Major Phrases Are Binary: Evidence from Taiwan Mandarin Flat Structure

Shu-hao Shih

1. Introduction

This paper presents new evidence for size restrictions on prosodic structures in Taiwan Mandarin, based on new experimental data. Several studies have argued that there are binarity restrictions at different prosodic levels (e.g. Prince 1980; Ito & Mester 1992; Selkirk 2000). In this paper, I provide new evidence in Taiwan Mandarin to support this claim. Specifically, Major Phrases in Taiwan Mandarin are obligatorily binary, consisting of two Minor Phrases.

I argue that syntactically flat structures like /wuL wuL wuL wuL wuL/ '55555' must be decomposed into Major and Minor Phrases. I identify new phonetic and phonological diagnostics that reveal a binary restriction for Major Phrases. The binarity restriction of Major Phrases accounts for the patterning of several phenomena in Taiwan Mandarin: glottal stops/glottalization, pauses, and tone sandhi. The proposed account differs from prior analyses as it does not depend on footing (Shih 1986, 1997; Chen 2000) and uses constraints to restrict the size of Major and Minor Phrases.

The organization of the paper is as follows. Section 2 reviews the theory of size restrictions on prosodic structure. Section 3 is the methodology. Section 4 presents the results of the experiment. Section 5 proposes the prosodic structure for numeral strings in Taiwan Mandarin. Section 6 provides a formal analysis. Section 7 compares previous studies on Mandarin prosody with the experimental data presented in this paper. Section 8 concludes this paper.

2. Minimal and maximal binarity

Many studies have argued that there are binarity requirements at different prosodic levels, such as feet (Prince 1980), Prosodic Words (Ito & Mester 1992), Major Phrases (Selkirk 2000), and so on. In Optimality Theory (Prince & Smolensky 1993), binarity constraints usually come in separate versions for minimal and maximal binarity (e.g. Mester 1994; Selkirk 2000; Elias-Ulloa 2006; Ito & Mester 2007). Constraints on the minimum and maximum size of prosodic constituents are argued to be part of the universal repertoire.

For a prosodic category C, we can distinguish MINBIN(C) and MAXBIN(C). For C = syllable, Prosodic Word, Minor Phrase, and so on, this yields a family of independently rankable constraints (Ito & Mester 2007). The constraint definition is given in (1).

(1) MINBIN(C): Incur a violation for each C that dominates fewer than two nodes.
MAXBIN(C): Incur a violation for each C that dominates more than two nodes.

MINBIN(C) is violated when C dominates fewer than two nodes; it is not violated when C dominates two or more nodes, regardless of whether those nodes are all of the level C^{i-1}. So, MINBIN(ω) is not violated by a Prosodic Word that contains a foot and a syllable node. In contrast, MAXBIN(C) is

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violated when C dominates more than two nodes. If a given prosodic structure C is binary (i.e. C dominates two and only two nodes), this incurs no violation of MINBIN(C) and MAXBIN(C). In this paper, these two constraints will be employed to account for binarity restrictions at different prosodic levels in Taiwan Mandarin.

3. Methodology

3.1. Experiment design

The goal of this experiment was to investigate the prosodic phrasing in Taiwan Mandarin syntactically flat structure. The five word string /wuL wuL wuL wuL wuL/ '55555' and the six word string /wuL wuL wuL wuL wuL wuL/ '555555' were used to examine prosodic phrasing patterns. As the numeral strings are syntactically flat, prosodic phrasing is not influenced by syntactic structure (Chen 2000:368). Two frame sentences were used in this experiment, as in (2). In the three environments shown below, the word strings (i.e. 55555, 555555) were placed in the first and second environments to test the default phrasing patterns.[1] A picture of telephone was used to help subjects familiarize with frame sentences and their context.

(2) Two frame sentences

a. [tjɛnHL xwaHL xauHL maL ʂɻ̩HL ______.] 'The telephone number is ___.'

b. [puHL, puMH ʂɻ̩HL ______, ʂɻ̩HL ______] 'No, it's not ____. It's ____.'

There were six recording sessions in this experiment. The first three sessions were for the five word strings while the last three sessions were for the six word strings. Participants read 30 stimuli in the first three sessions, and 36 stimuli in the last three sessions, yielding a total of 66 tokens per speaker. 44 fillers with other numbers were also included to divert speakers' attention from the tone sandhi patterns. The order of the stimuli was randomized and counter-balanced in each session.

3.2. Participants

Three male and two female native Taiwan Mandarin speakers participated in the experiment. Their ages ranged from 21 to 32 years old. All had recently moved to the United States and still communicated in Taiwan Mandarin on a daily basis. None of the participants had linguistic training or a history of speech impairments. They were naive as to the goal of the experiment.

3.3. Procedure

The experiment was performed at the Phonology and Field Research Laboratory (Phonolab) at Rutgers University. Participants were recorded while sitting in a sound-attenuated booth and wearing an AKG C420 head-worn microphone with behind-the-neck headband in order to keep the microphone at a constant distance from the mouth. The microphone was connected to an ART MPA Gold pre-amplifier, with output to an M-Audio Delta 1010LT sound card. The recording was done using GoldWave v6. 10 at a 44.1k Hz sampling rate and 16 bit quantizing rate in mono.

Participants were presented with a picture of telephone and stimuli on a computer screen. The two frame sentences were printed out on a paper in Mandarin characters. Participants read the stimuli in frame sentences when they were ready, at a normal conversational speed. Breaks were given after each recording session. Some effort was expended in ensuring that the subjects employed their vernacular. Specifically, the investigator engaged the participants in vernacular speech by having conversations with them during the breaks about mundane daily activities. Participants received a training session to familiarize the task. The recording sessions were conducted individually.

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[1] The third environment was used to investigate the focal phrasing pattern. Word strings like /tɕjouL wuL wuL wuL wuL/ '95555', in which one numeral differed from the string in the preceding sentence, were tested. The focal phrasing pattern is not the focus of this paper, so it will not be discussed here.

3.4. Analytical methods

Glottal stops/glottalization and pauses were labeled in Praat TextGrids for analyzing prosodic boundaries. Previous studies have shown that the occurrence of glottal stop/glottalization and pause indicates higher prosodic level boundaries. Cross-linguistically, nonmodal phonation (in particular creaky voice) is frequently used to mark prosodic boundaries, either initially and/or finally (Gordon & Ladefoged 2001). This kind of allophonic glottalization has been documented in a range of languages, including English (Pierrehumbert & Talkin 1992; Dilley et al. 1996), German (Kohler 1994) and French (Fougeron 2001). For example, English speakers are more likely to glottalize word-initial vowels when those vowels occur at the beginning of a new Intonational Phrase (Pierrehumbert & Talkin 1992; Dilley et al. 1996). Pauses are also indicators of Intontational Phrase boundaries (Nespor & Vogel 1987; Selkirk 1984).

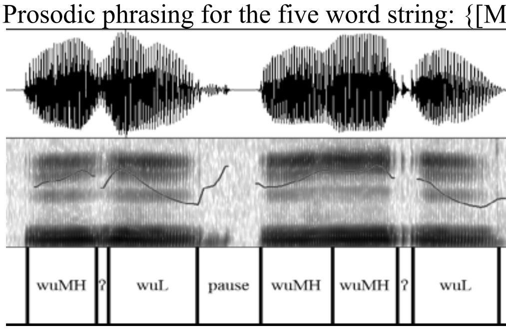
Tone sandhi was also used as a diagnostic of prosodic boundaries; it occurs iteratively from left to right when two underlying low tones are adjacent: /L L/→ [MH L]. Two native speakers of Taiwan Mandarin performed an auditory analysis of the tone sandhi patterns: a tone was coded as either L or MH and included in analysis only when both listeners agreed on the classification; there was 99% agreement. Any data with disfluency or hesitation was excluded from analysis.

4. Results

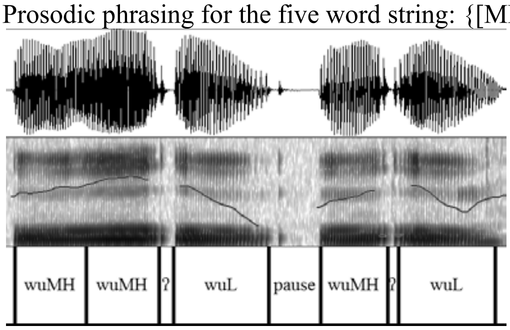
Three properties provided clear diagnostics for phrase boundaries: (a) a pause indicated a Major Phrase boundary; (b) a glottal stop/glottalization marked a Minor Phrase boundary; and (c) tone sandhi occurred within a Major Phrase.

For the five word string, all subjects produced two Major Phrases of two and three Prosodic Words, primarily {[MH][L]}{[MH.MH][L]}, as in (3) (Note: { } mark Major Phrase boundaries; [ ] mark Minor Phrase boundaries). Three of the subjects also produced the reverse pattern, {[MH.MH][L]}{[MH][L]}, as in (4). The production frequencies and percentages of the tone sandhi patterns are given in (5). Note that the data with disfluency or hesitation was excluded from analysis. Tone sandhi applies within each Major Phrase; the last syllable in each Major Phrase retains a L tone. Except for subject M1, the prosodic structure {[MH][L]}{[MH.MH][L]} was more frequent than the prosodic structure {[MH.MH][L]}{[MH][L]}.

(3) Prosodic phrasing for the five word string: {[MH][L]}{[MH.MH][L]}



(4) Prosodic phrasing for the five word string: {[MH.MH][L]}{[MH][L]}

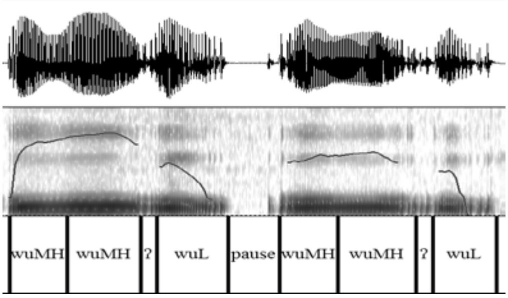


(5) Production frequencies and percentages for the five word string

Subject	{[MH][L]}{[MH.MH][L]}	{[MH.MH][L]}{[MH][L]}
M1	12 (44%)	15 (56%)
M2	20 (77%)	6 (23%)
F1	16 (59%)	11 (41%)
M3	30 (100%)	0 (0%)
F2	28 (100%)	0 (0%)

For the six word string, all subjects consistently produced two Major Phrases of three Prosodic Words (ω) each, with the first two in one Minor Phrase and the last one in another Minor Phrase: {[MH.MH][L]}{[MH.MH][L]}, as shown in (6). There was no variation in the six word string. The production frequencies and percentages of the tone sandhi pattern are given in (7).

(6) Prosodic phrasing for the six word string: {[MH.MH][L]}{[MH.MH][L]}



(7) Production frequencies and percentages for the six word string

Subject	{[MH.MH][L]}{[MH.MH][L]}
M1	32 (100%)
M2	36 (100%)
F1	36 (100%)
M3	28 (100%)
F2	30 (100%)

5. Phonological representation

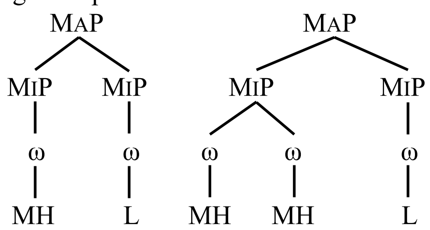
Based on the phonetic and phonological diagnostics, I propose that prosodic phrases in Taiwan Mandarin must be decomposed into Major and Minor phrases. Major Phrases dominate Minor Phrases. The Minor Phrase is the prosodic constituent that immediately dominates the Prosodic Word in the prosodic hierarchy (Selkirk et al. 2004). Since each syllable in the numeral string is a content word, each syllable forms a Prosodic Word, which is directly dominated by a Minor Phase.[2] The whole numeral string is an Intonational Phrase, directly dominating Major Phrases. Therefore, {[MH]} refers to a Major Phrase that dominates a Minor Phrase that dominates a Prosodic Word that dominates a foot that dominates a syllable node that bears the contour tone MH.

Because of the variation among speakers for the five word string, I propose there are two prosodic structures for the five word string, whereas there is one prosodic structure for the six word string. The phonological representations are provided in (8) and (9) (Note: ω = Prosodic Word, MIP = Minor Phrase, MAP = Major Phrase). Essentially, the phonetic and phonological evidence clearly show that Major Phrases must be binary, containing two Minor Phrases. Minor Phrases prefer to be binary but can also contain a single Prosodic Word.

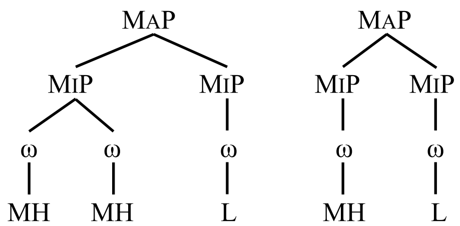
[2] According to L. Cheng (1987), two content words cannot be grouped into one Prosodic Word in Mandarin.

(8) Phonological representation for the five word string

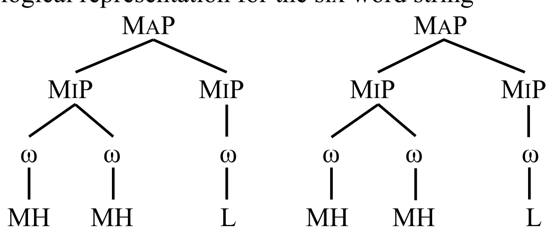
a.



b.



(9) Phonological representation for the six word string



6. Analysis

This section accounts for the prosodic phrasing using Optimality Theory. I propose that the asymmetry between Major and Minor Phrases is due to constraints on minimal and maximal size of the relevant prosodic domains and the ranking of these constraints (see Section 2).

(10) MAPMAX: Incur a violation for each Major Phrase that dominates more than two nodes.
MAPMIN: Incur a violation for each Major Phrase that dominates fewer than two nodes.
MIPMAX: Incur a violation for each Minor Phrase that dominates more than two nodes.
MIPMIN: Incur a violation for each Minor Phrase that dominates fewer than two nodes.

The constraint PARSE-ω requires every Prosodic Word to be domnated by a Minor Phrase. Similarly, PARSE-MIP requires every Minor Phrase to be dominated by a Major Phrase. In Taiwan Mandarin, unparsed Prosodic Words and Minor Phrases never occur in winners. So, both PARSE-ω and PARSE-MIP outrank any antagonistic constraints. Therefore, any candidates with unparsed elements such as *{[ωω]ω} and *{[ωω]}[ω] are eliminated by one of the PARSE constraints.

MAPMAX and MAPMIN must outrank MIPMIN to ensure that Major Phrases are obligatorily binary. By ranking MAPMAX over MIPMIN, a Major Phrase which contains three Minor Phrases is ruled out, as shown in (11c). Ranking MAPMIN over MIPMIN excludes a Major Phrase with only one Minor Phrase, as in (11d). In short, having MAPMAX and MAPMIN dominate MIPMIN guarantees that Major Phrases are strictly binary.

On the other hand, Minor Phrases can be either unary or binary. This is captured by ranking MIPMAX over MIPMIN. By doing so, a Minor Phrase which contains three Prosodic Words fatally violates MIPMAX, as in (11e). Consequently, a Minor Phrase with either one or two Prosodic Words is allowed.

(11) MAPMAX, MAPMIN, MIPMAX >> MIPMIN, ALIGN-R(MIP, MAP)

/55555/	MAPMAX	MAPMIN	MIPMAX	MIPMIN	ALIGN-R (MIP, MAP)
☞a. {[ω][ω]}{[ωω][ω]}				***	* *
☞b. {[ωω][ω]}{[ω][ω]}				***	* *
c. {[ωω][ωω][ω]}	*!			*	*** *
d. {[ωω][ω]}{[ωω]}		*!		*	*
e. {[ωω][ωωω]}			*!		***
f. {[ω][ω]}{[ω][ωω]}				***	* **!

Notice that candidate (11f) has the prosodic structure *{[ω][ωω]}, which is the reverse pattern of {[ωω][ω]} in candidates (11a) and (11b). The prosodic structures *{[ω][ωω]} and {[ωω][ω]} incur equal violations of MIPMIN since both have a Minor Phrase with one Prosodic Word. I argue that the ungrammatical candidate *{[ω][ωω]} fatally violates the constraint ALIGN-R(MIP, MAP) twice because the right edge of the first Minor Phrase is two Prosodic Words away from the right edge of the Major Phrase, whereas {[ωω][ω]} violates ALIGN-R(MIP, MAP) once.[3]

One remaining question is why there is variation among subjects. For subjects M1, M2, and F1, both candidates (11a) and (11b) are optimal outputs, whereas for subjects M3 and F2, only candidate (11a) is the optimal output. It should be noted that candidates (11a) and (11b) have the same violation profile in (11); they both violate MIPMIN three times. Thus, the proposed constraints are not sufficient to account for the variation observed in the five word string. I propose that variation occurs due to competing requirements for the Minor Phrase edges to be aligned with Intonational Phrase edges.

(12) ALIGN-L(MIP, IP): Align the left edge of every Minor Phrase with the left edge of an Intonational Phrase.
ALIGN-R(MIP, IP): Align the right edge of every Minor Phrase with the right edge of an Intonational Phrase.

(13)

/55555/	ALIGN-L (MIP, IP)	ALIGN-R (MIP, IP)
a. {[ω][ω]}{[ωω][ω]}	7	8
b. {[ωω][ω]}{[ω][ω]}	9	6

Assuming the whole numeral string is an Intonational Phrase, candidates (13a) and (13b) exhibit a conflict in the alignment constraints. (13b) incurs more violations in ALIGN-L(MIP, IP) than (13a) does, because the Minor Phrases are more distant from the left edge of the Intonational Phrase. However, (13a) incurs more violations in ALIGN-R(MIP, IP) than (13b) does, because the Minor Phrases are more distant from the right edge of the Intonational Phrase. For subjects with variation, ALIGN-L(MIP, IP) and ALIGN-R(MIP, IP) are partially ordered (cf. Anttila 2007). Hence, both candidates can be optimal outputs. For subjects with no variation, ALIGN-L(MIP, IP) dominates ALIGN-R(MIP, IP). As a result, candidate (13a) is the only winner. No subject learned the grammar ALIGN-R(MIP, IP) >> ALIGN-L(MIP, IP) because no subject solely produced the prosodic structure {[ωω][ω]}{[ω][ω]}. It is also possible that the variation could be explained by using constraints that align the Major Phrase edges with the Intonational Phrase edges. Unfortunately, the current data is not enough to distinguish the two approaches. Developing this line of research would go beyond the scope of this paper.

The proposed constraints and their ranking successfully predict the prosodic phrasing of the six word string. The tableau for the six word string is provided in (14). The important point here is that even though the length of the numeral string is changed from five to six, Major Phrases still maintain their binarity. Candidate (14b) violates MAPMAX because the Major Phrase contains three Minor

[3] An alternative analysis could be that *{[ω][ωω]} violates BRANCH-INITIAL(MIP), a constraint requires the first Minor Phrase to be branching in a Major Phrase (see Bennett 2012 for more details).

Phrases. Candidate (14c) incurs three violations in MAPMIN because each Major Phrase includes only one Minor Phrase. Candidate (14d) has two Minor Phrases, but each Minor Phrase has three Prosodic Words, thus violating MIPMAX. Candidate (14e) is ruled out because the right edge of the first Minor Phrase in each Major Phrase is two Prosodic Words away from the right edge of the Major Phrase. Finally, recall that there is no variation for the six word string. I argue that this is because the alignment constraints which determine the variation observed for the five word string are not crucial here. They do not distinguish any losing candidates from the winner. As a result, there is only one possible prosodic phrasing pattern for the six word string.

(14) Tableau for the six word string

/555555/	MAPMAX	MAPMIN	MIPMAX	MIPMIN	ALIGN-R (MIP, MAP)	ALIGN-L (MIP, IP)	ALIGN-R (MIP, IP)
☞a. {[ωω][ω]}{[ωω][ω]}				**	* *	10	8
b. {[ωω][ωω][ωω]}	*!				**** **	6	6
c. {[ωω]}{[ωω]}{[ωω]}		***!				6	6
d. {[ωωω][ωωω]}			**!		***	3	3
e. {[ω][ωω]}{[ω][ωω]}				**	** **!	8	10

7. Previous studies

Previous studies on Mandarin prosody mainly assume that the minimal prosodic unit for tone sandhi is feet, which are assigned from left to right and are typically disyllabic. An adjacent stranded monosyllable, if any, is incorporated into the neighboring foot, producing a recursive foot (e.g. Shih 1986, 1997; Chen 2000). This algorithm predicts that the numeral strings /wuL wuL wuL wuL wuL/ ‘55555’ and /wuL wuL wuL wuL wuL wuL/ ‘555555’ will have the following prosodic structures: [(wuMH wuL)$_{Ft}$ ((wuMH wuMH)$_{Ft}$ wuL)$_{Ft}$] and [(wuMH wuL)$_{Ft}$ (wuMH wuL)$_{Ft}$ (wuMH wuL)$_{Ft}$].

However, these predictions are not supported by the results of this experiment on phrasing patterns. The five word string exhibits more variability than what previous studies have predicted, whereas the six word string exhibits a completely different pattern. Contrary to previous studies, this paper presents phonetic and phonological evidence that there is a need to have two more levels: Minor Phrase and Major Phrase.

8. Conclusion

The aim of this paper was to show that there are binarity restrictions in Taiwan Mandarin. I have argued that numeral strings must be decomposed into Major and Minor Phrases, and that both levels have minimal and maximal size restrictions. The phonetic and phonological diagnostics suggest that Major Phrases are strictly binary, containing two Minor Phrases. In contrast, Minor Phrases can be either unary or binary; each Minor Phrase can have one or two Prosodic Words. The analysis of the numeral strings shows that the prosodic phrasing patterns are mainly affected by constraints on size restrictions and alignment. The most important part of the analysis, though, is that the binarity restrictions of Major and Minor Phrases are due to constraints which delimit the lower and upper bound of relevant prosodic domains – i.e. MAPMAX, MAPMIN, MIPMAX, MIPMIN.

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