Syllable Structure and Stress

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December 7, 2013

(To appear in *The Handbook of Chinese Linguistics*, First Edition, ed. C.-T. James Huang, Y.-H. Audrey Li, and Andrew Simpson, 422-442. New Jersey: John Wiley & Sons.)

1. Introduction

This chapter reviews major issues in the analysis of the Chinese syllable and its interaction with stress. We begin with a discussion of what a syllable is, followed by a discussion of the maximal and the minimal syllable in Chinese, including syllabic consonants. Next we discuss the difference between heavy and light syllables, which leads to the discussion of the interaction between syllable structure and stress. Throughout the discussions, data and descriptive generalizations are presented first. Then theoretical analyses are introduced and outstanding problems noted.

2. What is a syllable?

The notion of the syllable is not always clear in all languages (Duanmu 2008). In English, for example, it is notoriously difficult to determine syllable boundaries. For example, there are at least four analyses of a word like *city*: (i) [sɪ[t]i] (Pulgram 1970; Anderson 1975; Jones 1976; Kahn 1976), where [t] belongs to both the first and the second syllable; (ii) [sɪt][i] (Fudge 1969; Hoard 1971; Bailey 1978); (iii) [sɪ][ti] (Halle and Vergnaud 1987); and (iv) [sɪt][ti] (Burzio 1994), where [tt] is long and is split between two syllables. Consequently, some linguists discuss syllable peaks but not syllable boundaries (e.g. Jones 1950), some doubt whether the syllable can

be clearly defined (e.g. Gimson 1970: 53), and some avoid the syllable altogether (e.g. Chomsky and Halle 1968).

In Chinese, on the other hand, there is little controversy or ambiguity with regard to syllable boundaries: In most cases, each Chinese syllable corresponds to a morpheme, or a written graph. In addition, since Chinese lacks inflection, morphemes tend to keep their phonetic shape most of the time (e.g. no resyllabification across morpheme boundaries). Polysyllabic words do occur in translated foreign names, but such a name is represented by a concatenation of existing syllables, whose boundaries tend to stay.

3. The maximal syllable in Chinese

The maximal Chinese syllable, regardless of the dialect, is often thought to contain four positions, or CGVX, where C is a consonant, G is a glide, and VX is a diphthong, or a short vowel plus a consonant, or a long vowel. Some examples are shown in (1). For simplicity, I enclose phonetic transcription in square brackets, regardless of the level of analysis. In some analyses (e.g. Cheng 1966, Lin and Wang 1992), G is transcribed as a high vowel, which has little consequence for our discussion.

(1) The CGVX analysis of the maximal syllable in Standard Chinese

[k^{h}wai]	[t^{h}jan]	[kwaŋ]	[kwa:]	[tswan]
‘fast’	‘day’	‘light’	‘melon’	‘diamond’

The maximal syllable size is rather stable. Even when a suffix is added, the CGVX size is maintained (see Lin 1989, 1993, and 2008). For example, in Beijing Chinese [p^{h}ai] ‘plaque’ + [ɚ˞]

‘(diminutive)’ and [p^{h}an] ‘dish’ + [ɚ˞] ‘(diminutive)’ both become [p^{h}aɚ˞], where [ɚ˞] replaces the original occupant of X.

Chinese dialects differ in what can fill the four positions of a syllable. Three dialects are shown in (2), where a diphthong is treated as two vowels.

(2) Dialect variation: phonemes to fill each position in CGVX

	C	G	V	X
Beijing	most Cs	[j, w, ɥ]	any V	[i, u, n, ŋ, ɚ˞]
Cantonese	any C	[(j), w]	any V	[i, u, n, m, ŋ, p, t, k]
Shanghai	any C	[j, w, ɥ]	any V	([ʔ, ŋ])

In all dialects, the C position can be filled by almost any consonant, with occasional exceptions; for example, [ŋ] is not used in the C position in Beijing. The G position can be filled by one of three glides in Beijing and Shanghai. In Cantonese, there are two glides [w, j], which can occur without C, but when the C is filled, only [w] can be used. The V position can be filled by any V. For the X position, Cantonese is among the most conservative dialects, which has kept a full set of nasals and a full set of unreleased stops. In contrast, Shanghai is among the most advanced dialects, which only allows a glottal stop or a nasal; in addition, these two sounds often combine with the preceding vowel to form a single sound, a glottalized V or a nasalized V.

The VX portion can be called the rime, since it is the basis for riming in poems (Chao 1923). Syllables with the same VX can rime with each other; otherwise they typically do not. For example, [jaŋ] ‘lamb’ and [waŋ] ‘king’ rime with each other.

Let us now consider the structure of CGVX, where there is some disagreement on the affiliation of G. Four proposals are shown in (3).

(3) Proposals for the structure of CGVX

a. [C [GVX]] Xu (1980: 80)

b. [C [G [VX]] Cheng (1966: 136)

c. [[CG][VX]] Bao *et al*. (1997: 87)

d. [C^G[VX]] Duanmu (1990 and 2007), Ao (1992 and 1993)

In (3a) GVX form a flat structure. Since VX is the basis for riming to the exclusion of G (Chao 1923), (3a) does not seem optimal. (3b) and (3c) recognize VX as a unit but differ in the affiliation of G. In (3b) G is affiliated with VX, whereas in (3c) G is affiliated with C. In (3d), the maximal Chinese syllable has just three positions. The initial C can be a complex sound C^G, which is a consonant with a glide as secondary articulation (see Hirst 1985 for a similar proposal for English). Let us call (3d) the CVX analysis; its representation of some syllables in Beijing is shown in (4).

(4) The CVX analysis of the maximal syllable in Beijing

[k^{hw}ai]	[t^{hj}an]	[k^{w}aŋ]	[k^{w}a:]	[ts^{w}an]
‘fast’	‘day’	‘light’	‘melon’	‘diamond’

Arguments for various proposals have been drawn from a range of evidence, such as phonemic economy, cooccurrence restrictions, language games, and phonetic measurements.

With slightly different assumptions, most of the proposals can account for all the evidence (for a review, see Duanmu 1990 and 2007). Since there is no compelling evidence for the more complicated proposals, I shall use the CVX representation.

Rimes that exceed VX have been reported. Let us call them superheavy rimes. Some examples are shown in (5).

(5)	Beijing	[tuːei]	'correct'
	Cantonese	[saːm]	'shirt' (vs. [sam] 'heart')

In the Beijing example, [u] is a full vowel (and long); therefore the rime seems to be [uːei]. In the Cantonese example, the rime is VVC, if a long vowel takes two positions. However, such rimes are found in restricted environments. For example, in Beijing, 'correct' is usually [t^wei]. When uttered in isolation, the syllable can be lengthened to [tuːei], which sounds like two syllables [tuː][ei], each still within CGVX. Similarly, in Cantonese, the vowel length contrast can be attributed to vowel quality. For example, Huang (1970) represents the [saːm]-[sam] contrast in Cantonese as [sam]-[sʌm] instead.

Another case of superheavy rimes is reported in Fuzhou. According to Feng (1996), Fuzhou has six superheavy rimes in nonfinal positions, shown in (6).

(6) Superheavy rimes in Fuzhou

[pɛiŋ]	[pouŋ]	[pøyŋ]	[pɛiʔ]	[pouʔ]	[pøyʔ]
'class'	'help'	'hut'	'eight'	'broad'	'north'

However, Fuzhou only has two consonant codas, either [ŋ] or [ʔ]. Therefore, one could analyze the superheavy rimes as [ɛ̃ĩ, õũ, øỹ, εiʔ, ouʔ, øyʔ], where [ɛ̃ĩ, õũ, øỹ] are nasalized diphthongs and [εiʔ, ouʔ, øyʔ] are glottalized diphthongs, none of which exceeds VX.

4. The minimal syllable in Chinese

Many Chinese syllables are smaller than CGVX. For example, in Beijing the aspect marker *le* is CV [lə]. What is less obvious is whether a syllable can be smaller than CV.

There are two controversial issues involved. One is whether every syllable must have an onset. If it does (e.g. Blevins 1995), then the first syllable in *around* is CV [ʔə], where a glottal stop fills the required onset. If an onset is not required, then the first syllable in *around* is V [ə]. There is some evidence that the onset is not required. For example, in *get around*, the second word does not start with [ʔə] but [ə], which means that V can be a syllable by itself.

The second issue is whether every syllable must have a vowel. If every syllable does, then the second rime in *prism* is VC [əm]. If not every syllable does, then the second rime in *prism* is a syllabic C [m̩].

In Chinese, most syllables have an onset. For example, in Standard Chinese (Duanmu 2007), there are 404 syllables (ignoring tones, interjections, and dialectal loans), and only 14 of them lack an onset, or 3%. Most onsetless syllables are content words whose rimes are VX. The only onsetless syllable whose rime is V is an interjection [a], as in [tʰa: a] ‘him!’

In summary, Chinese has CV syllables. Occasionally, V syllables are also found, as well as some C syllables, to be discussed next.

5. Syllabic C

In a word like *prism*, it is hard to determine whether there is a vowel between [z] and [m]. Therefore, people who believe that every syllable must have a vowel (e.g. Luo and Wang 1957; Cheung 1986; Coleman 2001) can insist that the second rime is [əm].

In Chinese, there are syllables that are clearly made of a syllabic consonant only, without a vowel. Some examples are shown in (7), where length is not indicated.

(7) Syllabic consonants

Shanghai	[n]	'fish'
Cantonese	[m]	'not'

Such syllables are lexical words and cannot be dismissed as marginal interjections. In addition, they are pronounced without opening the mouth and therefore it is hard to claim that they contain a vowel.

Nevertheless, linguists who believe that every syllable must have a vowel have claimed that those in (7) have a 'hidden vowel'. For example, Cheung (1986: 150) proposes that [m] 'not' in Cantonese is underlyingly [mi:m], where the hidden vowel [i:] is not pronounced. Such proposals are counter-intuitive, lack phonetic predictions, and are hard to justify.

If syllabic consonants are accepted for cases like those in (7), we might as well accept them elsewhere. For example, we can accept syllabic [m] in English, as in *prism* [prɪzm̩]. Similarly, we can accept [z] and [z̩] in Beijing. Consider the examples in (8). The transcription is

based on several analyses, such as Dong (1958: 37), Chao (1968: 24), Ramsey (1987), Wiese (1997), and Duanmu (2007).

(8) Syllabic [z] and [ʐ̩] in Beijing

[z]:	tsz	tsʰz	sz	
	'self'	'time'	'four'	
[ʐ̩]:	ʈʂʐ̩	ʈʂʰʐ̩	ʂʐ̩	ʐʐ̩
	'paper'	'tooth'	'history'	'sun'

For those who do not accept syllabic consonants, the rimes in the above words are not [z] and [ʐ̩] but two special 'apical vowels' (Karlgren 1915-1926; Zee and Lee 2007). Interestingly, Lee and Zee (2003) seem to alternate between the terms 'syllabic consonant' and 'apical vowels'. Similarly, Ao (1993: 59) uses 'fricative vowels' to refer to such sounds in Nantong Chinese, although he transcribes them as syllabic fricatives, such as [z̩] and [β̩].

6. Heavy and light syllables

Chinese syllables can be divided into two kinds, full (or heavy) and weak (or light). They differ in rime duration, rime reduction, the ability to carry (or hold on to) a lexical tone, and whether they can be stressed. This is shown in (9).

(9) Properties of full (heavy) and weak (light) syllables

	Duration	Reduction	Lexical tone	Stress
Full (heavy)	Long	No	Yes	Yes
Weak (light)	Short	Yes	No	No

It is well known that full syllables carry a lexical tone while weak syllables do not. In addition, it is well known that full syllables can be stressed while weak syllables cannot (unless they revert to full syllables). Native judgment on the stress difference between full and weak syllables is quite clear and is consistently reported (e.g. Chao 1968: 38; Wang and Feng 2006). Phonetically, it has been found that the rime of a full syllable is twice as long as that of a weak syllable in Beijing (Woo 1969; Lin and Yan 1980 and 1988) and in Shanghai (Zhu 1995). In addition, a weak syllable undergoes rime reduction, so that a long vowel is shortened and is often reduced towards a schwa, and the coda is often deleted. Some examples in Beijing are shown in (10), where HL, H, and MH indicate lexical tones.

(10)

Stressed	Unstressed	Example
[kɤ:]-HL	[kə]	a classifier, as in [ʈʂei.kə] ‘this (one)’
[ma:]-H	[mə]	a question marker, as in [t^{w}ei.mə] ‘right?’
[faŋ]-H	[fə̃]	[ti:.fə̃] ‘land-direction (place)’
[t^{h}ou]-MH	[t^{h}o]	[mu:.t^{h}o] ‘wood-head (wood)’
[tai]-HL	[te]	[nau.te] ‘head-bag (head)’

The presence or absence of an onset has no effect on whether a syllable is full or weak. Some examples of full syllables in Beijing are shown in (11), where tones are omitted.

(11) Some full syllables in Beijing

[n^{j}au]	[wa:]	[mau]	[ai]	[ɤ:]	[m:]
'bird'	'frog'	'cat'	'love'	'goose'	'yes?'

Phonologically, the rime of a full syllable can be represented as VX, which has two positions, and that of a weak syllable can be represented as V (or sometimes a syllabic C), which has one position. In metrical terms, syllables with VX rimes are called heavy syllables and those whose rime is V are called light syllables.

There is a lack of studies on the phonetic differences between heavy and light syllables in other Chinese dialects. My own sense is that a similar contrast exists between them, too. VX rimes that end in [p, t, k] (as found in Cantonese) may sound shorter than those that end in a sonorant. However, if we include the closure duration of [p, t, k] codas, then all VX rimes should have comparable durations.

7. Stress, the Weight-Stress Principle, and tone

The difference between heavy and light syllables can be explained in standard phonological theory. First, a VX rime has two positions and so can be filled by VV (a long vowel or a diphthong) or VC. In addition, since VX has two positions, it is expected to be long. In contrast, a V rime has one position and can only hold a short vowel (or syllabic C). In addition, a V rime is expected to be half as long as a VX rime.

The stress difference between heavy and light rimes can also be explained by a well-known principle, known as the Weight-Stress Principle (WSP), stated in (12).

(12) The Weight-Stress Principle (WSP):

A syllable is stressed if and only if it is heavy.

This definition is based on Duanmu (2008: 58). There are other definitions, too. For example, Prokosch (1939) proposes that stressed syllables must be heavy but heavy syllables need not be unstressed. Hayes (1980) proposes that some languages may choose the WSP but others may not. Prince (1990) offers a definition, known as the Weight-to-Stress Principle, which requires heavy syllables to be stressed but allows light syllables to be stressed, too.

The WSP is related to other phonological requirements. For example, a heavy syllable has two moras and a light syllable has one (Hayes 1995). If a foot is binary (Prince 1980; Kager 1989) and if a language counts moras, then each heavy syllable forms a moraic foot. In addition, stress is metrically defined as the head of a foot and every foot has a head (Halle and Vergnaud 1987). Therefore, every heavy syllable has stress.

However, the WSP says more than the moraic foot. For example, according to Kager (1992), there are two possible moraic feet, shown in (13), where M is a stressed mora, m an unstressed mora, and a dot a syllable boundary.

(13) Moraic feet (Kager 1992)

	Description	Comment
(Mm)	a heavy syllable	satisfies the WSP
(M.m)	two light syllables	violates the WSP

While (Mm) satisfies the WSP, (M.m) violates it. In Chinese, (M.m) is not found, since a light syllable cannot be stressed. Therefore, it is insufficient to assume moraic feet in Chinese. Instead, we still need the WSP as defined above.

Can a light syllable be stressed in English (or other languages)? The answer depends on what kind of syllabification one assumes. If one assumes Max Onset without resyllabification (e.g. Halle and Vergnaud 1987), then a word like *lemma* is [lɛ][mə], where the first syllable is stressed and light. However, if one assumes that a stressed lax vowel must be followed by C in its syllable (Fudge 1969; Hoard 1971; Bailey 1978), then *lemma* is [lɛm][ə], where the first syllable is stressed and heavy and no stressed syllable is light, in agreement with the present definition of the WSP.

To account for the fact that light syllables do not carry a lexical tone, we need another principle, called the Tone-Stress Principle in Duanmu (2007), shown in (14).

(14) The 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.

The effect of the Tone-Stress Principle has been observed in other language, such as Tonga (Goldsmith 1984) and English (Liberman 1975; Pierrehumbert 1980; Goldsmith 1981), where tones or pitch accents are assigned to (or aligned with) stressed syllables and not to unstressed ones.

In Beijing Chinese, an unstressed syllable is usually a function word or the second syllable of some disyllabic expressions. In contrast, in Shanghai Chinese, unstressed syllables occur far more frequently. For example, the second syllable of every disyllabic noun, compound, or other nominal is unstressed. Some examples are shown in (15). The analysis is based on Duanmu (1999), where H is a high tone, L is a low tone, 0 indicates lack of tone (realized as H after L and L after H), and a hyphen between tones indicates a syllable boundary.

(15) Disyllabic compounds in Shanghai Chinese

Weight	heavy-heavy →	heavy-light	
Phoneme	[se: pe:]	[se: pe]	'three cups'
Tone	H-H	H-0	

Weight	heavy-heavy →	heavy-light	
Phoneme	[se: bø:]	[se: pø]	'three plates'
Tone	H-L	H-0	

Weight	heavy-heavy →	heavy-light	
Phoneme	[sz: pe:]	[sz: pe]	'four cups'
Tone	L-H	L-0	

Weight	heavy-heavy →	heavy-light	
Phoneme	[sz: bø:]	[sz: pø]	‘four plates’
Tone	L-L	L-0	

Shanghai (and many other dialects in the Wu family) only has conditionally heavy syllables, whose rimes are all V (or a syllabic C). These syllables are long in strong positions and short in weak positions. Phonetic studies confirm that in a disyllabic word or compound the rime of the second syllable is half as long as that of the first (Zhu 1995). Because of the Tone-Stress Principle, Shanghai has extensive tone deletion. For example, the second syllable of every disyllabic compound will lose its lexical tone. It is interesting to ask what determines domains of tone deletion in Shanghai, to which we return below.

8. Judgment of stress

In Chinese, the stress difference between a heavy syllable and a light syllable is quite clear and is consistently reported (e.g. Chao 1968: 38; Wang and Feng 2006). However, intuitive agreement on the stress difference between two heavy syllables, such as [jou dəŋ] ‘oil lamp’ in Beijing, is hard to obtain (e.g. Chao 1968; Shi 2004; Wang and Feng 2006). In contrast, most English speakers agree that in expressions like *oil lamp*, *pancake*, *blackboard*, and *gold watch*, the first syllable has more stress, whereas in *sardine*, *bamboo*, and *typhoon*, the second syllable has more stress. The difference between the two languages requires an explanation.

Duanmu (2007) offers an explanation based on a well-known phonetic study by Fry (1958). According to Fry, there are several phonetic cues for stress: duration, F0, intensity, and

vowel reduction (the last being often mentioned in the literature but not examined in his study). If we compare Chinese with English, then we realize a major difference between them: every heavy syllable has a lexical tone (or pitch accent) in Chinese but not in English. Bearing this in mind, let us consider why in a heavy-light disyllable, stress judgment is clear in both languages, but in a heavy-heavy disyllable, stress judgment is usually clear in English but unclear in Chinese. The heavy-light case is shown in (16).

(16) A heavy-light disyllable in English (e.g. *panda*) and Chinese (e.g. [ma:mə] ‘mother’)

	Heavy	Light
Duration	long	short
Tone	yes	no
Intensity	high	low
Reduction	no	yes

In both languages, a heavy syllable differs from a light one in all cues. Therefore, their difference is easy to perceive. Next consider a heavy-heavy disyllable in English, shown in (17).

(17) A heavy-heavy disyllabic compound in English (e.g. *oil lamp*)

	Heavy	Heavy
Duration	long	long
Tone	yes	no
Intensity	high	high
Reduction	no	no

While the first syllable has a pitch accent, often realized as a high tone, the second does not (Liberman 1975; Pierrehumbert 1980; Goldsmith 1981). Therefore, the difference between the syllables is still easy to perceive. Finally, let us consider a heavy-heavy disyllable in Chinese, shown in (18).

(18) A heavy-heavy disyllabic compound in Chinese (e.g. [jou dəŋ] ‘oil lamp’)

	Heavy	Heavy
Duration	long	long
Tone	yes	yes
Intensity	high	high
Reduction	no	no

Since every heavy syllable in Chinese has a lexical tone, both syllables have tone and all cues are now identical. Naturally, the stress difference between them becomes subtle.

In fact, main stress is not always clear in English either. For example, in a disyllabic [A N] phrase, such as *Red Cross* and *real deal*, stress judgment is inconsistent. Some linguists consider the stress pattern to be 2-1 (Chomsky and Halle 1968), where the first syllable has secondary stress; other linguists consider the stress pattern to be 1-1, where the two syllables have equal stress (Kenyon and Knott 1944; Gussenhoven 1991). The analysis is shown in (19).

(19) A heavy-heavy disyllabic [A N] phrase in English (e.g. *real deal*)

	Heavy	Heavy
Duration	long	long
Tone	yes	yes
Intensity	high	high
Reduction	no	no

In this case, both syllables have a pitch accent, and the syllables are similar in all cues for stress. Hence, the stress difference between them becomes less obvious.

A subtle difference does not mean no difference though. Phonetic studies have shown that heavy syllables in Chinese can differ in pitch range, duration, and intensity (Shen 1985; Lin et al. 1984; Shi 2004), though not as much as the difference between a heavy syllable and a light syllable. Native linguists have also reported fine judgments on stress differences between heavy syllables in Beijing Chinese (e.g. Chao 1968; Xu 1982; Hoa 1983; Wang and Feng 2006), to be discussed next.

9. Word stress

Word stress can differ among Chinese dialects. For example, in Chengdu (Qin 2009) and Shanghai (Zhu 1995), word stress falls on the first syllable in a disyllabic word or compound. In contrast, in Fuzhou (Wright 1983) and Beijing (Chao 1968; Xu 1982; Hoa 1983; Wang and Feng 2006), word stress usually falls on the second syllable in a disyllabic word or compound.

Let us take a closer look at Beijing, where different patterns of word stress can be found. Consider the data in (20), based on proposals by a number of linguists (Wang and Feng 2006 and

references therein), where 1 represents primary stress, 2 represents secondary stress, 0 represents lack of stress or lexical tone, and T indicates a lexical tone.

(20) Stress in disyllabic words/compounds in Beijing

Stress	Tone	Example	
2-1	T-T	[ta: ji:]	'big idea (abstract)'
1-0	T-0	[ta: ji]	'big idea (careless)'
1-2	T-T	[kuŋ ʈʂʰəŋ]	'work project'
0-1	(not found)		

The first two compounds are made of the same morphemes. They differ in stress and the consequent tone loss and rime reduction in 1-0. Among the three stress patterns, 2-1 is by far the most common and makes up over 70% of all in type count (Xu 1982). In addition, according to Shi (2004), many expressions that used to be 1-0 and 1-2 are now shifting to 2-1.

It is important to note, though, that 2-1 is used only in final position. In nonfinal positions, 2-1 reverts to 1-2, a property observed by previous linguists (e.g. Chao 1968; Hoa 1983). In other words, in nonfinal positions there is no 2-1, but 1-2 and 1-0 only. Consider the examples in (21), transcribed in Pinyin.

(21) Position-sensitive stress in Beijing

	Stress	Gloss
daxue	2-1	‘university’
daxue sheng	1-2 1	‘university student’
daxue jiaoshi	1-2 2-1	‘university teacher’
jiaoshi jie	1-2 1	‘Teacher’s Day’
jiaoshi shitang	1-2 2-1	‘teacher’s cafeteria’

The word ‘university’ is 2-1 in final position but 1-2 otherwise. Similarly, ‘teacher’ is 2-1 in final position and 1-2 otherwise. The stress shift in Chinese is a puzzle. In English, there is a similar case known as the Rhythm Rule, where 2-1 shifts to 1-2 when the next word starts with stress. For example, *thirteen* is 2-1 by itself but 1-2 in *thirteen men*. The English alternation is attributed to stress clash (Liberman and Prince 1977), but the Chinese case that cannot be explained this way. For example, if the underlying stress pattern is 2-1 for a disyllabic word in Chinese, then the underlying stress pattern of a two-word expression is 2-1 2-1, where there is no stress clash and no reason for the first word to change to 1-2.

Recall though that in some Chinese dialects all disyllabic words are 1-2 or 1-0. It is possible, therefore, that in all Chinese dialects disyllabic words are always 1-2 (or 1-0) underlyingly, except that in some dialects 1-2 changes to 2-1 in pre-pause position.

10. The disyllabic requirement

It is suggested earlier that Chinese counts moras, whereby every heavy syllable forms a moraic foot. Chinese also has a requirement for a minimal expression to have two syllables. The

requirement is quite well known and holds for all Chinese dialects. Some examples are shown in (22)-(25), transcribed in Pinyin. In (22)–(24) we see that, if a name is monosyllabic, a semantically redundant syllable (‘old’, ‘little’, ‘city’, ‘country’, etc.) is added. In (25) we see words in which a semantically empty morpheme is used (in parentheses in the gloss).

(22) Personal address

Lao Zhang	Xiao Zhang	*Zhang
‘Old Zhang’	‘Little Zhang’	‘Zhang’

(23) City names

Wuxi	Shanghai	Sha Shi	*Sha
‘Wuxi’	‘Shanghai’	‘Sha City’	‘Sha’

(24) Country names

Riben	Helan	Fa Guo	*Fa
‘Japan’	‘Holland’	‘France Country’	France

(25) Empty morphemes

lao hu	lao shu	zhuo zi	mu tou
‘(old) tiger’	‘(old) rat’	‘table (son)’	‘wood (head)’

Monosyllabic expressions can be found occasionally, such as [wei] ‘hello’ and [xau] ‘good’. In such cases the monosyllable is lengthened and can be seen as a disyllabic foot whose second syllable is empty (a pause).

The disyllabic requirement raises a theoretical problem. In prosodic morphology (McCarthy and Prince 1986 and 1990), a minimal word is a foot. If a heavy syllable is already a moraic foot, why does a minimal word need two syllables? In addition, it is commonly assumed that a language can use either moraic feet or syllabic feet, but not both (McCarthy and Prince 1986; Halle & Vergnaud 1987; Kager 1992). If so, what is the nature of the disyllabic unit in Chinese? Let us consider some possibilities.

First, one might suggest that there are two notions of feet: morphological feet and metrical feet, just as there are two notions of words: morphological words and phonological words. The metrical foot in Chinese is a moraic foot. A minimal word is a morphological foot. This proposal has two shortcomings. First, it creates theoretical redundancy. Second, it can be shown that the disyllabic foot in Chinese has metrical properties, too.

Chen (2000) proposed that the disyllabic unit in Chinese is a new prosodic entity, which he calls the ‘minimal rhythmic unit’ (MRU). If the MRU is similar to a morphological foot (in contrast to a metrical foot), the proposal faces the same problems just mentioned. If the MRU is unique to Chinese, its nature remains to be explained.

A third possibility is offered by Duanmu (1999), according to which Chinese counts both moras and syllables (and so does English). A heavy syllable forms a moraic trochee, as discussed earlier. A minimal word requires a syllabic trochee. The structure of a minimal word is shown in (26), where s is a syllable, m is a mora, and uppercase indicates the head of a foot. Since the unit contains two levels of trochees, it is called the dual-trochee (Duanmu 1999; Kim 2000).

(26) The dual-trochee (a minimal word)

a. Good structures

(S s)	(S s)	syllabic foot
(Mm).(Mm)	(Mm).m	moraic foot
heavy-heavy	heavy-light	syllable pattern
1-2	1-0	stress pattern

b. Bad structures

(S s)	(S s)	syllabic foot
(M).(Mm)	(M).m	(M) violates the WSP
light-heavy	light-light	syllable pattern
1-2	1-0	stress pattern

A minimal word can be heavy-heavy or heavy-light, but not light-heavy or light-light. This is because stress falls on the first syllable of a syllabic trochee and the WSP requires a stressed syllable to be heavy.

Monosyllabic expression, such as [wei] ‘hello’ and [xau] ‘good’ in Beijing Chinese, can be represented as a dual trochee, too, shown in (27), where 0 is an empty mora or syllable, physically realized as a pause or the lengthening of the syllable to its left. Structurally, a heavy-zero foot is similar to a heavy-light foot.

(27) Analysis of a monosyllabic word (e.g. [xau] ‘good’ in Beijing)

(S s)
(Mm).0
heavy-zero

Similarly, disyllabic words whose stress pattern is 2-1, such as *daxue* ‘university’ and *sushe* ‘dorm’ in Beijing, can be analyzed in (28), where the second syllable again forms a syllabic trochee with an empty syllable.

(28) Analysis of a disyllabic word with final stress (e.g. *daxue* ‘university’)

```
      (S    s)
(Mm).(Mm).0
```

heavy-heavy-zero

However, the analysis of (28) raises a question: If the second syllable can form a syllabic trochee with an empty syllable, why is the first syllable needed? In other words, why is (28) the most common minimal expression in Beijing, rather than (27)?

Recall though that all disyllabic 2-1 units revert to 1-2 when they occur in nonfinal positions. In addition, in some Chinese dialects all disyllabic words and compounds are 1-2 or 1-0. It is possible, therefore, that a heavy-heavy Chinese word is always 1-2 underlyingly, as suggested earlier. In some dialects, such as Beijing, 1-2 stays unchanged in nonfinal positions but changes to 2-1 in final position. This is shown in (29).

(29) Analysis of a heavy-heavy word in Beijing (e.g. *daxue* ‘university’)

Underlying and nonfinal	In final position
`(S  s )`	`(S  s)`
`(Mm).(Mm)`	`(Mm).(Mm).0`
heavy-heavy	heavy-heavy-zero
1-2	2-1

In this analysis, Chinese requires a minimal expression to be a syllabic foot (1-2 or 1-0), which in some dialects can change to 2-1 in final position.

11. Phrasal stress and the Information-Stress Principle (ISP)

We use phrasal stress to refer to stress assignment above the word level. This includes stress in compounds and phrases, in particular [N N] compounds and [V O] (verb-object) phrases.

Chomsky and Halle (1968) propose two rules for phrasal stress in English, re-phrased in (30), where A and B are the immediate constituents of a compound or phrase.

(30) Phrasal stress rules in English (Chomsky and Halle 1968)

a. Compound Stress Rule: In a compound [A B], assign stress to A (unless B is a compound itself, in which case assign stress to B).

b. Nuclear Stress Rule: In [A B], assign stress to B.

Two questions arise. First, do these rules apply to Chinese? Second, is there a connection between the rules? Let us consider the questions in turn.

Because stress judgment in Chinese is often subtle, there is no consensus on patterns of phrasal stress in Chinese. On the other hand, there are certain patterns that seem to reflect phrasal stress. Let us consider two of them: word length preferences and domains of tone deletion.

Most words in Chinese can be long or short but not all length combinations are equally preferred. The general patterns are shown in (31) and (32) and native judgment is quite robust.

(31) Word length preferences in [N N]: 1+2 is disfavored

2+2	meitan	shangdian	
2+1	meitan	dian	
*1+2	mei	shangdian	
1+1	mei	dian	
	coal	store	‘coal store’

(32) Word length preferences in [V O]: 2+1 is disfavored

2+2	zhongzhi	dasuan	
*2+1	zhongzhi	suan	
1+2	zhong	dasuan	
1+1	zhong	suan	
	plant	garlic	'plant garlic'

A corpus-based study shows that true exceptions are below 1% in either token count or type count (Duanmu 2012). The patterns can be analyzed if (i) a disyllabic word has initial stress underlyingly, as suggested above, and (ii) phrasal stress is assigned to the left in [N N] and to the right in [V O], similar to the case in English. This is shown in (33), where syllables with phrasal stress are underlined.

(33)

Analysis of [N N]		Analysis of [V O]	
2+2	(<u>S</u>S)(SS)	2+2	(SS)(<u>S</u>S)
2+1	(<u>S</u>S)S	*2+1	*(SS)(<u>S</u>)
*1+2	*(<u>S</u>)(SS)	1+2	S(<u>S</u>S)
1+1	(<u>S</u>S)	1+1	(<u>S</u>S)

Consider [N N] first. In 2+2, each word forms a binary foot. In 1+1, the two words can form one binary foot. In 2+1, the first word forms a binary foot; the second word need not form a foot, since it does not have phrasal stress. In 1+2, the second word forms a binary foot; the first word has phrasal stress and must also form a foot, creating a monosyllabic foot, which is ill formed. Next consider [V O]. In 2+2, each word forms a binary foot. In 1+1, the two words can

form one binary foot and serve as a compound, where phrasal stress goes to the left. In 1+2, the second word forms a binary foot; the first word need not form a foot, since it does not have phrasal stress. In 2+1, the first word forms a binary foot; the second word has phrasal stress and must also form a foot, creating a monosyllabic foot, which is ill formed.

Let us now consider domains of tone deletion in Shanghai (Duanmu 1993, 1999, and references therein). The general patterns are shown in (34)-(36), transcribed in Pinyin, where S is a syllable that is heavy and retain its underlying tone and S is a syllable that is light and loses its underlying tone. Phrasal stress is indicated by boldface.

(34) Polysyllabic names in Shanghai (heavy syllables underlined)

SS	Helan	'Holland'
SSS	Zhijiage	'Chicago'
SSSS	Maoliqiusi	'Mauritius'
SSSSS	Jialifoniya	'California'

(35) Compounds in Shanghai (heavy syllables underlined)

Length	Pattern	Example	
1+1	**S**+S	hei-yu	'black-fish'
1+2	**S**+SS	yu gutou	'fish bone'
1+5	**S**+SSSSS	nan Jialifoniya	'Southern California'
2+1	**S**S+S or SS+S	hei-yu tou	'black-fish head'
2+2	**S**S+SS	shucai shangdian	'vegetable store'

(36) [V O] phrases in Shanghai (heavy syllables underlined)

Length	Pattern	Example	
1+1	S+**S**	chao fan	'(to) fry rice'
1+2	S+**S**S	chao jidan	'(to) fry eggs'
2+2	SS+**S**S	shougou shucai	'(to) purchase vegetable'

Three generalizations can be observed. First, syllabic trochees are used, as seen in polysyllabic words. Second, phrasal stress is assigned to the left in compounds and to the right in [V O], similar to the case in English and Beijing. Third, phrasal stress cannot be followed by a stressed syllable, as seen in compounds.

The examples in word length preferences and tone deletion domains show that stress plays a central role in Chinese, even though phonetic stress is not always obvious to native intuition. Let us now consider the connection between the two phrasal stress rules. It can be seen that the constituent that receives phrasal stress is usually the syntactic non-head, or an XP in X-bar syntax (Chomsky 1970; Jackendoff 1977). The constituent that does not receive phrasal stress is the syntactic head, or an X^0 in X-bar syntax. Given this observation, various proposals have been made to unify the rules. Some are listed in (37).

(37) Unified phrasal stress rule:

Duanmu (1990): Stress the syntactic non-head.

Cinque (1993): Stress the constituent that branches deeper.

Zubizarreta and Vergnaud (2000): Stress XP but de-accent anaphoric materials.

Truckenbrodt (2005): Stress XP that is not contextually given.

The consensus is that a syntactic non-head, or XP, should be stressed, unless it carries old information, in which case it is not stressed (although some degree of language variation has been reported, e.g. by Vallduví 1991, Ladd 1996, and Cruttenden 2006). But several questions remain. First, why should XP have more stress than X^0? Second, what is the relation between stressing XP and not stressing words with old information? Finally, it has been independently noted that stress reduction occurs more often in frequent words than in infrequent words. For example, Fidelholtz (1975) offers the examples in (38), where sounds of interest are underlined.

(38) Word frequency and stress reduction

Frequent:	*information* [ɚ]	*astronomy* [ə]
Infrequent:	*importation* [oɚ]	*gastronomy* [æ]

A solution to the problems has been proposed by Duanmu (2007) that relies on the Information-Stress Principle, given in (39).

(39) The Information-Stress Principle (ISP, Duanmu 2007):

Words with more information are spoken with more stress.

The ISP explains why words with old information are not stressed. To answer other questions, let us first consider how the amount of information is determined. According to Information Theory (Shannon 1948), the information load of a sign depends on the probability of its occurrence. In particular, we can define information load in (40).

(40) Definition of information load

a. The more likely a word is expected, the less information load it has.

b. The more possible words there are for a given syntactic position, the less probability of occurrence each word has, and the more information load it has for that position.

The definition explains the frequency effect on stress reduction: frequent words have a higher probability of occurrence and hence lower information load. Therefore, they are more likely to be de-stressed or reduced. The definition also explains why XP has more stress than X^0. Consider the analysis in (41).

(41) Analysis of XP stress

	X^0 (head)	XP (non-head)
Level	word	phrase
Choices	limited	unlimited
Probability	high	low
Information	low	high
Stress	low	high

An X^0 is a word-level unit, which cannot be expanded. Regardless of how many choices there are, the number is limited. In contrast, an XP is a phrase-level unit, which can be expanded, and its number of choices is in principle unlimited. Therefore, an X^0 has a high probability of occurrence and a low information load. In contrast, an XP has a low probability of occurrence and a high information load. Therefore, an XP has more stress.

We have seen how phrasal stress can help account for word length preferences in Chinese, and domains of tone deletion in Shanghai. Phrasal stress can also account for other problems. For example, it offers a simple way to determine the domains of the well-known third-tone sandhi in Mandarin (Duanmu 2007: ch. 11). Similarly, phrasal stress is the key to understanding poetic rhythm in Chinese (Duanmu 2004; Duanmu 2007: ch. 12).

12. Concluding remarks

We have discussed a range of issues on syllables and stress in Chinese: the maximal and minimal sizes of syllables, their structures, whether syllables need an onset, whether syllabic consonants exist, the relation between syllable weight and stress, word stress and phrasal stress, native judgment of stress, and the effect of stress and foot structure on word length preferences and domains of tone deletion. I have argued that an understanding of the principles involved, in particular the Weight-Stress Principle, the Tone-Stress Principle, the dual-trochee structure, and the Information-Stress Principle, can help us a long way towards a better understanding of the issues.

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