STRESS IN CHINESE*

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1. Introduction

The topic of this paper raises some fundamental questions. For example, what is stress? Can stress differ in different languages or dialects? Does Chinese have stress? What evidence can we use to determine stress in a language? If Chinese has stress, what is the stress pattern?

In section 2 I discuss what stress is. In section 3 I discuss to what extent stress can differ in different languages. In section 4 I discuss stress in Chinese. I argue that Chinese has stress, even though native speakers may not feel it, and that stress is probably the same in all Chinese dialects. In section 5 I offer a comparison of stress in Chinese and English. In section 6 I offer concluding remarks.

2. What Is Stress?

In some languages stress can be felt by native speakers. For example, English speakers have no difficulty in distinguishing the verb *imPORT* from the noun *IMport*, because stress (shown in uppercase) is on the second syllable in the verb and the first syllable in the noun.

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Similarly, they can tell that in *Canada* stress is on the first syllable and in *banana* it is on the second, even though stress does not serve a contrastive purpose in these words. However, the attempt to define stress in phonetic terms, such as muscular activity, acoustic energy, or loudness, has been frustrating. Many linguists now believe that no specific phonetic correlation can be found. Instead, stress can be realized differently in different languages, or differently in different situations in the same language. In order to avoid specific physical predictions, some linguists define stress in vague terms such as 'prominence,' and some replace the term 'stress' with a more abstract term 'accent.'

With regard to the perception of stress, Fry (1958) has shown that it is primarily influenced by the contour of the fundamental frequency (F0 contour), and secondarily by duration. Amplitude is the least important for stress perception.

Despite its apparent lack of constant physical correlates, stress can be determined in many languages. Formal studies of stress, known as metrical phonology, have a history of only three decades, but there is already some common consensus. In simple terms, stress is a reflection of rhythm, and rhythm is the repetitive alternation between strong and weak beats. The minimal unit of rhythm, or foot, is one repetition of strong and weak beats. The standard representation of a foot in metrical phonology is shown in (1).

(1) `x` x = head of foot
`(x x)` x = beat, ( ) = foot boundaries

The foot in (1) consists of a pair of boundaries (according to Idsardi 1992, Halle and Idsardi 1995, only one boundary needs to be marked) and two beats. The stronger beat is called the head, marked with another x on top of it. The head of a foot is also called the stress.

Several questions arise. What phonological units can serve as beats? How many beats are there in a foot? Can the location of the head vary? How do we represent different degrees of stress? These questions will be addressed below.

3. How Does Stress Vary across Languages?

If one glances through various languages, one can see a wide range of stress patterns. For example, Hyman (1977) examined 444 languages and suggested that about 2/3 of them have stress and the rest have no stress. In the former group, stress can fall on different syllables in different languages, such as the first, the second, the antepenultimate, the penultimate, or the final. In some languages, such as Latin, Arabic, and English, stress can fall on different syllables in different words.

In metrical phonology, cross-linguistic variation in stress is attributed to the so-called 'parameters' (e.g. Halle and Vergnaud 1987, Hayes 1995). For example, one parameter is whether the beats in a language are syllables or moras (to be explained below). Another parameter is whether the head of a foot is on the left or on the right. A further parameter is whether the foot has two beats or an unlimited number of beats. Presumably, there can also be a parameter that decides whether a language has stress or not.

Upon careful examination, the stress system of a language is often much more complicated than it appears. For example, English has been subject to the most intensive study, yet some fundamental disagreements remain. For example, Halle and Vergnaud (1987) and Burzio (1994) believe that the beats in English are syllables, yet Mester (1994) believes that they

are moras. Similarly, most people believe that stress in English can fall on a light syllable (CV), yet Hammond (1997) argues that it can fall on heavy syllables (CVV or CVC) only. If we do not yet understand stress systems of well-documented languages, it is unclear how much value there is in generalizations that are based on broad surveys of poorly documented languages. Instead, more insights might be gained through in-depth studies of languages that are well-documented. This paper offers an in-depth look at stress in Chinese.

4. Stress in Chinese

I first discuss the apparent lack of phonetic stress in Chinese. Then I discuss two possible hypotheses that follow from the fact. Next I introduce evidence for stress in Chinese. Finally, I discuss the details of metrical structure in Chinese.

4.1 Lack of Phonetic Stress

It is well-known that stress in Chinese is hard to feel. Some linguists have offered rather subtle judgments on stress in Mandarin. For example, Chao (1968: 35) suggests that in a string of full syllables, the last has most stress, the first has slightly less, and the rest have still less. This is known as the 'medium-light-heavy' theory. However, as Chao (1968: 38) acknowledges, Mandarin speakers do not agree on where stress is, therefore the medium-light-heavy theory is hard to confirm.

Phonetic studies do not resolve the issue either. According to Yan and Lin (1988), when Mandarin words were read in isolation, the last syllable had the longest duration. However,

according to Wang and Wang (1993), when Mandarin words were read in a carrier sentence, the first syllable is usually longer than other syllables (by about 10%). The longer duration of the final syllable in Yan and Lin's study may be due to the final lengthening effect (Klatt 1975). The longer duration of the initial syllable in Wang and Wang's study may be due to the fact that there might be more lung pressure at the beginning of a breath group. Thus, neither study can be used as conclusive evidence for stress.

Similar difficulties remain in other dialects. For example, Selkirk and Shen (1990: 315) point out that speakers of Shanghai have no intuition for stress. Not surprisingly, stress is the least discussed area in Chinese phonology, and Hyman (1977) classifies Chinese as a language with no stress.

It should be pointed out that, as in other languages, Chinese speakers can add stress on words of interest. For example, consider the Mandarin example in (2), transcribed in Pinyin, where the four tones are indicated by the digits 1 through 4.

(2) ta1 yao4 ZU1 che1, bu2 yao4 MAI3 che1

he want RENT car, not want BUY car

'He wants to RENT a car, not to BUY a car'

The words in uppercase have contrastive stress, which is mainly realized by an expanded pitch range. Thus, while *zu1* 'rent' and *che1* 'car' both have a high tone and would otherwise be at the same pitch level, the former will be higher than the latter in (2). In what follows I will focus on expressions without contrastive stress.

There is another case where stress can be felt. In dialects like Mandarin, there is a

difference between full syllables, such as *le4* 'happy,' and weak syllables, such as the aspect marker *le* (which indicates completion). Full syllables are longer and carry tone. Weak syllables are shorter and usually do not carry tone. Intuitively, full syllables have more stress than weak syllables. However, some linguists argue that since the two kinds of syllables also differ in tone (with vs. without), there is no need to assume an additional difference in stress.

If we exclude contrastive stress and weak syllables, then it is quite true to say that native speakers can hardly feel stress in Chinese.

4.2 Two Hypotheses

The apparent lack of phonetic stress in Chinese can lead to two hypotheses. First, Chinese has no stress. Second, Chinese has stress, but phonetic cues for stress have been obscured by other factors. In particular, according to Fry (1958), F0 contour and duration are the two main perceptual cues for stress. Since Chinese is a tone language, F0 contour cannot be freely used to indicate stress. Also, since length is used to distinguish full syllables (long) and weak syllables (short), it cannot be used to indicate stress either. As a result, stress is hard to feel. It is relevant to note that, with regard to Fry's phonetic cues, every full syllable is qualified to be a stressed syllable: it is long, it has a specific F0 contour, and its amplitude is greater than that of a weak syllable.

The second hypothesis may seem counter-intuitive: If speakers do not feel stress, how can they be using it? The question derives from the assumption that we have a conscious knowledge of what we do, including the use of language. But the assumption is questionable. For example, our ears can locate the direction from which a sound comes, but we cannot really feel

how our ears do it. Similarly, how we make various sounds is far from obvious to the average person. A further example is that, while most linguists now agree that speech is made of a sequence of sounds (consonants and vowels), this knowledge is by no means intuitively obvious. Otherwise, most languages would have developed alphabetical writing a long time ago.

In summary, to assume that if we do not feel an activity then we are not involved in it is like assuming that if we do not see something then it is not there. Both assumptions are naïve. But to say that Chinese indeed has stress, we must see evidence.

4.3 Evidence for Stress

I offer four pieces of evidence for stress in Chinese: feet in poetry, a comparison of tone in Mandarin and Shanghai, the word length problem, and the word order problem.

4.3.1 Feet in Poetry

Chinese has poetry, in which syllables fall into disyllabic feet. Consider the example in (3), where feet are shown by parentheses, Ø indicates a silent beat (which can be realized as a silent beat literally, or as a lengthening of the preceding syllable, which then counts as two beats), and tones are omitted.

(3) (Zhang Lao) (San Ø), (wo wen) (ni Ø),

Zhang Lao San, I ask you

'I ask you, Zhang Lao San'

(ni de) (jia xiang) (zai na) (li Ø)?

you ’s home town at which place

‘Where is your hometown?’

The first line forms four feet, two of which contain a silent beat. The second line also forms four feet, the last of which contains a silent beat. If stress is the head of a foot, the presence of feet implies the presence of stress, even though it is not intuitively apparent.

4.3.2 Tone in Mandarin and Shanghai

In Mandarin, weak syllables are unstressed and do not carry an underlying tone. Full syllables have more stress than weak ones and usually keep their underlying tones. When a full syllable is de-stressed, it also loses its underlying tone, as exemplified in (4).

(4) chun1 tian1 → chun1 tian

spring day

‘spring’

The syllable *tian* can be read as a full syllable (with stress), in which case it carries tone 1 (a high tone). It can also be read as a weak syllable (no stress), in which case it loses its high tone. When unstressed, a syllable undergoes vowel reduction and loss of the coda (Lin and Yan 1988), which is not shown in (4).

In Shanghai non-initial syllables often lose their underlying tones. This is most obvious in polysyllabic names, which fall into disyllabic feet, as shown in (5), transcribed in Pinyin.

(5) (ye-lu)-(sa-leng) 'Jerusalem'

(jia-li)-(fu-ni)-ya 'California'

(jie-ke)-(si-luo)-(fa-ke) 'Czechoslovakia'

The foot boundaries are obvious because the initial syllable in each foot keeps its underlying tone while other syllables lose their underlying tones.

The Shanghai data can be accounted for if stress is on the left of each foot, so that stressed syllables keep their underlying tones (as full syllables in Mandarin do) and unstressed syllables lose their underlying tones (as weak syllables in Mandarin do).

However, a difference remains between the two dialects: in expressions like those in (5), all syllables keep their underlying tones in Mandarin. It turns out that the difference again lies in metrical structure, to be discussed below.

4.3.3 The Word Length Problem

Chinese has many words that can be either disyllabic or monosyllabic. Some examples are shown in (6).

(6)

Monosyllabic	Disyllabic	
suan	da-suan	'garlic'
zhong	zhong-zhi	'to plant'
mei	mei-tan	'coal'
dian	shang-dian	'store'

According to a popular view, because most Chinese words are monosyllabic, there are many homonyms. In order to avoid ambiguity, disyllabic forms are created. However, the choice between the two forms of a word is not always free. Consider the examples in (7) and (8).

(7)

	[Verb	Object]	
a.	zhong-zhi	da-suan	
b. *	zhong-zhi	suan	
c.	zhong	da-suan	
d.	zhong	suan	
	plant	garlic	'to plant garlic'

(8)

	[Modifier	Noun]	
a.	mei-tan	shang-dian	
b.	mei-tan	dian	
c. *	mei	shang-dian	
d.	mei	dian	
	coal	store	'coal store'

In general, [1 2] (disyllabic-monosyllabic) is bad for [V O] (verb-object) structures and [1 2] is bad for [M N] (Modifier-Noun) structures.

The difference between [V O] and [M N] has been a puzzle for the traditional view. But if Chinese has stress, then there is a solution. According to Lu and Duanmu (1991), the choice of word length is determined by stress, in that a word with more stress should not be shorter than a word with less stress. In [V O], O has more stress, so O should not be shorter than V. In contrast, [M N] is a compound (see Lu 1990, Dai 1992, and Duanmu 1998a), where M has more stress than N (cf. *BLACKboard* and *WEEKend* in English), so M should not be shorter than N. I will return to this issue below.

4.3.4 The Word Order Problem

The word order problem refers to the fact that sometimes a specific word order depends on the syllable count of the words involved. For example, consider (9) and (10).

(9) da-xing han-yu ci-dian
large-scale Han-language word-book
'large Chinese dictionary'

*han-yu da-xing ci-dian
Han-language large-scale word-book
'Chinese large dictionary'

(10) ?da han-yu ci-dian

large Han-language word-book

'large Chinese dictionary'

han-yu da ci-dian

Han-language large word-book

'Chinese large dictionary'

In (9), 'large' must precede 'Chinese.' In (10), it is preferred to put 'Chinese' before 'large.' The difference lies in the fact that 'large' is disyllabic in (9) and monosyllabic in (10), even though the two forms of 'large' are practically synonymous here. The word order problem has been noticed for some time, but there is no explanation in the traditional analysis. However, if Chinese has stress, there is a solution. Since the expressions in (9) and (10) are compounds in Chinese (see Lu 1990, Dai 1992, and Duanmu 1998a), and since stress is on the modifier, the first word has main stress. In addition, since a foot needs two beats, the first word should be disyllabic. When the first modifier is monosyllabic and the second disyllabic, the latter can be moved to initial position. I will return to this below.

4.4 Metrical Structure in Chinese

I have discussed several problems whose solutions remain unavailable unless we assume that Chinese has stress. I now discuss the details of the metrical structure in Chinese.

First, I assume that, as in English, stress in Chinese is sensitive to both moras and syllables. A mora is a measure of the length of a syllable rime. Each position in the rime counts as one mora. For example, the rime of [ma] is [a], which has a short vowel and no coda, therefore it has one mora. In contrast, the rimes of [maa], [mai], and [man] are [aa], [ai], and [an] respectively, each of which has two moras. A syllable with one mora is called a light syllable and a syllable with two moras is called a heavy syllable.

In Mandarin, all full syllables are heavy (see Woo 1969, Duanmu 1990, 1993). If moras are counted as beats, then every heavy syllable has two beats and forms a foot, and so every heavy syllable has stress. This explains why all full syllables can carry tone.

Chinese also counts syllables as beats, so every two syllables can form a foot. Following Duanmu (1999a) I use M-foot to refer to a bimoraic foot and S-foot to refer to a disyllabic foot. In addition, I assume that the head is always on the left in a foot, to be argued below (see Vijver 1998 for a similar view). Moreover, I assume that a foot must have two beats; this is known as the Binarity constraint in metrical literature. Finally, I assume that only heavy syllables can carry stress (see Hammond 1997 for a similar proposal for English). These assumptions predict two good S-foot types, shown in (11), where stress is always on a heavy syllable, and two bad S-foot types, shown (12), where a light syllable has stress. For typographical convenience, I use S to represent a syllable and m to represent a mora (instead of σ and μ respectively).

(11) Good S-feet

```
 x                 x
(S     S )        (S    S)     S-feet
(mm) . (mm)       (mm) .m      M-feet
 x     x           x
```

(12) Bad S-feet

```
 x                 x
(S   S )          (S  S)        S-feet
 m.(mm)            m.m          M-feet
    x
```

The S-foot is in some ways similar to the Germanic foot proposed by Dresher and Lahiri (1991), in that the head of the foot is on the left and cannot be filled by a light syllable. However, for Dresher and Lahiri the head can be filled either by a heavy syllable, or by two light syllables, or by a light syllable followed by a heavy syllable, whereas in the present analysis the head can be filled only by a heavy syllable.

The present analysis agrees with the fact that in Mandarin, both heavy-heavy and heavy-light disyllables are common, but light-heavy and light-light disyllables are not found, a point made by Lin (1994, and this volume).

Let us now consider stress in compounds and phrases. I follow Duanmu (1990), Lu and Duanmu (1991), and Cinque (1993) and assume that stress is determined by syntactic relation. Specifically, a syntactic nonhead should have more stress than a syntactic head. This is called Nonhead Stress. For the present discussion, it suffices to know that in [M N], M is the syntactic nonhead, so it has more stress than N, and that in [V O], O is the syntactic nonhead, so it has more stress than V.

Let us now consider the analysis of the problems discussed earlier. First, consider the tonal difference between Mandarin and Shanghai. As argued in Duanmu (1999a), full Mandarin syllables are heavy. However, Shanghai syllables are unspecified for weight, because Shanghai syllables do not have diphthongs or codas and there is no contrast between full and weak syllables (see also Duanmu 1990, 1993). Thus, while a polysyllabic name breaks into disyllabic

feet in both Mandarin and Shanghai, the Mandarin S-feet are heavy-heavy, whereas the Shanghai S-feet are heavy-light. This is because the Mandarin syllables are underlyingly heavy and remain so at surface. In contrast, the Shanghai syllables are unspecified for weight underlyingly, so they become heavy in stressed positions and light in unstressed positions. An example is shown in (13) and (14), transcribed in phonetic symbols (where [N] is a velar nasal and [a~] is a nasalized [a]).

(13) Mandarin

```
 x           x
(S    S   ) (S    S   )
(jee-luu)-(saa-leN)  'Jerusalem'
(mm)  (mm)  (mm)  (mm)
 x     x     x     x
```

(14) Shanghai

```
 x          x
(S    S   )(S    S   )
(jaa-lu)-(saa-la~)   'Jerusalem'
(mm)   m   (mm)   m
 x          x
```

As a result, all syllables in Mandarin keep their underlying tones, since each full syllable is an M-foot and has stress. In contrast, in Shanghai only S-foot initial syllables keep their underlying tones whereas other syllables lose them. The claim that Shanghai syllables are heavy in foot initial position and light in other positions is supported by the phonetic study of Zhu (1995), who found that the duration of a non-glottal rime is on the order of 200 ms in foot initial position but 100 ms in other positions.

Next consider the word length problem. The analysis of the four [V O] patterns are shown in (15), where V and O represent monosyllables and VV and OO represent disyllables.

(15)
```
        x            x
  x     x       x    x
 (VV) (OO)    (VV) (OØ)


   x            x
V(OO)        V(OØ)
```

[VV OO] forms two feet, so there is no problem. In [VV O], VV can form an foot and O can form an S-foot with an empty beat. However, as suggested by Burzio (1994), a foot with am empty beat is a weak foot, which is likely to lose stress to a full foot. This may explain the badness of [VV O]. In [V OO], V cannot form a foot (assuming that the empty beat is available only in final position), but OO can, so there is no problem. Finally, in [V O], O can form a foot with an empty beat, and since it is the only foot, it will not lose its stress. Thus, (15) explains why [VV O] is the worst pattern (for further differences among [VV OO], [V OO], and [V O], see Duanmu (1999b)). Next consider the analysis of [M N], shown in (16).

(16)
```
  x
  x     x       x
 (MM) (NN)    (MM)N


x
x  x           x
M(NN)        (M  N)
```

[MM NN] forms two S-feet, and there is no problem. In [MM N], MM can for an S-foot and N need not form a foot, so there is no problem (N can also form an S-foot with an empty beat, which I ignore). In [M N], neither can form an S-foot by itself, but M and N can form an S-foot together, which is good. In [M NN], NN can form an S-foot but M cannot, since it is a monosyllable. To keep the main stress on M, the foot on NN must be reanalyzed so that (M NN) forms one foot, shown in (17).

(17)
```
 x
(M NN)
```

The fact that (17) is not used for (8) suggests that reanalysis has a cost—a syntactic boundary does not match a foot boundary. However, for words that do not have flexible length, such as those in (18), (17) can be used.

(18)

da pingguo	bu shoutao
big apple	cloth glove
'big apple'	'cloth glove'

Neither *da* 'big' nor *bu* 'cloth' has a completely synonymous disyllabic form here (the disyllabic form *da-xing* 'large-scale' can be used for 'dictionary' but not for 'apple'), so [1 2] is the only choice for the expressions in (18).

Finally, let us consider the word order problem. Consider first the analysis of (9), shown in (19), where XX is the outer modifier and YY the inner one.

(19)
```
  x
  x     x
  x     x    x
[(XX)[(YY)(NN)]]
```

There are three cyclic steps (for the interpretation of cyclic steps in Optimality Theory, see Kenstowicz 1996 and Duanmu 1997b). First, each word forms an S-foot. Second, [(YY)(NN)] is analyzed, where (YY) is the syntactic nonhead and gets more stress. Third, the entire compound is analyzed, where XX is the syntactic nonhead and gets more stress. Since all feet are disyllabic, (19) is good. Next consider (10), analyzed in (20).

(20)
```
 x
 x   x
 x   x    x
[X[(YY)(NN)]]
```

On the first step, YY and NN can form an S-foot but X cannot. On the second step, (YY) gets more stress. Finally, X gets more stress. But since X is monosyllabic, it cannot form a foot, so the result is bad. To save this structure, X and YY must merge into one foot, shown in (21).

(21)
```
  x
  x      x
[(X YY)(NN)]
```

If YY is moved to the front, the metrical structure is as in (22).

(22)
```
  x
  x     x
[(YY)[(X NN)]]
```

This structure is good only if [X NN] is independently good, whose metrical structure is as in (17). Since YY is disyllabic, it can carry the main stress. The same analysis applies to alternative pairs like those in (23).

(23) Bei Sichuan Lu — Sichuan Bei Lu

'North Sichuan Road' — 'Sichuan North Road'

In addition, word order variation in [V-O N] (Verb-Object Noun) compounds, such as those in (24) and (25), can also be analyzed in the same way, as discussed in Duanmu (1997a) and Duanmu (forthcoming).

(24) sao lu ji (*lu sao ji)

sweep road machine

'Road-sweeping machine'

(25) ma-lu qing-sao ji (*qing-sao ma-lu ji)

road sweep machine

'Road-sweeping machine'

When both V and O are monosyllabic, [V O N] is the only good order, as shown in (24). But when V and O are both disyllabic, [O V N] is the only good order, as shown in (25). Without a

metrical approach, such word order variations have no explanation.

5. Comparison with in English

English stress has been intensively studied in the formal framework since Chomsky and Halle (1968), yet some fundamental disagreements still remain. For illustration, consider the words in (26).

(26) sit city banana Canada bungalow

According to Halle and Vergnaud (1987), the beats in English are syllables, and the feet are left-headed, build from the end of the word. In addition, the last syllable can be ignored (extrametrical, shown by <>). The analysis of the words are shown in (27), where syllable boundaries are indicated by a dot.

(27)

x	x	x	x	x
(S)	S(SS)	(S)<S>	(SS)<S>	(SS)<S>
sit	ba.na.na	ci.ty	Ca.na.da	bun.ga.low

This analysis has some shortcomings. First, extrametricality is not predictable; for example, it applies in *Canada* and *city* but not in *banana* or *Japan*. Second, the content of a foot is variable. It can be a light syllable (L), as in *city*, a heavy syllable (H), as in *sit*, (LL), as in *banana*, and (HL), as in *bungalow*. This is summarized in (28).

(28)

(H)	S(LL)	(L)<S>	(HL)<S>
sit	ba.na.na	ci.ty	bun.ga.low

Third, L can form a foot in a disyllabic word but not in a monosyllabic word, as shown in (29). A stressed monosyllable must be heavy.

(29)

(L)<S>	*(L)	(H)
[sI.ti] 'city'	[sI]	[sIt] 'sit'

It is unexplained why a light monosyllable cannot form a foot. Fourth, according to some dictionaries, such as Kenyon and Knott (1944), the last syllable in *bungalow* has secondary stress. If the syllable is extrametrical, it is hard to explain why it has stress (since only the head of a foot has stress).

Burzio (1994) also assumes that the beats in English are syllables. However, unlike Halle and Vergnaud, he proposes that English does not have extrametricality but has both disyllabic and trisyllabic feet. Moreover, he argues that an empty beat, or a zero syllable, can be added to the end of a word. (30) shows his analysis.

(30)

x	x	x	x	x
(HØ)	S(HL)	(HH)	(LLL)	(HLH)
sit	ba.nan.na	cit.ty	Ca.na.da	bun.ga.low

There are also some questions about Burzio's analysis. First, there are various types of feet. Second, he stipulates that the stressed syllable must be heavy in a disyllabic foot (see *city* and

banana) but can be light in a trisyllabic foot (see *Canada*). Third, since the last syllable in *bungalow* is not the head of a foot, Burzio must say that it has no stress, which goes against the judgment of some other linguists, such as Kenyon and Knott (1944).

Mester (1994) and Hayes (1995) propose that (as far as main stress is concerned) beats in English are moras. Like Halle and Vergnaud, they also assume that the last syllable can be extrametrical. Their analysis is shown in (31).

(31)

```
 x        x        x          x            x
(mm)   m(m.m)   (m)<S>    (m.m)<S>   (mm)m<S>

sit     ba.na.na   ci.ty      Ca.na.da    bun.ga.low
```

This analysis also has problems. First, extrametricality is not predictable. Second, the foot is variable; it can be L, H, or LL. Third, there is no explanation why L can be a foot in *city* but not in a monosyllable (see (29)). Fourth, there is again the question of whether the last syllable in *bungalow* has stress. If it is extrametrical, it ought not have stress, but some linguists consider it to have stress.

Hammond (1997) makes yet another proposal. Based on the distribution of lax vowels, he argues that unreduced lax vowels can occur only in a closed CVC syllable. This means that all stressed syllables are heavy. The reason is that a tense vowel is long and hence bimoraic, and a stressed lax vowel is in a CVC syllable, which is also bimoraic. If we incorporate Hammond's proposal into Halle and Vergnaud's analysis, we get (32).

(32)

```
 x       x        x         x          x
(H)    S(HL)    (H)<S>    (HL)<S>    (HL)<S>
```

sit ba.nan.na cit.ty Can.na.da bun.ga.low

This analysis has more consistent foot types—the head of a foot is always H, so it can explain why a light monosyllable cannot be a foot. On the other hand, it still has a problem explaining why the last syllable in bungalow has some stress.

It can be seen that previous analyses assume that beats in English are either moras or syllables, but not both. However, it is evident that both moras and syllables must be considered. For example, in the moraic analysis, there is a constraint known as syllable integrity, by which the two moras of a heavy syllable cannot be split into two feet. In the syllabic analysis, one must also distinguish heavy and light syllables, which is evidence that mora-count is involved. Following Duanmu (1998b), I propose that English stress involves both M-feet and S-feet. In addition, as discussed above, (HL) and (HH) are the only two good S-feet. Moreover, following Hammond (1997), I assume that all stressed syllables are heavy. Finally, I assume that there is a constraint *Lapse (Kager 1993), which allows one syllable to be without a foot but not a sequence of two. (33) shows the present analysis.

(33)

```
 x              x              x
(SS)          S(SS)          (SS)
```

sit. Ø ba.nan.na cit.ty

```
(mm).m        m.(mm).m       (mm).(mm)
 x              x              x     x
```

```
 x              x                 x
(SS)S          (SS)S             (SS)

Can.na.da      bun.ga.low        rab.bi

(mm).m.m       (mm).m.(mm)       (mm).(mm)
 x              x       x         x     x
```

There is no need to assume extrametricality. Just as there can be a free (un-footed) syllable at the beginning of a word (see *banana*), there can be one at the end (see *Canada* and *bungalow*). In addition, since the last syllable in *bungalow* is not extrametrical, it can form an M-foot, which explains why it has stress.

The present analysis raises two questions. First, it assumes that there may be a geminate consonant in words like *city* and *banana*. Second, it assumes that an empty beat can be added at the end of a word. However, as noted by Hammond (1997), there is no phonetic evidence that the predicted geminate consonants are longer than regular consonants. Hammond argues, essentially, that a phonological difference (geminate vs. non-geminate) need not be realized phonetically. An alternative answer is that not every syllable needs an onset, especially those that are not in foot initial position. Thus, words like *city* and *banana* can be analyzed in (34).

(34) cit.y ba.nan.a

For a recent argument that syllables need not have an onset, see Breen and Pensalfini (1999).

Let us now consider evidence for the empty beat. I have shown above that empty beats exist in Chinese poetry. The same is true in English, shown in (35).

(35) (Ding ø) (dong ø) (bell ø)

(Kit-ty's) (in the) (well ø)

Each line forms three feet. On the first line each foot is made of a monosyllable and an empty beat. On the second line the first two feet are each made of two overt syllables, and the third is made of a monosyllable and an empty beat. Without the empty beat, it is hard to explain how the two lines can pair together. For further argument for the empty beat, see Abercrombie (1967), Liberman (1975), Selkirk (1984), Hogg and McCully (1987), and Burzio (1994).

6. Concluding Remarks

I have argued that Chinese has a stress system, despite the fact that native speakers hardly feel stress. The stress system consists of left-headed moraic feet (M-feet) and left-headed syllabic feet (S-feet). The present proposal differs from that of Duanmu (1995), which argues that Shanghai and Taiwanese (Southern Min) have different stress systems. I have also suggested that English may have the same stress system as Chinese.

The fact that the same stress pattern is found in a language where stress is intuitively obvious (English) and in a language where it is not (Chinese), suggests the possibility that all languages have a stress system and that all stress systems are essentially the same.

REFERENCES

Abercrombie, D. 1967. *Elements of general phonetics*. Chicago: Aldine.

Breen, G., and R. Pensalfini. 1999. Arrernte: a language with no syllable onsets. *Linguistic Inquiry* 30.1: 1-25.

Burzio, L. 1994. *Principles of English stress*. Cambridge, UK: Cambridge University Press.

Chao, Y-R. 1968. *A grammar of spoken Chinese*. Berkeley, California: University of California Press.

Chomsky, N., and M. Halle. 1968. *The sound pattern of English*. N.Y.: Harper and Row.

Cinque, G. 1993. A null theory of phrase and compound stress. *Linguistic inquiry* 24.2: 239-297.

Dai, J.X.L. 1992. *Chinese morphology and its interface with the syntax*. Ph.D. dissertation, Ohio State University, Columbus.

Dresher, B.E., and A. Lahiri. 1991. The Germanic foot: metrical coherence in Old English. *Linguistic Inquiry* 22.2: 251-86.

Duanmu, S. 1990. *A formal study of syllable, tone, stress and domain in Chinese languages*. Ph.D. dissertation, MIT, Cambridge, Mass.

Duanmu, S. 1993. Rhyme length, stress, and association domains. *Journal of East Asian linguistics* 2.1: 1-44.

Duanmu, S. 1995. Metrical and tonal phonology of compounds in two Chinese dialects. *Language* 71.2: 225-259.

Duanmu, S. 1997a. Phonologically motivated word order movement: evidence from Chinese compounds. *Studies in the Linguistic Sciences* 27.1: 49-77.

Duanmu, S. 1997b. Recursive constraint evaluation in Optimality Theory: evidence from cyclic compounds in Shanghai. *Natural language & linguistc theory* 14: 465-507.

Duanmu, S. 1998a. Wordhood in Chinese. In *New approaches to Chinese word formation: morphology, phonology and the lexicon in modern and ancient Chinese*, ed. Jerome Packard, 135-196. Berlin: Mouton de Gruyter.

Duanmu, S. 1998b. *English Stress and metrical structure*. Paper presented at The Fourth Mid-Continental Workshop on Phonology, October 16-18, University of Michigan, Ann Arbor.

Duanmu, S. 1999a. Metrical Structure and Tone: evidence from Mandarin and Shanghai. *Journal of East Asian*

Linguistics 8.1: 1-38.

Duanmu, S. 1999b. Stress and the development of disyllabic vocabulary in Chinese. *Diachronica*. (In press.)

Duanmu, S. Forthcoming. *The Phonology of Standard Chinese*. Oxford University Press.

Fry, D.B. 1958. Experiments in the perception of stress. Language and Speech 1: 126-152.

Halle, M., and J.R. Vergnaud. 1987. *A essay on stress*. Cambridge, Mass.: MIT Press.

Halle, M., and W. Idsardi. 1995. General properties of stress and metrical structure. In *The handbook of phonological theory*, ed. John Goldsmith, 403-443. Cambridge, MA: Blackwell.

Hammond, M. 1997. Vowel quantity and syllabification in English. *Language* 73: 1-17.

Hayes, B. 1995. *Metrical stress theory: principles and case studies*. Chicago: University of Chicago Press.

Hogg, R, and C.B. McCully. 1987. *Metrical phonology: a coursebook*. Cambridge, UK: Cambridge University Press.

Hyman, L. 1977. On the nature of linguistic stress. In *Studies in stress and accent*, ed. L. Hyman, 37-82. Southern California Occasional Papers in Linguistics 4. Los Angeles: Department of Linguistics, University of Southern California.

Idsardi, W. 1992. *The computation of prosody*. Ph.D. dissertation, MIT, Cambridge, Mass.

Kager, R. 1993. Alternatives to the Iambic-Trochee Law. *Natural Language & Linguistic Theory* 11.3: 381-432.

Kenstowicz, M. 1996. Base identity and uniform exponence: alternatives to cyclicity. In *Current trends in phonology: models and methods*, vol. 1, ed. J. Durand and B. Laks, 363-393. European Studies Research Institute, University of Salford.

Kenyon, J.S., and T.A. Knott. 1944. *A pronouncing dictionary of American English*. Springfield, MA: Merriam.

Klatt, D.H. 1975. Vowel lengthening is syntactically determined in a connected discourse. *Journal of phonetics* 3.3:129-140.

Liberman, M. 1975. *The intonational system of English*. Ph.D. dissertation, MIT, Cambridge, Mass.

Lin, H. 1994. *Against domain-final stress in Mandarin*. Paper presented at the Sixth North American Conference on Chinese Linguistics, May, Los Angeles: University of Southern California.

Lin, M.C., and J.Z. Yan. 1988. The characteristic features of the final reduction in the neutral-tone syllable of Beijing Mandarin. *Phonetic Laboratory Annual Report of Phonetic Research*, 37-51. Beijing: Phonetic

Laboratory, Institute of Linguistics, Chinese Academy of Social Sciences.

Lu, B.F. 1990. *The structure of Chinese nominal phrases*. M.A. thesis, University of Connecticut.

Lu, B.F., and S. Duanmu. 1991. *A case study of the relation between rhythm and syntax in Chinese.* Paper presented at the Third North America Conference on Chinese Linguistics, May 3-5, Ithaca.

Mester, R. A. 1994. The quantitative trochee in Latin. *Natural Language & Linguistic Theory* 12: 1-61.

Selkirk, E. 1984. P*honology and syntax: the relation between sound and structure*, Cambridge, Massachusetts: MIT Press.

Selkirk, E. and T. Shen. 1990. Prosodic domains in Shanghai Chinese. In *The phonology-syntax connection*, ed. Sharon Inkelas and Draga Zec, 313-337. CSLI, Stanford University, Stanford, Calif. Distributed by University of Chicago Press.

Vijver, R. van de. 1998. *The iambic issue: iambs as a result of constraint interaction*. Ph.D. dissertation, Vrije Universiteit Amsterdam. Distributed by HIL Dissertations.

Wang, J., and L.J. Wang. 1993. Putonghua duo yinjie ci yinjie shi chang fenbu moshi [The types of relative lengths of syllables in polysyllabic words in Putonghua]. *Zhongguo yuwen* 1993.2 (233): 112-116.

Woo, N. 1969. *Prosody and phonology*. Ph.D. dissertation, MIT, Cambridge, Mass.

Yan, J.Z., and M. Lin. 1988. Beijinghua sanzizu zhongyin de shengxue biaoixian [Acoustic characteristics of the stress in Beijing trisyllables]. *Fanyan* 1988.3: 227-237.

Zhu, X.N. 1995. *Shanghai tonetics*. Ph.D. dissertation, Australian National University, Canberra.