

Duration reflexes of syllable structure in Mandarin

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Received 14 August 2014; received in revised form 19 June 2015; accepted 21 June 2015

Available online

Abstract

Recent discussions of Mandarin phonology have appealed to various aspects of phonetic duration as support for hypotheses concerning the structure of the syllable. But the actual empirical evidence for these claims is based on early studies typically conducted with a limited number of speakers (often just one) using varied methods of data collection and analysis. This paper provides a more firm empirical foundation for various durational reflections of the Mandarin syllable based on the analysis of 960 monosyllabic words recorded by five female speakers. Our main findings are as follows. We find no statistically significant difference between CV and CVN syllables, supporting the bimoraic analysis of the former. We replicate the Tone 3 > Tone 2 > Tone 1 > Tone 4 duration hierarchy of earlier studies with a larger variety of syllable types. Relative to CV syllables, the nuclear vowel is shortened in both CGV and CVN structures suggesting that the prenuclear glide is associated to the syllable rhyme. The vowel is shortest in CGVN syllables supporting the analysis of the Cjan > Cjen low vowel raising process as motivated by phonetic undershoot. Finally, in Cuan syllables the nuclear vowel's backness is determined more by the coda than the prenuclear glide.

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Keywords: Syllable structure; Duration, Undershoot, Bimoraic, Tone

1. Introduction

The structure of the Standard Chinese (Mandarin) syllable has been a subject of some controversy ever since the introduction of formal models of this prosodic constituent. Major questions concern the presence or absence of duration contrasts based on the number of segmental constituents, the affiliation of the prenuclear vocoid/glide, and the existence of onsetless syllables. We focus on the first two issues in this paper and leave the third for future research.

As a canonical monosyllabic language, most free-standing morphemes in Mandarin are composed of a single syllable (though there are clear preferences for disyllables in certain prosodic contexts; see [Feng, 2001](#); [Duanmu, 2012](#)). There are no initial or final consonant clusters. Morphemic shapes include CV, CVN, CVG, CGV, CGVG, and CGVN, where C = consonant, G = glide /j, w, ɥ/, N = /n, ŋ/, V = /i, y, u, ə, a/, the latter two with several allophonic realizations. Given that each segment occupies some timing slot in the sense of [Clements and Keyser \(1983\)](#), we expect the following durational hierarchy, other things being equal: CV < CVG, CVN, CGV < CGVG, CGVN. However, CV syllables in Mandarin are typically analyzed as bimoraic, with a long vowel ([Duanmu, 2007:82](#)). A number of factors motivate this analysis. First, the vowel of *bā* 'eight' sounds longer than the one in *bān* 'class'. Second, CV syllables fully contrast the four tones parallel to

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the segmentally more complex CVN, CVG, CGV, as shown by the famous suite of *mā* ‘mother’, *má* ‘hemp’, *mǎ* ‘horse’, *mà* ‘scold’ compared to *pēng* ‘impulsive’, *péng* ‘friend’, *pěng* ‘to clasp’, *pèng* ‘to touch’, and to *bāo* ‘to cover’, *báo* ‘thin’, *bǎo* ‘jewel’, *bào* ‘to announce’. Finally, many languages impose a bimoraic minimality requirement on free-standing prosodic words and so it would not be surprising that Mandarin does as well.

Scholars such as Duanmu (2000, 2007) treat the contrast of toneless vs. tone-bearing syllables in Mandarin as a stress difference. Since each free-standing morpheme is tone-bearing, it must also be stressed under this view. Moreover, in many languages stressed syllables are bimoraic (cf. OT’s Stress-to-Weight constraint, Kager, 1999:268) and so this factor provides additional motivation for equating CV with CVN, CVG, CGV, etc. prosodically. In his discussion of the bimoraic syllable, Duanmu (2007:90) remarks “one would expect that all heavy syllables have similar durations.” He goes on to say that “This seems to be the case in controlled environments, such as read speech in a carrier sentence”. The principal sources cited are Howie (1976) and Lin and Yan (1980). The former study is based on the speech of a single individual (136 words in a carrier sentence) while the latter focused on unstressed syllables. Hence, a more systematic exploration of the durational properties of the various Mandarin stressed syllables employing multiple speakers is warranted in order to corroborate the bimoraic status of CV syllables.

Another phonological contrast that has a significant phonetic duration correlate is tone. Various studies have found that syllables with tone 3 are longest. Duanmu (2007:90) cites Woo’s (1969) finding that “Standard Chinese syllables with the third tone have an extra tone feature H in prepausal positions, and their average rhyme duration is about 50% longer than that of nonfinal syllables.” As far as we can determine, Woo’s remark was based on a few data points taken from her own speech. Published studies with more information on this point include Ho (1976) and Xu (1997). Both of these focused on the co-articulatory effects of the four tones in sentential contexts but also report duration measures for isolation forms. Ho’s study included a substantial number of CV words from five Beijing speakers while Xu’s was restricted to six repetitions of the *mā*, *má*, *mǎ*, *mà* suite produced by eight male Beijing speakers. The average syllable durations are shown in (1). The numbers from Ho’s study are estimated based on the first chart shown in this paper.

(1) Average syllable durations (ms) under the four Mandarin tones in two previous studies

	Tone 1 (55)	Tone 2 (35)	Tone 3 (314)	Tone 4 (51)
Ho (1976)	260	300	400	195
Xu (1997)	247	273	349	214

So here as well a study with a greater variety of syllable shapes is called for in order to better determine the durational profiles of the four-way tonal contrast.

Another, more vexed question has concerned the syllabic affiliation of the prenuclear glide. Virtually every conceivable attachment has been proposed based on different types of evidence including judgments of syllable rhyme, speech errors, language games, loanword adaptation, as well as phonotactic restrictions. They include treating the glide as the first portion of a nuclear diphthong (Wang and Chang, 2001), as a sister constituent of the rhyme parallel to the nuclear vowel and coda (Chao, 1968), as a specifier c-commanding the entire rhyme (Van de Weijer and Zhang, 2008), as the immediate constituent of a flat syllable structure with no internal grouping (Yip, 2003), or as a component of the onset (Bao, 2000; Lin, 2002). See Van de Weijer and Zhang (2008) for a recent review of these analyses. Perhaps most controversial is Duanmu’s (2000, 2007) proposal that the medial glide is realized as a secondary articulation on the onset consonant. One of his arguments (p. 80) is that “the presence of G does not increase the length of the syllable in any appreciable way. Rather, CVX and CGVX are more or less similar in duration.” Again Howie’s (1976) study with one speaker is cited as support for this analysis. Also, Van de Weijer and Zhang (2008) mention an unpublished acoustic study by Lu (2005) who is reported to have found that CGVX syllables were reliably longer than CVX by an average of (only) 7 ms, $p = 0.012$. They do not indicate the range of X in the stimuli nor how many speakers were recorded or how many data points were collected in Lu’s (2005) experiment. They take this difference as a challenge to Duanmu’s secondary articulation analysis of the glide.

A final instance where appeal to phonetic duration has been crucially invoked in the analysis of Mandarin is Hsieh’s (2012) treatment of the fronting and raising of the low vowel in syllables with the underlying shape /jan/ and /Cjan/, which are realized as [jen] and [Cjen]: e.g. /ján/ → [jén] ‘salt’, /tjān/ → [tjēn] ‘sky’. This low-vowel raising process is found in a number of other Sinitic languages besides Mandarin. What is puzzling about this process (or an equivalent phonotactic constraint *Cjan) is that both the preceding palatal glide and the following coronal nasal must be present in order for the change (or restriction) to occur: cf. /tān/ → [tān] ‘to carry on shoulders’ and /jà/ → [jà] ‘duck’. Inspired by Flemming’s (2001, 2003) analysis of the fronting of back vowels between coronal consonants in Cantonese, Hsieh sees low-vowel raising as motivated by two factors: undershoot of the low vowel target under presumed time pressure in the closed syllable environment combined with assimilation to the front tongue-body position of the palatal glide. Crucial to this analysis is the presumption that /a/ is significantly shorter in a closed syllable and that as a result the vowel is articulated with a higher tongue-body position. As evidence for the latter point, Hsieh cites Lee and Zee’s (2003) IPA sketch of Standard Chinese, who report that “in closed syllables [a] = [a̠]” based on the speech of one 26 year old female speaker from Beijing. Since no

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