VERBAL REDUPLICATION IN MANDARIN CHINESE: AN ANALYSIS AT THE SYNTAX-PHONOLOGY INTERFACE*

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1 Introduction

Verbal reduplication in Mandarin Chinese is an example of full reduplication. The two problems below have been acknowledged in many literatures.

The **first problem** is the morphosyntactic mapping of the *le* suffix in the context of verbal reduplication. Verbal reduplication expresses a bounded event and is compatible only with perfective aspectual marker *le*. When verbal reduplication occurs with *le*, *le* appears in between the base and the reduplicant, as if it is an infix in (1a)[1]. Suffixing *le* to the reduplicated structure as in (1b) is unacceptable. This is also the case with disyllabic verbs as in (1c-d).

(1) a. *xiang.le.xiang* think.PERF.think ('think a little/for a short while')
b. * *xiang.xiang.le* think.think.PERF
c. *xue.xi.le.xue.xi* study.PERF.study ('study a little/for a short while')
d. * *xue.xi.xue.xi.le* study.study.PERF

(2)

Possible	*Impossible*
VERB.*le*.RED	*VERB.RED.*le*

As schematized in (2), the possible surface order of affixation is 'VERB-*le*-RED', while 'VERB-RED-*le*' is unattested. If the aspectual marker *le* is strictly a suffix in Mandarin Chinese, and verbal reduplication is the realization of an aspectual projection in syntax as will be defended in section 2, then the infixation of *le* on the surface requires explanation.

The **second problem** involves the surface tonal patterns, which is a morphophonological issue. For monosyllabic verbs, the reduplicant is always unstressed and toneless. Thus (3a) is attested while (3b) is out[2]. When monosyllabic verbs are reduplicated, the numeral *yi* ('one') is optional

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[1]The verbal reduplication in Mandarin Chinese is suffixation and the reduplicant is underlined.

[2]The tones are noted in five-point scale (Chao, 1968), where '5' indicates the highest pitch while '1' is the lowest. In this paper, the four tones of Mandarin Chinese are notated as 55 (T1), 35 (T2), 21 (T3), 53 (T4), respectively.

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between the base and the reduplicant; see (3c). In such case, however, the verbal reduplicant has a full tone. This is also the case with (3d) where the perfective *le* co-occurs with verbal reduplication. In this case, when the verb is monosyllabic, the *yi* 'one' is also optional. When the verb is disyllabic, however, the *yi* 'one' cannot occur.

(3) a. kan^{53}.kan look.look
b. * kan^{53}.kan^{53}
c. kan^{53}.yi.kan^{53} look.one.look
d. kan^{53}.lə.kan^{53} look.PERF.look
e. kan^{53}.lə.yi.kan^{53} look.PERF.one.look

The difference on surface tonal patterns is observed in Li and Thompson (1981) and Paris (2013), and Paris (2013) uses the tonal difference as a piece of evidence to argue that VV and V-*yi*-V have different syntactic structures[3]. Then the questions include 1) Does the tonal difference really indicate that VV, V-*le*-V and V-*yi*-V have distinct structures, only VV being genuine verb reduplication? 2) If they are actually derived from the same syntactic structure, what causes their different phonological patterns?

Further, for disyllabic verbs, the tonal patterns of ABAB and AB-*le*-AB have not been much discussed in previous studies. We will also extend our discussion to the disyllabic verbs, and give a comprehensive examination of various types of verbal reduplication in Mandarin Chinese. Since different variations of Mandarin may demonstrate different tonal patterns, our investigation mainly focuses on Beijing Mandarin.

This paper touches upon several issues that have not been well addressed in previous work, including the linear order of V-*le*-V, and the tonal patterns of A-*le*-A, ABAB, and AB-*le*-AB. We investigate these issues from both syntactic and phonological perspectives, providing new understanding of verbal reduplication in Mandarin Chinese. Though these issues are seemingly unrelated, we will show that the linear order can be attributed to an alignment constraint which is motivated by historical syntactic evidence, and the linear order will influence the metrical structure, and therefore the surface tonal patterns.

The paper is organized as follows. In section 2 we argue that verbal reduplication is a functional projection in synchronic Mandarin Chinese, while the 'verb-classifier' analysis, with the reduplicant being a verbal classifier, is problematic. Based on the diachronic evolutionary process, we propose a generalized alignment constraint to address the first problem. Section 3 spells out the proposal and further accounts for the issue of tones in Optimality Theory (OT) (Prince and Smolensky, 1993/2004). Section 4 is the summary.

2 The Syntax of Verbal Reduplication

In this section, we first discuss two syntactic analyses on verbal reduplication: the verbal classifier analysis and the diminutive/tentative aspect analysis. We then show three arguments in favor of the latter analysis. Finally, we present an account for the affixation problem based on the historical evidence and formalize the idea as an alignment constraint on the perfective aspect marker *le*.

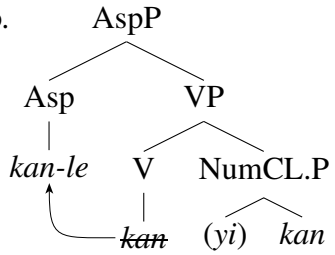
[3]In this paper, we simply use 'V' when indicating a verb. When necessary, 'AA' is used to represent the reduplication of a monosyllabic verb while 'ABAB' is used to indicate the reduplication of a disyllabic verb.

2.1 Two Morphosyntactic Analyses of Verbal Reduplication

In the verbal classifier analysis (Fan 1964, Zhu 1982, Xiong 2016), the second verb is not a copy of the stem, but a 'verbal classifier' counting the time of the action expressed by the stem verb. As shown in (4), the second verb first form a numeral classifier phrase with the numeral word *yi* 'one'. Then the phrase modifies the verb. Under this analysis, *le* is a suffix to the verb stem and the 'infixation' word order is due to the optional elision of the numeral word *yi* 'one'.

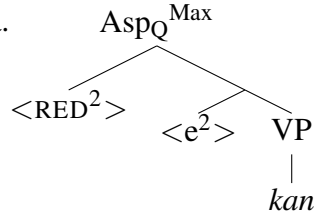
(4) a. *kan-le (yi) kan*
look.PERF one look

b.

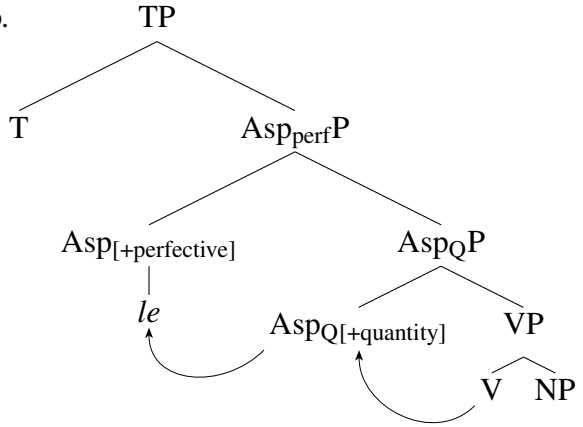


In the diminutive/tentative aspect analysis, the verb reduplication is the phonological realization of the diminutive/tentative aspect (cf. Chao 1968, Li and Thompson 1981, Smith 1991, 1994, among many others). We further propose that the diminutive/tentative aspect is a head feature which assigns quantity range to an aspectual head (cf. Borer, 2005a,b). The structure is represented in (5a). An alternative is to follow the split INFL structure and assume verb reduplication as an aspectual projection located among one of the layered aspect as in (5b) (cf. Tsai, 2008).

(5) a.



b.



We are not going to compare (5a) and (5b) here, because both proposals crucially capture the functional property of verb reduplication and can account for the following evidence, in contrast to the 'verbal classifier' analysis.

2.1.1 The Abstract Meaning of '*yi*-V'

In contemporary Mandarin Chinese, the numeral *yi* 'one' is optional in most cases. Thus, it is argued in the first analysis that the V-V form comes from V-*yi*-V with *yi*-V being the numeral classifier phrase and *yi* being omitted. However, the '*yi*-V' is different from other numeral quantifier phrases in Chinese such as *xia* or *hui* which both mean 'time'. The *yi* 'one' in '*yi*-V' has lost its meaning in counting actual occurrence of action and only has a vague meaning indicating a short while or small amount. In other words, it is a conventionalized usage which is correctly characterized as diminutive or tentative. Furthermore, the numeral in the so-called numeral

classifier phrase of '*yi*-V' is restricted to *yi* 'one'. '*Yi*' cannot be replaced by other numerals such as **kan san-kan* 'look three-look'. Therefore, we analyze '*yi*-V' as the realization of the functional projection of diminutive/tentative aspect, and *yi* is an optional morph without concrete meaning.

2.1.2 The reduplication of non-activity, non-volitional verbs

Descriptive grammars generalize that only activity and volitional verbs can be reduplicated to mean 'doing something for a little/a short while' (Chao 1968, Li and Thompson 1981, Zhu 1982 Smith 1991). However, the reduplication of achievement and stative verbs is acceptable, such as in (6)-(8). We have also obtained more examples with the following verbs: *si* 'die', *bing* 'be sick', *sha* 'kill', *xing* 'be surnamed', etc.

(6) Ta bu ai wo, wo jiu bu neng ai.yi.ai ta?
she not love me, I then not can love.one.love her
'Even if she doesn't love me, can't I love her for a little bit?'
(Q.Chen 2001, (25))

(7) Rang ta sheng.sheng xiaohai, jiu zhidao zuo muqin de ganku le.
make her birth.birth baby, then know be mother DE hardship LE
'Let her try to give birth to a baby; she'll know the hardship of being a mother.'
(L.Chen 2005, (7))

(8) Deng renmen ba zhe-jian-shi wang.wang zai shuo ba.
wait people BA this.CL.thing forget.forget then talk PARTICLE.
'Let's wait for people to forget this thing for a while and then talk about it.'
(L.Chen 2005, (11))

Such examples show that it is not the internal semantic properties that determine what kind of verbs can be reduplicated. On the one hand, such 'notorious flexibility' can be explained with the structure we adopt in (5). We assume that the lexical entries do not contain information about the aspectual features, and the aktionsart and argument structure are syntactically represented; thus, the lexical entry simply does not posit any restrictions. Moreover, as the diminutive/tentative aspect is a head feature assigning quantity range, given an appropriate context, much of the oddity from the verb reduplication can be overridden and the diminutive/tentative interpretation can be coerced. On the other hand, if the '(*yi*)-V' part is a numeral quantifier phrase, then it should not be compatible with stative or achievement verbs as above.

2.1.3 The Availability of Idiomatic Readings with Reduplication

Idiomatic reading provides another plausible argument against the verbal classifier analysis. The reasoning is that, when V-O idiom phrases are used with verbal classifiers like *san xia* 'three times', the verb phrases loses its idiomatic reading, and only literal meaning is available (Deng 2012). On the contrary, both literal and idiom meaning are possible in the reduplicated form. For instance, in (9) *bao fojiao* 'clasp Buddha's foot' is an idiom meaning 'make a last-minute effort'. With a verbal classifier in (10), only literal reading is possible. However, in (11), both literal and idiomatic interpretations are available.

(9) bao fo.jiao.
clasp Buddha.foot
Idiomatic reading: '*make a last-minute effort*'
Literal reading: '*clasp pthe Buddha (statue's) foot*'

(10) Ta kaoshi qian **bao.le** **san.xia** fo.jiao.
he tests before clasp.PERF three.times Buddha.foot
(Literal reading only)

(11) Ta kaoshi qian **bao.le.bao** **fo.jiao**
he tests before clasp.PERF.clasp Buddha.foot
(Both literal and idiomatic reading possible)

If verb reduplication is treated structurally the same as verbal classifier, we do not expect the difference in interpretation between (10) and (11). On the other hand, we could explain the contrast with the assumption that VO idiomatic chunk is a constituent on certain level of syntactic representation. Verbal classifier takes up the complement position of the verb, and thus the object is in the specifier position, which does not form a constituent with the verb. The idiomatic reading is therefore not available with verbal classifier *xia* 'time'. By contrast, verb reduplication is a surface realization of a functional projection, and the verb and its object form a constituent in the base position, so the idiomatic reading is available in (11).

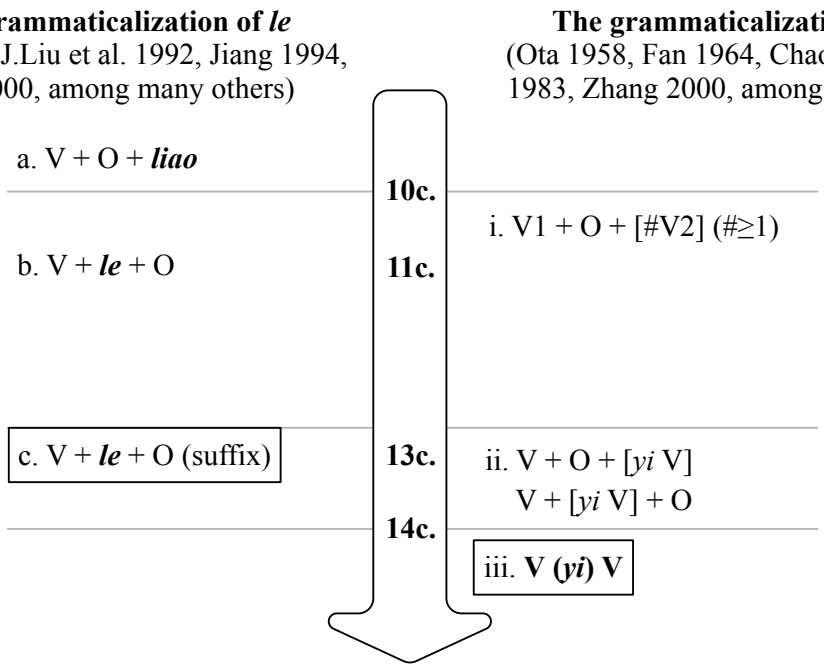
To summarize, the three arguments presented in this section indicate that verb reduplication is a highly grammaticalized form in modern Mandarin Chinese and it is better analyzed as a functional projection in syntax with reduplication being its morphosyntactic realization.

2.2 'V-*le*-V' Word Order as a Result of Historical Change

If the functional projection analysis for verb reduplication is adopted, then we may expect that the output is VERB-RED-*le* ('RED' represents 'reduplicant morpheme'), which is unattested (recall the schema in (2)). Thus, the functional projection analysis requires an account for the surface order of the *le* suffix which seems to be infixed between the stem and the reduplicant. We argue that the surface position of *le* results from an alignment constraint that requires *le* be adjacent to the verb stem, though violating LINEARITY.

The perfective marker *le* takes up the privileged position adjacent to the verb stem, and this is supported by the evidence from the grammaticalization of the perfective marker and the tentative/diminutive reduplication: *le* became a perfective suffix before the second V in 'V-*le*-V' is reanalyzed as a verb copy. We compare the grammaticalization processes based on the previous studies in (12).

(12)



The key time point is that, when the suffix *le* was grammaticalized and became a suffix around 13th century, the usage of V-*yi*-V had just appeared. The example in (13) from the 13th century shows that the numeral can be more than *yi* 'one'. Then the second verb *chui* 'blow' should be analyzed as a verbal classifier. However, such a sentence is not acceptable in modern Mandarin Chinese. As the numeral *yi* 'one' gradually lost its concrete meaning in counting, it is proposed that the verb reduplication is grammaticalized after 14th century, indicated by the examples where *yi* is omitted.

(13) 师乃拈一枝吹 两 吹，度与百丈。（南宋《五灯会元》卷九）
… chui liang chui …
blow two blow
(Southern Song Dynasty, 13c; Unacceptable in Modern Chinese)

Therefore, synchronically there is a competition between the alignment of the suffix *le* and RED, but diachronically, *le* has taken the privileged position of being on the edge of verb stem before the second verb is reanalyzed from a verbal classifier to a copy. Based on this fact, we propose an alignment constraint to capture the priority of the suffix *le*, in the schema of Generalized Alignment (McCarthy and Prince, 1993):

(14) **ALIGN(*le*, L, ROOT, R)**:
Assign a violation mark if the left edge of perfective marker *le* is not aligned with the right edge of the verbal root. (ALIGN-*le*: '*le*' must immediately follow a verbal root).

So far, we have discussed the syntax of verbal reduplication, and have argued that it is better viewed as the phonological realization of a functional head. Further, we propose a constraint

that can interact with other phonological constraints and derive the correct surface linear order of verbal reduplication. In the following section, the problems of the linear order and the surface tonal patterns will be addressed in the framework of OT.

3 The Phonological Analysis of Verbal Reduplication

With the input 'Verb-RED-*le*' provided by syntax, as well as the alignment constraint motivated by historical evidence, this section shows how to generate the surface linear order of the morphemes (§3.1) and the surface tonal patterns (§3.2) by employing Base-Reduplicant Correspondence Theory (McCarthy and Prince, 1995) and the Dual Trochee (Duanmu 1999, 2007, 2014).

3.1 Deriving the Surface Shape and Linear Order

In Mandarin Chinese, all types of reduplication are full reduplication, which results from the high ranking of MAX-BR. In the meantime, the copied segments violate the constraint INTEGRITY, which should be dominated by MAX-BR. The definitions of the constraints are given in (15–16).

(15) **MAX-BR**:
The segments in the base must be maximally preserved in the reduplicant (McCarthy and Prince, 1995).

(16) **INTEGRITY**:
Assign one violation mark for each segment in the input that has multiple correspondents in the output (McCarthy and Prince 1995, Struijke 2000).

In terms of the linear order, the proposed alignment constraint requires the perfective aspectual marker *le* immediately follow the verbal root, at the expense of LINEARITY(M). Therefore, there should be ALIGN-*le* ≫ LINEARITY(M). The definitions of the constraints are given in (17) and (18). Note that the constraint LINEARITY is modified and slightly different from the original definition in McCarthy and Prince (1995). This definition here follows the proposal of McCarthy (2003), which argues that all the constraints in OT should be categorically defined.

(17) **LINEARITY(M)**:
If the linear order of the morphemes in the input is not kept in the output, assign a violation mark (cf. Lin 2015:853)

(18) **ALIGN(*le*, L, ROOT, R)**:
Assign a violation mark if the left edge of perfective marker *le* is not aligned with the right edge of the verbal root. (ALIGN-*le*: '*le*' must immediately follow a verbal root).

The tableaux in (19) and (20) illustrate the effects of the crucial rankings MAX-BR ≫ INTEGRITY and ALIGN-*le* ≫ LINEARITY(M). For a monosyllabic verb /kʰan/ ('look', 'read'), the optimal output is [kʰan.lə.kʰan]. For a disyllabic verb, exemplified by /ɕyɛ.ɕi/ ('study'), the output is [ɕyɛ.ɕi.lə.ɕyɛ.ɕi] (the reduplicants are underlined).

(19) Monosyllabic verb /kʰan/, 'look/read'

kʰan-RED-*le*	ALIGN-*le*	MAX-BR	LINEARITY(M)	INTEGRITY
a. ☞ kʰan.lə.kʰan			1	3
b. kʰan.kʰan.lə	1W		L	3
c. kʰan.lə.kʰa		1W	1	2L

(20) Disyllabic verb /ɕyɛ.ɕi/, 'study'

ɕyɛ.ɕi-RED-*le*	ALIGN-*le*	MAX-BR	LINEARITY(M)	INTEGRITY
a. ☞ ɕyɛ.ɕi.lə.ɕyɛ.ɕi			1	5
b. ɕyɛ.ɕi.ɕyɛ.ɕi.lə	1W		L	5
c. ɕyɛ.ɕi.lə.ɕyɛ		2W	1	3L

3.2 Deriving the Surface Tonal Patterns

3.2.1 The Dual Trochee

In the following analysis, we follow Duanmu's (1999, 2007, 2014) proposal that Mandarin Chinese (as well as other variations of Chinese) has Dual Trochees, i.e. both moraic and syllabic trochee exist in Mandarin Chinese. Though some researchers have argued that there is no foot on the prosodic hierarchy of Mandarin Chinese (e.g. Li 2010, Zhang 2014), the surface tonal patterns of verbal reduplication demonstrate the necessity of foot structure and the utility of the Dual Trochee.

The main proposal of the Dual Trochee is that a heavy syllable forms a bimoraic trochee (M-foot), and a minimal word must be a disyllabic trochee (S-foot) (Duanmu, 1999). The well-formed trochee and bad foot structures are shown below (adapted from Duamu 2007:139)('( )'−foot boundary; **boldface**−stressed syllable/mora, i.e. foot head):

(21) The well-formed trochee (Dual Trochee)

a. (**σ** σ) b. (**σ** σ) Syllabic foot
(**μμ**) (**μμ**) (**μμ**) μ Moraic foot
heavy-heavy heavy-light

(22) Bad foot structures

a. (**σ** σ) b. (**σ** σ) Syllabic foot
μ μ **μ** (**μμ**) Moraic foot
light-light light-heavy

The wellformedness of the trochaic foot is in accordance with the well-known Weight-to-Stress Principle, given in (23) (Duanmu 2008:58). In (21), each foot, either moraic or syllabic, is trochaic, and the stressed syllable is heavy. In (22), however, these patterns are ill-formed since the stressed syllable in each foot is light, violating Weight-to-Stress Principle.

(23) **Weight-to-Stress Principle**:
A syllable is stressed iff it is heavy

3.2.2 The Surface Tonal Patterns of Verbal Reduplication

Stress is closely related to tone. Duanmu (2007:249) proposes the Tone-Stress Principle:

(24) **Tone-Stress Principle**:
A stressed syllable can be assigned a lexical tone or pitch accent. An unstressed syllable is not assigned a lexical tone or pitch accent.

In Mandarin Chinese, it is a consensus that the tone of the base is copied in verbal reduplication (e.g. Yin 2008, Sui 2007), which is evidenced by tone sandhi. Look at the example below:

(25) ɕiɑŋ^{21} + RED, 'think'

ɕiɑŋ^{21}ɕiɑŋ^{21}	→	ɕiɑŋ^{35}ɕiɑŋ^{21}	→	ɕiɑŋ^{35}ɕiɑŋ
reduplication		*tone sandhi*		*neutralization*

The tone of the base in (25) is copied, triggering tone sandhi (T3 + T3 → T2 + T3), and the output of verbal reduplication forms a disyllabic trochee. Based on the Tone-Stress Principle (Duanmu 2007:249), the second syllable (i.e. the reduplicant) in the trochaic foot is unstressed, and therefore toneless. The disyllabic trochee can be represented as (21b).

Nevertheless, when both reduplication and the perfective aspectual marker *le* come into the picture, the surface tonal pattern becomes different. Take *kan.le.kan* ('have watched/read a little bit') for example, even though the pitch of the reduplicant is less prominent than that of the base, the reduplicant still carries a lexical tone instead of being atonic, i.e. [k^{h}an^{53}.lə.k^{h}an^{53}] instead of [k^{h}an^{53}.lə.k^{h}an]. Further, one important property of the neutral tone is that its surface pitch contour is predictable based on its preceding syllable (Wang, 2004), and it is clear that the tone of the reduplicant *kan* is not the result of *le*. Several examples are given in (26) to illustrate the difference of tones between 'VERB+RED' and 'VERB+RED+*le*'[4]:

(26) The tones of 'VERB+RED' and 'VERB+RED+*le*'

Tone of the base	VERB+RED	VERB+RED+*le*	gloss of the base
T1 (55)	[t^{h}iŋ^{55}.t^{h}iŋ]	[t^{h}iŋ^{55}.lə.t^{h}iŋ^{55}]	'listen'
T2 (35)	[tʂɑŋ^{35}.tʂɑŋ]	[tʂɑŋ^{35}.lə.tʂɑŋ^{35}]	'taste'
T3 (21)	[ɕiɑŋ^{35}.ɕiɑŋ]	[ɕiɑŋ^{21}.lə.ɕiɑŋ^{21}]	'think'
T4 (53)	[k^{h}an^{53}.k^{h}an]	[k^{h}an^{53}.lə.k^{h}an^{53}]	'look/read'

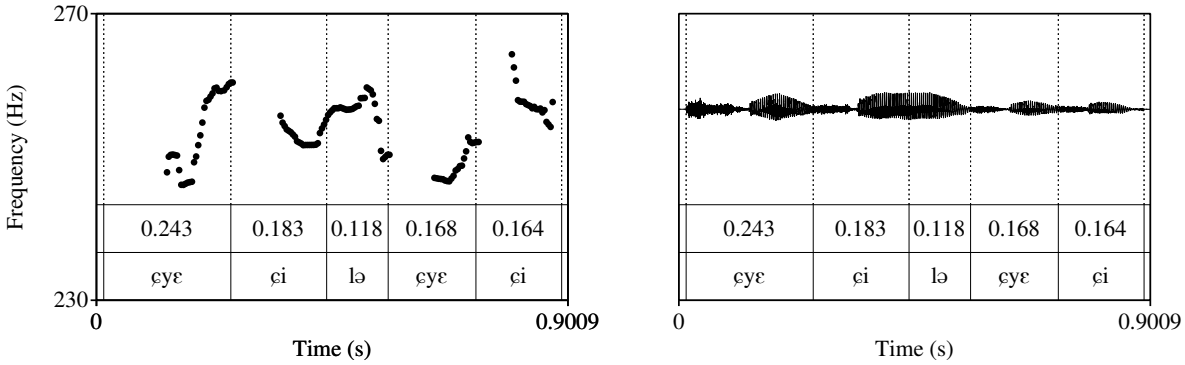
When the verb is disyllabic, the tones of 'VERB+RED' and 'VERB+RED+*le*' are more complicated and have not been discussed much in the literature[5]. Though some work describes the tonal patterns of ABAB verbal reduplication, there is still no consensus. Li and Thompson (1981:30) describe disyllabic verbal reduplication as 'no phonological change', while Zhu (1982:26) claims that the tones on the last two syllables of ABAB verbal reduplication are neutralized. Our interview suggests that the *last syllable* of the disyllabic reduplicant is better

[4]The main purpose here is to illustrate the tonal pattern of the reduplicant. Although the marker *le* is underlyingly toneless, it can acquire surface tones in different contexts, such as a H tone when it is preceded by T3 ([ɕiɑŋ^{21}lə^{5}ɕiɑŋ^{21}], 'think'). Apart from this context, the maker *le* is always specified as a surface L tone, and we simply leave out the tone on *le*.

[5]An anonymous reviewer points out that AB-*le*-AB (a reduplicated disyllabic verb with a suffix *le*) is unacceptable. However, our field investigation shows that around 50% of the informants accept AB-*le*-AB. The inter-speaker variation in the judgement awaits further study.

analyzed as *unstressed*. Take *xue.xi* ([ɕyɛ^{35}.ɕi^{35}], 'study') for example, the reduplicated form should be [ɕyɛ^{35}.ɕi^{35}.ɕyɛ^{35}.ɕi], where the last syllable is unstressed. Further, when the marker *le* co-occurs with the reduplicant, the surface form is [ɕyɛ^{35}.ɕi^{35}.lə.ɕyɛ^{35}.ɕi]. This point can be proved by acoustic evidence. The waveform and the pitch contour of *xue.xi.le.xue.xi* produced in natural speech by a female native speaker of Beijing Mandarin are illustrated in (27).

(27) Pitch contour and waveform of *xue.xi.le.xue.xi* ([ɕyɛ.ɕi.lə.ɕyɛ.ɕi])



Two things can be interpreted from the pitch contour in (27). First, the syllable [ɕyɛ] in the reduplicant still has a rising tone (T2), indicating that the tone of the base is copied and not neutralized. Second, the last syllable [ɕi] surfaces as a falling tone, which suggests that it is neutralized and its surface pitch contour is influenced by the preceding syllable. This observation conforms to other experimental studies on neutral tone of Beijing Mandarin. In Lin and Yan (1980), the experiment shows that the surface pitch contour of a neutral tone will be falling when it follows T2. Moreover, the waveform in (27) also indicates that the last syllable is weak and therefore unstressed.

To sum up, despite the divergence of description in earlier work, our interview and acoustic data suggest that the last syllable is better treated as unstressed, monomoraic, and toneless (though it can still acquire a surface pitch contour from its preceding syllable). However, some informants feel that the last two syllables in ABAB and AB-*le*-AB can be unstressed, and we view this as contextual variation since the metrical pattern can be influenced by various factors, including speech rate, semantic and pragmatic focus, etc. We save the issue of variation for further research.

The patterns discussed above can be predicted by the interaction of some metrical constraints. The analysis is given in the following section.

3.2.3 The Constraint-based Analysis

Since the unstressed syllable cannot be assigned a lexical tone (i.e. Tone-Stress Principle), a relevant constraint is used to illustrate this point (adapted from Lee-Kim (2016)):

(28) ***NON-HEAD/TONE (*NON-HD/T)**:
In a *syllabic* trochee, assign a violation mark for every non-head syllable that carries lexical tone.

This constraint is in conflict with MAX-TONE-BR, which requires the maximal preservation of the tone on the reduplicant. Further, the undominated constraint TROCHEE requires the

output be trochaic and therefore the second syllable in a foot should be unstressed (non-head). Thus, the ranking TROCHEE, *NON-HEAD/TONE ≫ MAX-TONE-BR ensures that the candidate [kan^{53}.kan^{53}] is ruled out. The definitions of Trochee and MAX-TONE-BR are given below:

(29) **TROCHEE** (at both moraic and syllabic levels):
The head of a foot is on the left (Duanmu 1999:8).

(30) **MAX-TONE-BR**:
Assign a violation mark for every red that has no corresponding tone to the base.

Another constraint that conflicts with MAX-TONE-BR is *RED(T), which penalizes any copied tones:

(31) ***RED(T)**:
There must be no tones in reduplicant (Yin 2008:38).[6]

With the constraints above, the tableau for the input /k^{h}an^{53}+RED/ is given in (32). The constraint TROCHEE and the candidates that are not trochaic are not included in the following tableaux due to the limit of space. Further, the constraints that ensure the position of *le* and the shape of the reduplicant are also left out.

(32) *kan.kan* 'watch/read a little bit'

/k^{h}an^{53}+RED/	*NON-HD/T	MAX-T-BR	*RED(T)
a. ☞ (**σ** σ) ∧ | (**μμ**) μ k^{h}an^{53} k^{h}an		1	
b. (**σ** σ) ∧ ∧ (**μμ**) (**μμ**) k^{h}an^{53} k^{h}an^{53}	1W	L	1W

When both RED and the perfective marker *le* appear in the input, i.e. /k^{h}an^{53}-RED-lə/, the metrification is different, and the surface tonal pattern can still be predicted by the same constraints. The tableau is shown below.

[6] In Yin (2008), the constraint penalizes the copy of tonal features (H and L). For example, a falling tone on the reduplicant is treated as HL, which incurs two violations of the constraint. In the following tableau, as long as a tone is copied, be it a rising tone (LH) or falling tone (HL), one violation is marked for the sake of simplicity. Although the effect of *RED(T) is not apparent in the following tableaux, we include this constraint since it can potentially account for variations. It is possible that *RED(T) and MAX-T-BR are unranked, and therefore result in variations on tonal patterns.

(33) *kan.le.kan* ‘have watched/read for a little while’

/k^{h}an^{53}-RED-lə/	*NON-HD/T	MAX-T-BR	*RED(T)
a. ☞ (**σ** σ) σ ∧ | ∧ (**μμ**) μ (**μμ**) k^{h}an^{53} lə k^{h}an^{53}			1
b. (**σ** σ) σ ∧ | | (**μμ**) μ μ k^{h}an^{53} lə k^{h}an		1W	L

In (33a), the tone of the base is copied but not in (33b), violating MAX-T-BR. So far, the constraints have predicted that the second *kan* in *kan.kan* has a neutral tone while the second *kan* in *kan.le.kan* has a full tone. However, the reduplicant *kan* is less prominent than the base *kan*. We attribute this to the rhythmic pattern of a higher level of metrical structure. Since the whole output *kan.le.kan* can be viewed as a prosodic word, the first foot that contains a verb should be the head foot, which has greater prominence.

When the verbal base is disyllabic, exemplified by *xue.xi* ([ɕyɛ^{35}.ɕi^{35}], ‘study’), the surface tonal patterns of ABAB and AB-*le*-AB can be predicted by the same ranking, shown in (34) and (35). Note that the tones of the base are protected by the positional faithfulness constraint MAX-TONE-ROOT, which is not included in the following tableaux.

(34) *xue.xi.xue.xi* ‘study a little bit’

/ɕyɛ^{35}.ɕi^{53}+RED/	*NON-HD/T	MAX-T-BR	*RED(T)
a. ☞ (**σ** σ) (**σ** σ) ∧ ∧ ∧ | (**μμ**) (**μμ**) (**μμ**) μ ɕyɛ^{35} ɕi^{35} ɕyɛ^{35} ɕi	1	1	1
b. (**σ** σ) σ σ ∧ ∧ | | (**μμ**) (**μμ**) μ μ ɕyɛ^{35} ɕi^{35} ɕyɛ ɕi	1	2W	L
c. (**σ** σ) (**σ** σ) ∧ ∧ ∧ | (**μμ**) (**μμ**) (**μμ**) (**μμ**) ɕyɛ^{35} ɕi^{35} ɕyɛ^{35} ɕi^{35}	2W		2W

(35) *xue.xi.le.xue.xi* 'have studied for a little while'

/ɕyɛ^{35}.ɕi^{53}+RED+lə/	*NON-HD/T	MAX-T-BR	*RED(T)
a. ☞ (σ (σ σ) (σ σ)) / (μμ) (μμ) μ (μμ) μ / ɕyɛ^{35} ɕi^{53} lə ɕyɛ^{35} ɕi		1	1
b. (σ (σ σ) (σ σ)) / (μμ) (μμ) μ (μμ) (μμ) / ɕyɛ^{35} ɕi^{35} lə ɕyɛ^{35} ɕi^{35}	1W	L	2W
c. (σ σ) σ σ σ / (μμ) (μμ) μ μ μ / ɕyɛ^{35} ɕi^{35} lə ɕyɛ ɕi	1W	2W	L

Before closing the section, two more issues should be mentioned. First, recall the example in (4). The tonal pattern of *kan.yi.kan* is the same as *kan.le.kan*, and the metrical structure of *kan.yi.kan* is the same as the one shown in (33a). We claim that the tonal difference between *k^{h}an^{53}.k^{h}an* and *k^{h}an^{53}.yi.k^{h}an^{53}* does not mean they have different syntactic structures. Instead, both 'RED' and '*yi*-RED' can be viewed as the realization of the delimitative/tentative functional head, and they are free variations, since there is no semantic distinction.

Second, though A-*yi*-A (e.g. *kan.yi.kan*, 'look.one.look') is perfectly acceptable and has the same tonal pattern as A-*le*-A, our field investigation shows that none of the informants can accept *AB-*yi*-AB (e.g. **xue.xi.yi.xue.xi*, '*study.one.study'). Studies on verb reduplication that have noticed this phenomenon give the explanation that perhaps the structure is too long and thus not permissible. However, the form AB-*le*-AB is acceptable, though it has the equal length to *AB-*yi*-AB. We attribute this to the size restriction of prosodic word of Mandarin Chinese.

In a natural production experiment by Guo (2016), 99.74% of the identified prosodic words are less or equal to four syllables. Moreover, various researchers also suggest four syllables could be the maximal size of Mandarin prosodic words[7] (e.g. C.Zhang 2000, Deng et al. 2007, Wang 2008, etc.). Therefore, we propose a hypothesis about the size of Mandarin prosodic word:

(36) 1. Mandarin has lexical stratification, and the size restriction of prosodic word can be different for native words and loan words[8];
2. In terms of the native words, the maximal size of a prosodic word does not exceed four syllables.(*PRWD$_{\text{native}}$>4σ)

Under this hypothesis, even though either RED or *yi*-RED can be used to realize the delimitative/tentative aspectual head, only RED can be selected when the verb is disyllabic

[7]According to Li (2010:167), a prosodic word in Chinese '*should contain at least one syllable with full tone … and the affixes, together with the stem that they attach to.*'

[8]See Itô and Mester 1999, 2001 for the discussion of lexical stratification; see Kim (2012) for the lexical stratification in Mandarin. Kim (2012) mentions three main types of loan words in Mandarin, i.e. Japanese graphic loans, semantic loans and alphabetic loans, among which the alphabetic loans are the least restricted in terms of prosodic word size.

(i.e. *xue.xi.xue.xi*) since the form **xue.xi.yi.xue.xi* is too long as a prosodic word, violating *PRWD$_{native}$>4σ. In contrast, though the output *xue.xi.le.xue.xi* also violates the size restriction, the perfective aspectual marker *le* must be realized under the pressure of high-ranked REALIZEMORPHEME, which requires that every morpheme must have some exponence (Walker, 2000). In other words, though both RED and *yi*-RED are the exponents of the aspectual functional head, only RED can be realized when the verb is disyllabic while either of them can be realized when the verb is monosyllabic, due to the size restriction proposed above. As a hypothesis, we do not include many details here, and we leave the size restriction of Chinese prosodic word as an open question.

4 Summary

In this paper, we focus on two issues of verbal reduplication when it co-occurs with the perfective marker *le* in Mandarin Chinese, i.e. 1) the surface order of affixation and 2) the various tonal patterns of the reduplicated forms. We developed on the previous argument that verb reduplication is an aspectual functional projection in syntax and cannot be analyzed as a verbal classifier structure and it is the generalized alignment constraint ALIGN-*le*, justified on the ground of diachronic processes, that determines the output order of 'VERB-*le*-RED'. Also, the linear order influences the surface metrical structure, giving rise to the attested surface tonal patterns, which can be derived by a set of metrical and tonal constraints in the framework of OT.

Finally, several issues still need further investigation. First, not all the informants accept AB-*le*-AB, and the across-speaker variation on the acceptability should be further tested and modeled. Second, some Mandarin speakers with southern dialect background can accept the order ABAB-*le* (while rejecting AA-*le*), which is not acceptable by most Beijing Mandarin speakers. The examination of different variations can help us better understand the syntax and phonology of verbal reduplication in Mandarin Chinese.

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