold.

	IP-medial	IP-final
UnFoc	A: [**mɑʊ1** mi1 pa1 pi4 ʂɤŋ4 ma?] Does **Cat** EIGHT win? B: [pu4] # [**ma1** mi1 *pa1* pi4 ʂɤŋ4.] No. **Mommy** *EIGHT* wins.	A: [ni3 tʂʰu1 **mɑʊ1** mi1 pa1 ma?] Do you play **Cat** EIGHT? B: [pu4] # [uɔ3 tʂʰu1 **ma1** mi1 *pa1*] # [pi4 ʂɤŋ4 pa?] No. I play **Mommy** *EIGHT*. Must win, right?
Foc	A: [ma1 mi1 **ta1** pi4 ʂɤŋ4 ma?] Does Mommy **BUILD** win? B: [pu4] # [ma1 mi1 ***pa1*** pi4 ʂɤŋ4.] No. Mommy ***EIGHT*** wins.	A: [ni3 tʂʰu1 ma1 mi1 **ta1** ma?] Do you play Mommy **BUILD**? B: [pu4] # [uɔ3 tʂʰu1 ma1 mi1 ***pa1***] # [pi4 ʂɤŋ4 pa?] No. I play Mommy ***EIGHT***. Must win, right?

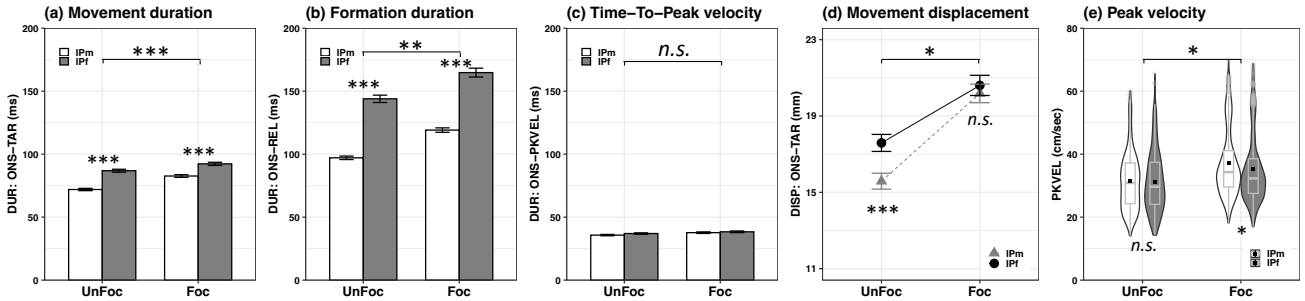

Fig.1 PBL x Prominence interactions for the lip opening gesture. Error bars show standard errors.

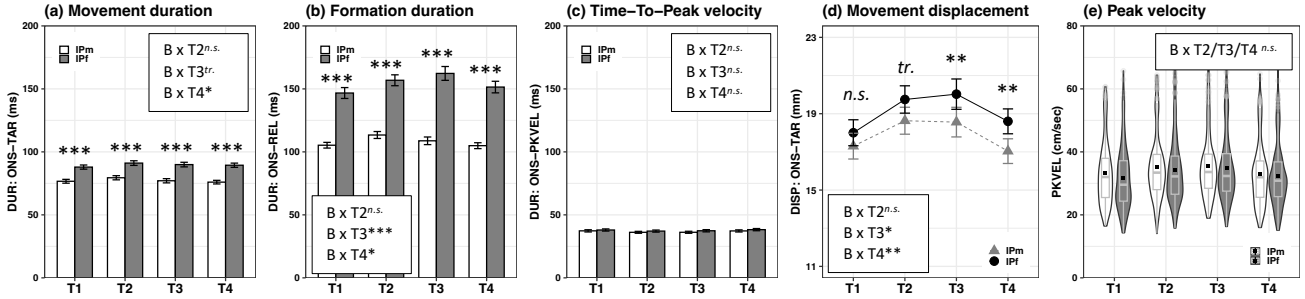

Fig. 2 PBL x Tone interactions for the lip opening gesture. Error bars show standard errors.

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