Feet, tonal reduction and speech rate at the word and phrase level in Chinese

Abstract

Chinese languages group syllables into prosodic units, which I will call feet, and these feet form the domain of tone deletion and tone sandhi processes, as well as segmental lenition effects. This paper offers an OT analysis of the cross-linguistic variation in tone retention/tone deletion in non-head syllables and feet, and the variation in foot size. It is shown that the tonal facts require HEADMAX constraints that require retention of head tones. Together with the HEADDEP and HEADIDENT constraints of Alderete 1995, this completes the family of positional faithfulness constraints. In the tonal analog of Russian vowel reduction, it is shown that in Wu dialects faithfulness may be complete in head syllables, partial in head feet, and violated elsewhere. It is further shown that n-ary feet must be admitted, and this is achieved by a low ranking of FT-BIN-MAX. The final section looks closely at n-ary feet in Nantong, and compares two alternative analyses of apparent changes in prosodic structure conditioned by speech rate.

Feet, tonal reduction and speech rate at the word and phrase level in Chinese

Moira Yip

University of California, Irvine

1. Introduction The term ›foot= has been used for two distinct types of structure in Chinese. In one type, only the head syllable retains its tone, whereas in the other, all syllables retain some vestige of their lexical tone. Diagnostics for such feet include sandhi domains (Shih 1986), and clash effects (Duanmu 1995).They are produced by morpho-syntax-prosody alignment, and by rhythmic forces, such as Binarity. They are found inside words, inside compounds, and in many cases across words within a phrase. Indeed, compounds and phrases are not always readily distinguishable in Chinese. Throughout this paper I have tried to use data from words, compounds, and phrases, and I will comment on any significant differences.

The groups of syllables called feet in this paper are consistently the first prosodic grouping above the level of the syllable, hence the term ›foot=. Unlike in many other language families, prominence is not consistently realized as length, duration, or higher pitch, so identification of the head is sometimes difficult. The primary diagnostic here will be that if one and only one syllable surfaces with its citation tone unchanged, while the others either lose or change their tone, the intact syllable will be taken to be the head.

1.1 Feet in which only the head syllable bears its lexical tone The first major foot-type is one in which non-head syllables are toneless, and their surface pitch is either spread from the head syllable, acquired from a phrasal boundary tone, or inserted by default. Using o for such syllables, such feet can be denoted as (Too..) or (..ooT). Such feet may be built on underlyingly toneless syllables, which may never be heads, or on syllables that lose their tone as a consequence of their position in the foot. Shanghai has a (Tooo..) pattern. The complex tone of the first syllable is realized over the first two syllables; other syllables get a default [l] tone. Here I use Selkirk & Shen=s (1986) tone notation; actually, the inventory can be simplified to just /lh, hl/.

(1) a. taw ?iq pe ›zo mh mh hl lh (m h l) (lh) ›pour a cup of tea=
pour one cup tea

b. fi siaN poqtsiN hl mh mh hl (h l) (m h) ›fly towards Beijing= (lit)
fly towards Beijing

The syntax partially determines the structure of these units, as shown by Selkirk and Shen, but Duanmu (1995) has shown that these feet are preferentially binary, and show rhythmic clash avoidance effects.

Wenzhou (Zhengzhang 1964) is in the relevant respects an example of the mirror-image type, (..oooT). Only the tone of the final syllable matters; all else is neutralized: (p136: D4). (With certain final tones, the penult also matters; see ' 3.2.1 for details.) In the examples below, both strings end in a 45 toned syllable, preceded by a variety of other tones. The output strings have identical patterns controlled only by the final tone. The origins of the exact surface pattern will not concern us here. Using pinyin:

		Citation	*Surface*	*Gloss*
(2)	san chang liang duan	44 31 34 45	(2 4 43 34)	›3 long 2 short:
	tong hang tong zou	31 31 31 45	(2 4 43 34)	›together walk together walk:

In this section we have seen examples of feet where non-heads are toneless. Here and throughout I abstract away from the surface pitch of these toneless syllables, although I touch on the case of spreading from the head in a later section. I restrict my analysis to explaining why the *underlying* tones of non-head syllables are lost.

1.2 Feet in which all syllables carry a lexical tone or its contextual allotone. The second type of foot is also usually but not always binary. Each syllable retains its lexical tone, or an allotone of that tone. Using T for a head syllable bearing a lexical, citation tone, and t for a non-head still bearing an underlying tone or its surface allotone, such feet can be denoted as (Ttt...) or (..ttT). Evidence for grouping these syllables into one prosodic unit comes from the use of that unit as the domain of tone sandhi rules.

1.2.1 Mandarin: (Ttt..) The existence of feet in Mandarin is motivated primarily by their function as a domain for the well-known third-tone sandhi rule, which turns the first of two low 21(4) "third" tones into a high rising 35 "second" tone. Shih 1986 argues that the domain of this rule is a prosodic unit, the foot. The headedness of these feet is in dispute; traditionally they have been assumed to be right-headed, but Duanmu (1994, 1996) argues that they are left-headed. In support of this view, one might note Shih's (1989) claim that focussed elements induce a foot boundary to their left, with the consequence that they themselves head a left-headed foot. These feet are preferentially binary, but the syntax also exerts an influence. Monosyllabic feet are avoided, so strays are grouped into a ternary foot. For full details, see Shih 1986, 1989.

			Citation		*Surface*	*Gloss*
(3)	a.	wu wu wu wu	21 21 21 214	ÿ	(35 21) (35 214)	›5555'
	b.	shui leng hao	21 21 214	ÿ	(35 35 214)	›It=s better if the water is
	water cool good				cool=	
	c.	gei gou shui	21 21 214	ÿ	(35 35 214)	›Give water to dog=
		give water dog				

Within these feet, each syllable has a full lexical tone or its allotone.

<u>1.2.2 Xiamen: (..ttT)</u> The mirror-image case can be found in Xiamen (also known as Taiwanese or Amoy). Xiamen has a set of tone sandhi known as the Min tone circle by which each citation/pre-pausal/phrase-final tone changes to an allotone in non-final position. Citation tones are to the left of the arrows, non-final allotones to the right.

(4) 24 ÿ 22 ÿ 21 ÿ 53 ÿ 44
8____________________|

Chen 1987 shows that these changes take place in tonal domains which are largely defined by alignment with the syntax. For example, the subject and predicate normally form two separate domains, as in (a), whereas the VP may form a single domain, as in (b-c).

(5)			*Citation*	*Surface*	*Gloss*
	a.	teng jin sio	44 44 44 ÿ	(44)(22 44)	›The soup is very hot=
	b.	tsu san tng	53 44 21	(44 22 21)	›cook three meals=
	c.	song-tsin t=en liong	21 22 44 24	(53 21 22 24)	›have no conscience=
		lose-out conscience			

The syntactic conditioning, and the variable size, may make these seem more like phonological phrases than feet, but Hsu 1992 shows that there is a strong binary influence on these domains (at least in idioms), as expected if we are dealing with feet. Consider the following examples of four-syllabled idioms from Hsu (Chen=s tone values); in (b), the syntax alone would lead us to expect two domains, with breaks between NP and VP only. Instead, we find three domains, in obedience to a preference for maximally binary feet.

(6)	a.	[Ying-hiong]$_{NP}$ $_{VP}$[kiu bi]	44 24 21 53	(22 24)(53 53)	›A hero saves a beauty=
	b.	[Tsai]$_{NP}$ $_{VP}$[ko pat tao]	24 55 21 53	(24)(55)(53 53)	›exceedingly talented=
		Talent high eight peck			

Note that one language may have more than one ›foot= type. Chaoyang and Xiamen, for example, have both (..ttT) and (Too..) ›feet=.

In such cases, the toneless syllables are underlyingly toneless.

The following questions arise. (i) Are both the (To) and (Tt) units feet, and if so why are the tones lost in the former but not in the latter? (ii) Are both the binary and the n-ary units really feet, or should this term be reserved for the rhythmic binary units of Shih 1986, 1989, Duanmu 1995? If feet are strictly binary, what do we call the larger units? The remainder of this paper addresses each of these issues in turn. Section 2 outlines a proposal for the typology of tone loss in non-head positions in which a positionally biased MAX constraint, HEADMAX(T), enforces tonal retention in heads. In non-heads tone loss is found when tonal markedness constraints out-rank the more general MAX(T) constraint that requires retention of all input tones. Section 3 then extends this to cases of partial tone loss. First, tonal markedness must distinguish between more marked tones, which survive only in heads, and less marked tones, which survive everywhere. Second, HEADMAX constraints must distinguish between head syllables and head feet. Section 4 briefly summarizes the results of these two sections. Section 5 looks at possible n-ary feet in Nantong fast speech, and compares two very different approaches. A purely phonological account makes use of different grammars at different speeds, and requires n-ary feet. A phonology-phonetics interface account holds the grammar constant, with feet always binary, and a higher-level n-ary super-foot.

2. Tone loss in non-head positions: Tone loss = Vowel Reduction The parallels between tone loss and vowel reduction are obvious. (Note that tone loss is not comparable to vowel *loss*, because only the latter removes an entire syllable.) Among the similarities are (i) both are found in non-head position (ii) both are found in head-final systems (Muskogean and Algonquian: Hayes 1995, Wenzhou initial syllable tone) (iii) both are found in head-initial systems (Maithili, Icelandic, English: Hayes 1995, Shanghai tone) (iv) both come in two variants: total elimination of contrasts to schwa (English), or tonelessness (Shanghai), or a reduction in the number of contrasts (e.g. Italian, Russian, Catalan; Taiwan or Wenzhou medial syllable tones (see below)) (v) both may go together: Mandarin toneless syllables also show vowels that are somewhat centralized and loss of post-nuclear material (Lin and Yan 1988). Tone loss is not limited to Chinese: see Noyer 1991 on Huave, Bickmore 1995 on Bantu. Also Sietsema 1988, and many papers in Inkelas and Zec 1990, on the attraction of tones to head positions. These parallels suggest that we take a close look at treatments of vowel reduction as a starting point for our investigations.

2.1 Previous approaches to non-head change versus head-faithfulness: Dresher and van der Hulst (1995) point out that heads typically allow more phonological complexity, such as featural specification, than non-heads. They coin the term "head-dependent asymmetries" for this phenomenon. In OT, such asymmetries have been discussed by Alderete 1995 and Beckman 1995, 1996, building on ideas from Selkirk 1994. Alderete formulates faithfulness constraints that are specific to Head positions. If these outrank markedness constraints, and markedness in turn outranks the more general faithfulness constraints that apply to non-heads as well, then marked segments/features will survive in head position only. He begins by noting that heads cannot contain epenthetic material, and formulates a constraint of the DEP family specific to head position.

(7) Head (Pcat)-DEP
Every segment contained in a prosodic head PCat in S_2 has a correspondent in S_1. If PCat is a prosodic head in S_2, and PCat contains â, then â å Range (U).

Here, PCat = syllable. This will block epenthesis into heads, and thus block stressing epenthetic vowels. An extension to DEP's partner, MAX, would block deletion from heads, and thus loss of material such as codas or post-nuclear glides from stressed syllables.

The above constraints refer to entire segments, and block their insertion/deletion in heads. Alderete continues by noting that the mere presence of a correspondent is not enough: heads must also be featurally identical, whereas non-heads may undergo neutralization. He thus proposes the following:

(8) HEAD(PCat)-IDENT(F)
Correspondent segments in prosodic heads PCat agree in value for feature [F]. If PCat is a prosodic head, PCat contains â, and áUâ, then á and â agree in the value of F.

To explain retention of contrasts in heads, but their loss elsewhere, this constraint dominates featural markedness constraints. For example, if mid vowels are raised/lowered in nonheads only, HEAD-IDENT >> *MID >> IDENT.

This comes close to offering an explanation for tone. Suppose HEAD-IDENT(T) >> *T >> IDENT(T). Consider the following tableau, using *T for the entire family of tonal markedness constraints, and indices for underlying associations (cf McCarthy and Prince 1995)

(9)

_$_1$ ó$_2$ ó$_3$ | || t$_1$ t$_2$ t$_3$	HEAD-IDENT(T)	*T	IDENT(T)
_$_1$ ó$_2$ ó$_3$ | || t$_1$ t$_2$ t$_3$		***!	
L _$_1$ ó$_2$ ó$_3$ | t$_1$		*	**
_$_1$ ó$_2$ ó$_3$	*!		***

However, this works perfectly if and only if the head syllable bears all and only its underlying tone, and the non-head syllables have no tone of any kind, at the surface.[1] Unfortunately, neither of these statements is reliably true for tone, because tone is a movable feature, and cannot be relied on to stay put on its underlying host. As a result a Head-Ident account fails for tone, or other movable elements: (cf Zoll 1996 , Akinlabi 1994). The following tableau illustrates how this approach fails for a case like Shanghai, where the head syllable has two underlying tones, and the second of these moves onto the second syllable in the output.

(10)

_$_1$ ó$_2$ ó$_3$ |\ | | t$_1$ t$_1$ t$_2$ t$_3$	HEAD-IDENT(T)	*T	IDENT(T)
a. _$_1$ ó$_2$ ó$_3$ | | t$_1$ t$_1$	*	**	***!
K b. _$_1$ ó$_2$ ó$_3$ | | t$_1$ t$_2$	*	**	**

No matter what the ranking, the grammar will prefer candidate (b), with one tone of each syllable preserved, over candidate (a), in which both preserved tones originate in the head syllable and are redistributed in the output. Yet (b) is never the actual surface outcome, (a) is.

Let us recap the basic patterns to be explained. As I have already emphasized, tones do not necessarily stay in place. The following four facts must be explained: (i) If a syllable is a head, its underlying tone(s) must be preserved. (ii) If a syllable is a non-head, in many dialects its tone is lost. (iii) However, the Ahead@ tone may not all surface on the head syllable (flop, spreading). (iv) Further, non-head syllables may have surface tones, from the head, or phrasal sources, or by default. It is clear that **survival** of the tone is at stake here, suggesting an extension of Max to features, not just segments. If features can only be referred to in terms of whether their host segments are featurally identical, their mobility becomes an intractable problem. Alderete's constraints regulate faithfulness strictly with reference to **output position**. But tonal preservation/loss depends on **input position**, in that tones that belong to the output head **in the input** are preserved, and tones that belong to output non-heads **in the input** are lost. In a derivational approach this is achieved by ordering tone loss before rules that readjust tone associations, such as flop, spreading, or default insertion, but a non-derivational grammar with a commitment to a single output level such as OT cannot do this

I will develop an alternative within Optimality Theory in which tonal preservation is caused by extending the MAX family of constraints to features (cf Myers 1993, Myers and Carleton 1996, McCarthy and Prince 1995), and allowing them to be relativized to head position.

<u>2.2 The proposal</u> For tone retention in heads, we can use a constraint from the MAX-IO family (McCarthy and Prince 1995).

(11) HEAD-MAX-(F)

Every feature in S_1 associated in S_1 with a segment whose correspondent is contained in a prosodic head in S_2 has a correspondent in S_2.

The surface association of this tone will be governed by familiar constraints on tone associations, such as a preference for one-to-one association, a preference for syllables to bear tones, NO-FLOP (McCarthy 1995), and NO-SPREAD (McCarthy 1995). I will have nothing to say about these here.[2] For consistency,the general faithfulness constraint that enforces tonal retention will also be formulated as one of the MAX family, instead of one of the IDENT family. If these constraints are ranked HEADMAX(T) o*T o MAX(T) , we will correctly deal with cases of tone-loss in non-heads, and preservation of head tones. The following tableau shows how the new proposal works for the problem case where "head" tones show up on non-head syllables.

(12)

$\_{}_1$ $ó_2$ $ó_3$ |\ | | t_1 t_1 t_2 t_3	HEAD-MAX(T)	*T	MAX(T)
L a. $\_{}_1$ $ó_2$ $ó_3$ | | t_1 t_1		**	**
b. $\_{}_1$ $ó_2$ $ó_3$ | | t_1 t_2	*!	**	**

Two details remain to be explained. Recall that in actuality the syllables shown as toneless above may receive a default low tone , as in Shanghai. The grammar as given above will penalize insertion of a low tone, since this L violates *T. Suppose the grammar includes a constraint requiring syllables to bear tones, which I will refer to as *NOTONE. If we break *T up into *H and *L, and rank *NOTONE between *H and *L, then we can explain why only low tones survive/are inserted on non-head syllables: *H + *NOTONE + *L. In the remainder of the paper I will abstract away from this issue, and show candidates with toneless syllables.

Secondly, we need one addition to this grammar in order to characterize the fact that underlyingly toneless syllables may never be heads. I call this the Stress-to-Tone Principle, AHeads must bear tone@, by analogy with the Stress-to-Weight Principle, and the Weight-to-Stress Principle (WSP) of Prince 1990. Candidates which violate this will not be considered here.

2.3 Applying the Proposal

Let us see how this proposal derives the major foot types discussed in section 1. For (Tt) or (tT) feet, we need only assume that MAX(T) out-ranks the tonal markedness constraint *T. The ranking of HEADMAX(T) is irrelevant: any ranking will give the same output.

(13)

/tt/	MAX-TONE	*T
L a. Tt		**
b. To	*!	*

For (To) or (oT) feet, as we have already seen, Head-Max(T) + *T + Max(T). This is the case for which the proposal was developed, and the following tableau illustrates its workings. (Note: O stands for a stressed but toneless syllable).

(14)

/tt/	HEAD-MAX(T)	*T	MAX(T)
L a. To		*	*
b. Tt		**!	
c. Oo	*!		**
d. Ot	*!		*

A third grammar is logically possible given these three constraints under review here. Suppose *T + HEAD-MAX(T), MAX(T). Such a grammar would have no surface tones at all, so the net effect would be to produce a language that lacked tones, without any necessary commitment to toneless inputs. There are no other surface patterns produced by these three constraints.

Lastly, consider languages with both (tT) and (To) feet, such as Taiwanese. Inputs with fully-toned syllables surface as [tT], showing that the ranking is HEAD-MAX(T), MAX(T) + *T. ALIGN-R (Head, Ft) captures the right-headed nature of the language. However, /to/ inputs surface as left-headed [To], so the Stress-to-Tone principle dominates right-headedness. Lastly, tone is not *inserted* in order to allow right-headed feet, so Head-Dep(T) + Align-R(Head, Ft).

Up to this point, I have only discussed languages in which tones are retained in their entirety, or in which they are completely lost, but many languages show a sort of partial tone reduction. I will distinguish two types. In the first, all non-head syllables show loss of some but not all tones. In the second, non-head syllables do not behave as a single class, with those in some positions (typically closer to the head) showing less neutralization than others. In the next two sections I deal with these in turn.

3. Partial Tonal Reduction: Tonal Markedness, Head Syllables, and Head Feet

3.1 Partial Tonal Reduction: Type 1. In some languages hybrid feet exist, where the non-head syllables have tones that are partially neutralized and/or reduced, but not eliminated entirely. Recall that in Taiwanese tones have two allotones, one in final position, one in non-final position. Non-finally, there is in fact limited neutralization, so that /24/, /44/ merge into [22].

(15)= (4) 24 ÿ 22 ÿ 21 ÿ 53 ÿ 44
8____________________|

All non-final (i.e. non-head) syllables undergo this change.

The approach I take here is very similar to Alderete's, in that it divides the featural markedness constraints into two groups, singling out one feature as more marked than the others. Consider the 24 tone, which only appears in peak position. We must divide *T into two parts, one referring to rising tones only: *Rising, vs *T, and assume the ranking HEAD-MAX(T) + *RISING + MAX(T) + *T.

(16) (Heads are underlined)

/24 24/	HEAD-MAX(T)	*RISING
L a. 22 24		*
b. 24 24		**!
c. 24 22	*!	*
d. 22 22	*!	

In later sections we wil again need to distinguish between more and less marked tones.[3]

3.2 Partial Tone Reduction:Type 2: In this second and more interesting type, syllables closer to the head undergo partial neutralization, while syllables further away lose their tones entirely. Such words can be denoted as [..o(tT)] or [(Tt)o..]. Wenzhou and Suzhou are examples of these respectively.

3.2.1 Wenzhou: [o..o(tT)] (Zhengzhang 1964) In unchecked syllables, Wenzhou has the tonal inventory: 44, 31, 45, 34, 42, 22. In compounds and some phrases, the general pattern is that the final syllable tone determines the contour of the overall span, in non-obvious ways whose details will not concern us here. For certain final tones, such as /45/, all preceding tones are neutralized, as shown in (2) in section 1. However, the tone of the penult has some influence in the case of a subset of final tones, although all preceding tones are still completely neutralized. It is this latter pattern that is the subject of this section. I will focus here only on whether or not an underlying tone has any influence on the output pattern, and not on the details of how particular input tones result in specific output tones. The data below shows various strings ending in a /44/ tone. If the penult is from the type of tone known as Ping, a historical category that is not an obvious natural class synchronically, then we get the pattern shown in (21a). If the penult is from the other historical category, known as Ze, then we get the pattern in (21b). Examples are given in pinyin.[4]

(17)**Strings ending in /44/:**
a. Penult is APing@, /44/ or /31/: Surface pattern [34 43 22 33]

31 44 44 44 you zhi gong si ›oil factory: (p.134, A4)
31 44 31 44 min zhi min gao ›people:s property:

b. Penult is AZe@, /45, 22, 42, or 34/: Surface pattern [2 4 42 33]

31 44 45 44 chang sheng duan sheng ›long sound, short sound: (p.135, B4)
44 22 22 44 xiang xia di fang ›rural area:

Crucially, Faithfulness must distinguish the final (head) syllable from the penult, and each from all other syllables. To do this, I will borrow an idea proposed by Alderete 1995 for gradations of vowel reduction in Russian. He suggests that retention of some contrasts in the last two syllables is actually retention in the last binary foot. Suppose then that Wenzhou also has binary feet; in longer strings there is in fact an alternating pitch pattern that shows some indications of binary rhythm, but for the data under discussion we need only assume a single binary foot at the right edge, and this will be optimal in a grammar in which ALLFT-R and FT-BIN are undominated.

We must now add to positional faithfulness in the head *syllable* (the notion used in our previous analyses) the idea of positional faithulness in the head *foot*. The two constraints are given below:

(18) HEADSYLL-MAX-(F) (formerly HEAD-MAX(F))
Every feature in S_1 associated in S_1 with a segment whose correspondent is contained in a head syllable in S_2 has a correspondent in S_2.

(19) HEADFOOT-MAX-(F)
Every feature in S_1 associated in S_1 with a segment whose correspondent is contained in a head foot in S_2 has a correspondent in S_2.

It seems plausible that head syllables always require greater faithfulness than non-head syllables that are merely enclosed in head feet, so I hypothesize that in UG, HEADPCAT$_A$-MAX(T) + HEADPCAT$_B$-MAX(T) iff PCat$_a$ < PCat$_b$.

Finally, we must allow tonal markedness to distinguish between the full range of "contour" distinctions (kept in the head syllable only) from the residual Ping/Ze distinction (kept on last two syllables only). We can achieve this by the use of two tonal markedness constraints, *CONTOUR and *T, which interrupt the faithfulness constraints at two different points, giving the ranking HEADSYLL-MAX(T) + *CONTOUR + HEADFOOT-MAX(T) + *T + MAX(T). The tableau illustrates the workings of this mini-grammar. Note that any candidate in which the head (final) syllable has lost any tonal specifications will be immediately ruled out by the top-tanked HEADSYLL-MAX(T). Such candidates are not considered in the tableau. The table uses C as a cover term for "contour" features, and PZ as a cover term for the Ping/Ze distinction. Every specification, whether C or PZ, incurs a * under *T. Obviously, the actual distinctive features responsible remain to be understood.[5]

(20)

	HEADSYLL-MAX(T)	*CONTOUR	HEADFOOT-MAX(T)	*T
L a. PZ PZ | | ó ó (ó ó) | C		*	*	***
b. PZ PZ PZ | | | ó ó (ó ó) | C		*	*	****!
c. PZ | ó ó (ó ó) | C		*	**!	**
d. PZ PZ | | ó ó (ó ó) | | C C		**!		****

This interest of this approach is that it limits tone retention to a foot-sized window. The next language differs in that the foot in question is n-ary, not binary.[6]

<u>3.2.2 Suzhou: [(Tt..t)o]</u> Suzhou differs from Wenzhou in two respects. It is left-headed not right-headed, and the foot within which some tones are retained is n-ary, not binary. The Suzhou generalizations, followed by data for syllables with no glottalization in the rhyme are given below; data are from Ye 1979; other sources report somewhat different facts.

(21) a. Initial syllables retain their own tone, and determine the tone of entire span
b. Final syllables lose their own tone, and their tone depends entirely on the preceding tone.
c. Medial syllables retain their register, but lose their contour (in the sense of Yip 1980, Bao 1990):
/44, 412, 55/ become 44; /13,31/ become 33. True of any number of medial syllables.
d. Voicing distinctions in onsets are preserved under tonal change.

(22)

Underlying tones	*Surface tones*	*Example*	*Gloss*	*Translation*
a. 52 52 44	52 44 21	tã hcu ²I	hit fire machine	cigarette lighter
52 412 23	52 44 21	siæ ts=E lE		small vegetable basket
b. 52 13 44	52 33 21	tsæ ñi kæ	date paste cake	jujube
52 31 13	52 33 21	sia zv dE	write character desk	writing desk
c. 52 52 44 52	52 44 44 21	sv ts=æ ko °v		water fry melon seeds
52 23 <u>33</u> 23	52 33 33 21	si ñin bc dp		dead man nose
52 23 44 31	52 33 44 21	siæ zæ kY sã		little Cao=s home lane
d. 13 52 31	13 44 21	suã tE bin	jaundice illness	jaundice
13 412 44	13 44 21	sIp pæ ho	oil quick-fry shrimp	quick-fried shrimp
e. 13 13 13	13 33 21	nø mcn ¯iæ		south gate bridge
13 31 31	13 33 21	soŋ miw k=oŋ		red face
f. 13 412 <u>33</u> 21	13 44 <u>33</u> 21	zcn ²=i suc siw		very vigorous
13 13 44 31	13 33 44 21	zen min koŋ zo		people=s commune
13 13 31 31	13 33 33 21	loŋ ¯iæ dY dE		Longqiao group

The crucial difference from Wenzhou is that all medial syllables retain some contrast in Suzhou, so pursuing the same line as in Wenzhou we may postulate a left-headed non-final unbounded foot in Suzhou: [(<u>ó</u> .... ó) ó]. The initial syllable is the head, all medial syllables are contained in the head foot, but the final syllable is not. This foot structure can be attributed to the ranking ALIGN-L (FOOT, PRWD), FT-BIN-MIN+FT-BIN-MAX, *ALIGN-R (FOOT PRWD). Given this move, and decomposing *T into *Contour and *T, the Wenzhou hierarchy now also deals with Suzhou. I use R as a cover term for register, and C as a cover term for contour. All candidates are left-headed.

(23)

	HEADSYLL-MAX(T)	*CONTOUR	HEADFOOT-MAX(T)	*T	MAX(T)

L a. R R
   | |
(ó ó) ó
  |
  C
		*	*	***	***

b. R R | | (ó ó) ó	*!		**	**	****

c. R R
   | |
(ó ó) ó
  | |
  C C
		**!		****	**

d. R
  |
(ó ó) ó
  |
  C
		*	**!	**	****

e. R R R
  | | |
(ó ó) ó
  |
  C
		*	*	****!	**

Finally, let us see how the further refinements made necessary by the Wenzhou and Suzhou data play out when we return to the simpler languages discussed earlier. Reviewing the previous cases, we see that if the UG ranking HEADSYLL-MAX(T) + HEADFOOT-MAX(T) + MAX(T) is interrupted at various points by the tonal markedness constraints, which may themselves be fragmented into two (or more?) blocks, we readily derive the range of languages discussed so far:

(24)

! All non-head syllables lose all tones (Shanghai):
HEADSYLL-MAX(T) + ***T** + HEADFOOT-MAX(T) + MAX(T)

! All syllables (heads and non-heads) keep all tones (Mandarin):
HEADSYLL-MAX(T) + HEADFOOT-MAX(T) + MAX(T) + ***T**

! Certain tones (eg Xiamen rising tone) lost everywhere except in head syllable; other tones kept on all syllables
HEADSYLL-MAX(T) + ***RISING** + HEADFOOT-MAX(T) + MAX(T)+ ***T**

! Certain tones (eg Wenzhou contours) lost everywhere except in head syllable; other tones kept on syllables contained in head

foot; other syllables lose all tones:
HEADSYLL-MAX(T) **+ *CONTOUR +** HEADFOOT-MAX(T) **+ *T +** MAX(T)

We also predict a language type I have not yet encountered. Suppose HEADSYLL-MAX(T), HEADFOOT-MAX(T) **+***T **+** MAX(T) . Then all syllables in the head foot (binary or n-ary) will keep all tones, and all other syllables will lose all tones. I take it to be a weakness of this approach that such languages are not to my knowledge attested.

<u>4. Conclusion to sections 2 and 3:</u> Sections 2 and 3 have provided us with several arguments for not limiting feet to the (T...o) type. First, languages such as Mandarin and Taiwanese clearly have (T..t) prosodic units, which I have called feet. It is true that one could construct an alternative account in which each tone-bearing syllable was its own foot, and the larger units are re-named prosodic word, phonological phrase, or some such. This, it seems to me, is largely a matter of terminology: cross-linguistically, we would then have grammars in which tones are lost in this larger prosodic unit, and grammars in which they are not, and the account offered here could be carried over renamed but otherwise unchanged . Second, if we consider each tone-bearing syllable to be its own foot in such languages, FT-BIN, which would of course prefer a (Tt) foot to two (T)(t) ones, must be out-ranked by an additional constraint banning tones in non-heads, a sort of Tone-to-Stress principle. The account offered here is superior in that it has no need of such a constraint. Thirdly, the Wenzhou and Suzhou analyses make crucial use of the idea that tones can be retained within feet, but not outside feet. Hence (T..t) feet are at the core of these analyses. Finally, while these sections have concentrated on the question of how and why tones are lost in some feet, and not in others, the data also bear on the question of whether feet are always binary, and it appears that they are not. I have made crucial use of n-ary feet in my analysis of Suzhou, for example.[7]

The core of the analysis offered here is very close in spirit to accounts of vowel reduction by Alderete and Beckman. The particular contribution of the tonal facts is twofold. First, the mobility of tone requires that faithfulness be handled through MAX, not IDENT. The analysis thus offers support for extending MAX to features, and for allowing positional MAX constraints, thus completing the array of positional faithfulness constraints. Second, the tonal facts show complex interactions betwen head syllable and head foot faithfulness, and foot size. In particular, n-ary feet as well as binary feet are needed to explain the full range of facts. In the next section I take a closer look at n-ary feet.

<u>5. Should only binary units be considered feet?</u> I now turn to the question of foot size, and offer an analysis of Nantong in which feet may be binary in normal speech, but larger at higher speeds. I argue that as speed increases the constraint which places an upper bound on foot size is demoted. In very slow speech, on the other hand, the faithfulness constraint MAX(T) is promoted, resulting in less tone loss at very slow speeds. Under this approach, the grammar itself is altered at different speech rates. This account is then contrasted with an approach in which there is a single constant grammar, and in which the speech-rate related differences are attributed to a change in the mapping from phonology to phonetics. This alternative account makes no reference to n-ary feet, but instead has recourse to an n-ary super-foot unit. All the data, insights and generalizations in this section are from Ao 1993.

5.1 A phonological account The following examples show the foot structure of morpho-syntactically flat cases: following Ao, I show phonetic tones; phonologically, all feet are of the (Tooo...) type.[8]

(25)

Segments	*Underlying tones*	*Slow*	*Normal*	*Fast*	*Gloss*
c c c c	LM LM LM LM	(MH)(ML)(MH)(MLM)	(ML M)(MH)(MLM)	(M H H)(MLM)	22222
c c c c c	LM LM LM LM LM	(MH)(ML)(MH)(MH)(MLM)	(ML M)(M H)(MLM)	(M H H H)(MLM)	22222
pulini•¥j]	L LM MH L L	(M)(ML)(MH)(M)(ML)	(M M)(M H)(ML)	(M M M M)(ML)	Polynesia
Prosodic words		[ ][ ]	[ ]	[ ]	

Ao gives precise foot diagnostics, including tone deletion on non-head syllables, followed by spreading or default, and Onset and Coda Lenition in weak syllables. He also gives many Prosodic Word diagnostics, including raising of LM to MH in feet that are non-final in the Prosodic Word.

Notice first that at all speeds, all syllables are footed, and the final syllable forms a foot on its own. I will not consider candidates that violate these generalizations, which can be attributed to an undominated pair of constraints PARSE-ó and FINALSTRESS. At normal speeds, feet are binary, left-to-right, but unary feet are allowed in two circumstances: to satisfy FINALSTRESS, or to satisfy PARSE-ó. Feet of more than two syllables are never found, suggesting that FT-BIN-MAX (Hewitt 1994) is undominated. Thus far, then, we can construct a grammar with the following ranking: PARSE-ó, FINALSTRESS, FT-BINMAX + FT-BIN-MIN, ALL-FT-LEFT. For reasons of space I will not formulate these familiar constraints here: statements can be found in any OT work on stress such as Cohn and McCarthy (1994) , Kager(1994), and many others. Within a foot, tones are deleted, in violation of MAX(T). These violations occur because of the need for feet to be binary, showing that FT-BIN-MIN+MAX(T). The relevant portion of the grammar is thus PARSE-ó,

FINALSTRESS, FT-BINMAX + FT-BIN-MIN, ALL-FT-LEFT + MAX(T)

At fast speeds, feet enlarge, even though this means the loss of more tones, and of course violates FT-BIN-MAX. The advantage of fewer and larger feet is that they better satisfy ALL-FT-LEFT, which must thus dominate FT-BIN-MAX. The fast speech grammar is thus PARSE-ó, FINALSTRESS + FT-BIN-MIN, ALL-FT-LEFT + MAX(T), FT-BINMAX. The change from normal to fast speech thus involves demotion of FT-BIN-MAX.

At slow speeds, each syllable forms its own foot, in violation of FT-BIN-MIN, and incurring even more violations of ALL-FT-LEFT. There is however a dramatic improvement in the eyes of MAX(T), since no tones are lost. It is clear then that MAX(T) has been promoted above FT-BIN-MIN and ALL-FT-LEFT. The slow speech grammar looks like this: PARSE-ó,FINALSTRESS, FT-BINMAX, MAX(T) + FT-BIN-MIN, ALL-FT-LEFT. The change from normal to slow speech thus involves promotion of MAX(T).

(26)<u>Summary of Constraint Rankings at Varying Speeds</u>:

Slow: PARSE-ó,FINALSTRESS, FT-BINMAX, MAX(T) + FT-BIN-MIN, ALL-FT-LEFT

8______________________________ 8

Normal PARSE-ó, FINALSTRESS, FT-BINMAX + FT-BIN-MIN, ALL-FT-LEFT + MAX(T)

9____ 9

Fast: PARSE-ó, FINALSTRESS + FT-BIN-MIN, ALL-FT-LEFT + MAX(T), FT-BINMAX

Here I take the normal speed grammar to be the real grammar, and derive the others from it by simple, principled changes. Which grammar is used at which speed must surely be predictable: no language would presumably show the opposite matching of grammars to speeds. However, it is not clear how OT, with its commitment to factorial typology via re-ranking, would ensure the right match of grammar to speech rate.

The implications of this account for our starting question "Can feet be larger than binary?"are clear. By allowing feet to vary from one syllable (slow speed) through binary (normal speed) to n-ary (fast speed), we can stick to a unified statement of tone deletion: tones delete in the non-head position of a foot. In OT terms, the module HEADSYLL-MAX(T) + *T + HEADFOOT-MAX(T) , MAX(T) remains constant across normal and fast speech rates, resulting in (Too...) feet whose size is controlled by the rate-dependent ranking of FT-BIN.[9] On the other hand, if only the binary units are called feet, then in fast speech we must say there are no feet, and that tones are lost in the non-head position of prosodic words. This needs two changes in the grammar instead of one:

the loss of the foot level, and a change in the tone deletion conditions.

<u>5.2 A tempo-based alternative</u> The previous analysis assumes that as speech rate increases, the grammar itself changes. A more attractive alternative would be to assume that the grammar is held constant, but the mapping onto the phonetics is affected by speech rate. Below I outline such an approach.

By hypothesis, the constant grammar will supply a single structured output to the phonetics at all speech rates. What must this structure look like? Across speech rates, we see that the tonal facts require access to syllables, to binary units, which I will call feet,ö, to a final unary unit, which I will also take to be a foot,ö, and to an n-ary unit that encompasses the whole word except the final syllable, which I will call the super-foot, ö', since it is larger than the foot but smaller than the prosodic word. The crucial difference here is the addition of the extra ö' level, and this move is rendered unavoidable by the hypothesis that a single structure is present at all speech rates, since that single structure must simultanously encode the binary pattern of normal speed, and the n-ary pattern of fast speech. Thus the binary and the n-ary units must be *different* units, rather than two instances of a single unit, and the term foot can be reserved for those which are maximally binary.

The structures required for 4 and 5 syllabled strings are thus as shown:[10]

(27

```
          Wd                    Wd
       /      \                          /       \
    ö'                ö'                 ö'               ö'
    |   \        |                        |  \        |
    ö    ö        ö                       ö    ö        ö
    | \  |      |              |\  | \    |
    ó  ó   ó       ó                     ó  ó  ó   ó   ó
```

These structures will be chosen as optimal by the normal-speed OT grammar from the previous section, with the addition of an undominated constraint requiring the prosodic word to be strictly binary at the level of the super-foot.

There are two differences that concern us as speech rate increases. First, obviously, the output is faster! Secondly, more tones are deleted. I will deal with each of these in turn.To characterize the additional speed, let us assume that the timing is controlled by the mapping of prosodic units onto timing units, which I will call beats. For a somewhat similar use of the timing tier, see Dresher and van der Hulst 1995:10. At slow speeds, smaller units are mapped onto these beats; at higher speeds, larger units are mapped onto the beats. I will assume the beats are grouped into measures, [xx]. For Nantong, the mapping is given below:

(28	Slow speed:	Map ó to [xx]
	Normal speed:	Map ö to [xx]
	Fast speed:	Map ö' to [xx]

The beat representation is located at the phonology-phonetics interface. It cannot replace the prosodic structure, nor is it a final phonetic specification, since its translation into actual duration is influenced by any number of factors, including most obviously syllable count, and segment quality. I have in mind something similar to the Asonority specification@ of Beckman, Edwards and Fletcher (1992:83), who develop their model A to describe the quantitative properties of the lengthenings associated with nuclear accent.. and overall tempo decrease in terms of some abstract phonetic representation that can mediate between the prosodic hierarchy and the gestural dynamics.@ This said, the model I propose makes some interesing predictions that await experimental verification. If [xx] represent measures of two beats of roughly constant phonetic duration, these mappings will result in a 4ó phonological word occupying 4 measures at slow speed, 3 measures at normal speed, and 2 measures at fast speed. A 5ó phonological word will occupy 5 measures at slow speed, 3 measures at normal speed, and 2 measures at fast speed. Notice that this leads to several strong predictions: *ceteris paribus*, at normal and fast speed, phonological words of 4 and 5 syllables will be of the same approximate duration as each other: 3 measures at normal speed, and 2 measures at fast speed. Ao (p.c.) tells me that this is essentially correct.

A second and even more startling prediction is that at fast speed *all* phonological words will occupy exactly two measures, irrespective of length. A third prediction is that in such phonological words the final syllable, which is a ö' unto itself, will be of the same duration as the entire preceding sub-string. The theory can be made subtler by allowing for some variation in beat duration, so that there is a continuum of speeds under the umbrella of "fast speed", but this does not affect the three predictions made above, which concern "within speed" durations. Testing these predictions experimentally is tricky because we know that in 'foot-timed' languages feet are not really of equal duration, but that their duration is heavily influenced by a number of things, including most obviously syllable count and segment quality. I leave this question for future research.

Turning to the tonal facts, a rather surprising consequence follows from this analysis. If the phonological output structure is constant at all speeds, but the tonal deletion facts vary, then any phonological statement of tonal deletion will have to differ at different speech rates. In fact, the same is true for any other alternations in the weak position in a foot, such as Onset and Coda Lenition. For reasons of space, I will confine my discussion to the tonal case.

(29 <u>Phonological Tone Deletion:</u>

Slow speed:	No deletion
Normal speed:	Delete tones in the weak positions of feet, ö.
Fast speed:	Delete tones in the weak positions of super-feet, ö'.

As speech rates increases, then, the phonology does not stay constant after all, but varies in its choice of tone deletion rule. This then undermines the initial premise of this section: that speech rate differences are better handled in the phonetics than in the phonology.

However, suppose that tone deletion is not a phonological but a phonetic matter. In that case it can be simply and uniformly stated at all speech rates as follows:

(30 <u>"Phonetic" tone deletion:</u>
Delete all tones except the first in a [xx] measure.

At slow speed, each syllable is a measure, and keeps its one and only tone. At normal speed, each foot is a measure, so this is equivalent to retaining tone on the head only. At fast speed, each super-foot is a measure, and in the initial n-ary super-foot only the first tone will survive.

Attractive though this rule may be, we have to stop and ask ourselves what kind of rule it is. To call it phonetic is misleading; like the mapping from prosodic structure to beats and measures, it more properly belongs on the interface between phonology and phonetics, where phonological structures are interpreted. Under this view, consider the stages in the interpretation of a five-syllabled structure at fast speed: [11]

(31 *Prosodic Structure* *Mapping to beats: Each ö' maps to [xx]* *Deletion of non-initial T in each [xx] measure*

```
   Word
  /      \
ö'        ö'              [xx]  [xx]                          [xx]  [xx]
| \       |          (óóóó) (ó)                          (óóóó) (ó)
ö   ö     ö               ||||  |                               |        |
|\  | \   |          TTTT  T                     T        T
ó  ó  ó  ó   ó
```

So far, then, this approach gives a straightforward account of speech rate changes by locating them entirely at the phonology-phonetics interface. It remains to be seen, however, whether the strong predictions outlined earlier are born out. [12]

I have put aside up until now a problem for the view that the prosodic structure is held constant across all speech rates. Ao reports that at slow speed a single morphological word may be composed of two prosodic words, and he gives several diagnostics for prosodic word-hood. The structure demanded by these facts is incompatible with the structure assumed in the preceding discussion, for two reasons. First, I have assumed that the prosodic word is co-extensive with the morphological word (as indeed Ao has it at normal and fast speeds), and second, the constituency of these slow speed internal prosodic words cross-cuts the constituency of the fast speed super-feet:

```
(32    Slow speed prosodic words:   (   )(       )
                                    ó ó  ó  ó  ó
       Fast speed super-feet:      (         )(  )
```

At normal and slow speeds, these binary prosodic words not only play no role, but they make it impossible to single out the final syllable as a special prosodic unit. I thus conclude that some degree of phonological restructuring at the level of the prosodic word is necessary at slow speeds. However, I would claim that the core grammar is that of normal (and fast) speech, and that slow speech involves a type of restructuring that is the inverse of that most commonly reported in the literature. The more familiar type of restructuring erases prosodic boundaries when speech rate increases (Nespor and Vogel 1986 on Italian, Shih 1986 on Mandarin). In contrast, Nantong inserts additional prosodic boundaries when speech slows down sufficiently, turning one prosodic word into two. This shows parallels to Dresher's rule of Division in Tiberian Hebrew (1994:34), which applies only to phrases in prominent positions, and divides one phrase into two. As Dresher says (p.33), "..prominent phrases have characteristics of deliberate speech", and the discovery of a comparable process to the Hebrew prominence-conditioned division in Nantong slow speech confirms this insightful observation.

I have presented an account of Nantong speech rate changes which has the following central characteristics: (a). The grammar builds a single prosodic structure. (b). In slow speech, limited restructuring takes place at the prosodic word level, dividing the string into two or more smaller prosodic words. (c). The phonology-phonetics interface maps prosodic units onto measures. As speech rate increases, the unit mapped enlarges from ó, to ö, to ö'. (d). The interface deletes all non-initial tones in a measure. The starting point for this exploration was an investigation of foot size: Nantong appeared to be a language in which foot size enlarged as speech rate increased, and in which even n-ary units had to be treated as feet in order to state tone deletion as a unified process. However, the alternative presented here treats only the binary units as feet, and has a clear conceptual advantage in that it allows us to assume the speaker has a single grammar, rather than many. It does this at the cost of positing an n-ary super-foot unit, instead of considering this to be an enlarged foot. The tone deletion generalization is stated at the level of the interface with the phonetics, at the beat level. A final advantage of this proposal is that it avoids the problem of explaining why particular grammars are chosen at particular speeds: the variation in mapping is systematic, working its way up to larger units as speed increases.

6. Conclusion: The picture presented in this paper is one that is entirely to be expected from an OT perspective. Tone loss results from tonal markedness pressures, but these interact with Faithulness constraints so that the respective rankings of the two determine whether tones survive or not. Heads enforce more stringent faithfulness, so tones are more likely to survive there. Foot size is controlled by BIN constraints, and these are, as expected, violable, so n-ary feet are optimal in some languages under pressure from prosody-syntax or prosody-prosody (such as ALLFT-LEFT) alignment constraints. Finally, the striking parallels between tone loss and vowel reduction are clarified by this approach, which builds heavily on earlier OT work on vowel reduction.

Endnotes:

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1. Presumably one could admit phonetic interpolation of tone on phonologically toneless syllables, but any kind of phonological tone, even default tone-assignment, would be banned.

2.This constraint will generalize to the vowel-reduction situation, raising the question as to whether Head-Ident is really necessary. The main difference is that only Head-Ident bans the *insertion* of extra features on heads, as in the insertion of H tone on heads in some languages.

3.The other allotonic variation, and its circular nature, is beyond the scope of this paper. See Kirchner 1996 for a recent OT approach.

4. Data do not give tones of each non-final syllable, only the general category›ping/ze‹. Tones have been reconstructed by comparison with known tones in other dialects, so that if Cantonese has this syllable as Ayin qu@, it is assumed it is also Ayin qu@ in Wenzhou, and Zhengzhang gives Ayin qu@ as 42. Any errors introduced by this procedure do not affect the central generalizations.

5. Note that there is no need for the constraints to refer to the mysterious (and therefore problematic) *Ping/Ze contrast directly.

6. Under this approach, these languages have (tT) feet. We must assume the other syllables are unfooted, since otherwise al head sylables would retain tone. Thus the head foot is also the only foot, and the importance of specifying head foot in the constraint remains to be demonstrated.

7. An obvious question for future research is whether there are UG markedness-based rankings of the various tonal faithfulness constraints. I have made use of three: Xiamen: *RISING + *T, Suzhou: *CONTOUR + *T, and Wenzhou: *CONTOUR + *T. Without a precise understanding of what features are behind these cover terms, however, no theory of markedness can be developed, and I leave this topic for future research.

8. In morphologically complex cases, the right edges of MWd:s and feet coincide, and these alignments survive at all speech rates. [[AB]C]D] or [[[AB][CD]] are footed (óó)(ó)(ó), but [A[BC]D] is footed (óóó)(ó).

9. In Mandarin, on the other hand, increased speech rate seems not so much to increase foot size, as to allow for more tone deletion, changing (Tt..) feet into (Too..) ones, suggesting that MAX(T) is demoted.

10. I will return later to the prosodic word, which according to Ao is binary at slow speeds.

11. This could easily be achieved by an OT grammar, but it is not at all clear what type of mechanism is involved in this type of interface procedure, so I give a sequential statement here.

12. Thanks to Benjamin Ao, Kathleen Hubbard and Janet Pierrehumbert for help with this section. They are not of course responsible for the views expressed here.