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A TYPOLOGY OF TONE SANDHI RULES IN NORTHERN WU

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Introduction Generally speaking, the reasons for segmental phonological behaviour are transparent, given knowledge of the phonetic nature (articulatory; acoustic; perceptual) of the segments in question. Palatalisation of alveolars before (high) front vowels; nasalisation of vowels before nasal consonants; diachronic interchange between labials and velars: these are transparent. This is not invariably the case for tonological behaviour, however. Hyman and Schuh, in their 1974 study of West African languages, provide examples of some phonetically transparent tone rules, like the raising effect of a high tone, or rightwards spreading of tone. In contrast to this stand the Wu dialects of east central China, which have long been known to exhibit the most complex tone sandhi of the various Chinese languages. One of the sources of complexity lies in the apparent phonetic opacity of the rules which relate underlying or citation forms to sandhi forms. Consider the following cases of Wu lexical tone sandhi. In Zhenhai dialect, a tone with a high falling pitch e.g. [tɛŋ 441] 'present' followed by a stressed syllable with low convex pitch e.g. [tɛp 231] 'day' results in a pitch pattern of mid level plus high fall: [tɛŋ dɛŋ 33 441] 'today' (Rose 1990:8). The same thing appears to happen in Shaoxing (Wang 1959:77,84), although no mention is made of stress. In Daishan dialect, a high rising pitch tone, e.g. [hau 335] 'fire' followed by a low convex pitch, e.g. [ju 231] 'oil' yields a falling pitch: [hau ju 53 21] 'kerosene' (Toda 1989b). In Suzhou, two falling-rising pitches [513] give [44 21]. It is not immediately apparent what is going on here, and it was examples like these which prompted Ballard's (1986:144-153) observations that Wu tone sandhi rules appear for the most part to be not phonetically natural in the sense of Hyman and Schuh's West African data, and probably need to refer to other phonetic features like stress and phonation type to be made sense of (Ballard 1988:10,108). This has in fact been demonstrated in Rose (1990), where it was shown that including stress and Register (qua phonation type) motivated the tone sandhi rules phonetically.

The aim of this paper is to classify some of the different types of relationships which obtain between the phonetic shapes of Wu dialect citation tones and their sandhiied forms in disyllabic words. In order to do this, types of relationships were first established from cases where there is the least doubt about the phonetic reality of the entities involved, that is, where reliable acoustic data is available. This is mainly from the authors' acoustic work on the dialects of the Ningbo area, especially Daishan (Toda 1989b) and Zhenhai (Rose 1990). The by now rather plentiful, though still to a certain extent descriptively inadequate auditory descriptions were then scanned for further possible examples of these types. Five types of relationship are distinguished: Contour Spreading; Default Realisation; Contour Leveling; Citation Target; and Categorical Shift. These are treated in turn below.

Contour Spreading. This constitutes one of the most unambiguous relationships between citation and sandhi tones. It occurs when the F0 contour on a polysyllable can be shown to be statistically the same as that on a citation monosyllable, once intrinsic features are discounted. Clear examples of contour spreading occur in Daishan. In this dialect, the high falling pitch of citation tone 1 on a first syllable (S1) is spread over a disyllable, e.g. [ɣjɔ 51] 'to heat' + [tɛ ju 335] 'liquor' -> [ɣjɔ tɛ ju 53 21] 'distilled spirit' (Toda 1989b:35). The acoustics of such combinations are shown in figure 1, which compares the mean F0 of citation tone 1 ("T1", 6 tokens) with the mean F0 of disyllables with the spread contour. F0 is plotted as a function of absolute duration. Mean tones and upstep tones are shown, both with Shu tones on S2: "1" indicates combinations with voiceless S2 syllable-initial consonant (30 tokens); "2" indicates combinations with voiced S2 syllable-initial consonant (24 tokens). The boundaries of the intervocalic consonant are shown by short vertical lines.
It is obvious from figure 1. and has been demonstrated in Toda (1989a & 1990:385), that the F0 contour of the disyllable is the same as a linearly expanded contour of the citation tone segmentally aligned such that the first 50% of its contour is realised on the Final of the S1, and the rest distributed equally over the S2 initial consonant and the S2 Final. The F0 contour is not realised, of course, over the voiceless S2 consonant. Details of other intrinsic effects like the Ru/Shu difference on the S2, or the effect of the voicing of the intervocalic consonant are given in Toda (1989a). This constitutes therefore a clear example of phonetic contour spreading.

![Figure 1. Contour Spreading in Daishan](image)

Daishan also has examples of a convex F0 contour being realised over two syllables, the first syllable of which has a convex F0 in isolation, e.g. [pə 231] 'friend' + [ju 113] 'friend' -> [pə ju 2321] 'friend' (Toda 1989:36). As with the spreading of the high fall, the S1 Final takes up half of the duration of the disyllable, with the rest being distributed equally between the S2 initial consonant and the S2 Final.

Figure 2 shows a spread low level-rising F0 contour in Ciqi dialect. The citation tone F0 ('4 cit', 5 tokens) is compared with the F0 on disyllabic x + [z] combinations ('4 + z', 7 tokens) meaning 'the character x', e.g. [mà ç 114] 'the character ma' ([mà 114]). The point of onset of the S2 is indicated by the short vertical line; no onset to the S2 Final is shown because there is no acoustic discontinuity to mark this point in syllables with [z]. Again it can be seen that the F0 contour of the citation form is spread over both syllables.

From the F0 and duration data on Suzhou in Liao (1983) it is also possible to identify spreading of F0 shapes other than high falling and rise-fall (which also occur in the Suzhou data as well as in Zhenhai and Daishan). Thus the high fall-rise [513] and low rise [24] (though not the high level [44]) F0 contours on Suzhou citation monosyllables are also phonetically spread.

The examples above show contour spreading is clearly a phonetic reality in Northern Wu. Any contour can spread, but it must be from right to left and the result appears to be a trochaic disyllable with stressed-unstressed or stressed-atomic pattern. It is not yet clear whether level F0 shapes can spread, since the level pitch on disyllables can usually be interpreted as the result of a process other than spreading of the first syllable tone. This occurs in Danyang, where there is for example a change from an underlying tone on the S2 to that of the S1, as in Danyang [11 11]; or a change to another level...
tone in the system, as in Changzhou $\S$ + any Shu tone -> [5 55], where [55] is the value for tone IIa (yin shang).

**Figure 2. Contour spreading in Ciqi**

![Contour spreading in Ciqi](image)

**Default Realisation** In Zhenhai there is a subset of Shu tones on S2 which have the following characteristics (Rose 1990). They occur after stressed S1 tones with either high level or rising pitches ([5, 44, 334, 114]); neither their acoustic nor their auditory values correspond to values found on citation tones; they are a little more than half the duration of the first syllable tones; they have falling amplitude; their F0 onset values can be accurately predicted from the F0 of the S1 by extrapolation of the S1 F0 trajectory for the duration of the intervocalic consonant; the correlation between their amplitude and F0 is significantly higher than in other tones. There is also a corresponding set of Ru tones, which show the same characteristics as the Shu tones once their extrinsic short duration and glottal-stop offset have been allowed for. The pitch values for Zhenhai disyllables containing these S2 tones are ['44 31] & ['44 32']; ['334 51] & ['334 5?]'; ['114 51] & ['114 5?], and ['5 51] & ['5 5?]. These S2 tones were dubbed 'default' in Rose (1990:31) since their acoustic characteristics assume default shapes determined by phonatory inertial effects from the preceding syllable.

Similar duration and F0 characteristics have also been demonstrated for S2 in Daishan combinations ['44 31] & ['44 3?], ['113 41] & ['113 5?] & ['5 21] (Toda 1989b, 1990:385), and Shanghai ['44 21] combinations (Toda 1990:384).

Figure 3 shows the mean acoustics of three of these Daishan S2 defaults. F0 is plotted as a function of absolute duration for S2 Shu tones with voiceless syllable-initial consonant after [44] ("3a", 21 tokens); ['3] ("4a", 18 tokens); and [113] ("2b", 21 tokens) on S1. The F0 of the preceding S1 has been shown, separated from the S2 F0 by the duration of the voiceless intervocalic consonant. The F0 shapes have been aligned at the onset of the S2 Final (csec 0) to facilitate comparison with the Zhenhai S2 default data in Rose (1990:29). Typical short falling default F0 shapes can be seen on S2, with onset (at csec 0) intrinsically correlated with F0 offset values on the S1.
A survey of the existing auditory descriptions yields many examples of an S2 with a falling pitch after high level, or rising pitch on S1. With only one exception, the falling pitches do not occur on any citation tones of the variety in question. Although there is no indication of the relative length of the S2, it is possible to identify some of these shapes (where the onset value of the S2 is, say, within one point of the offset value of the S1) as defaults of the type described for Zhenhai or Daishan. Such examples are [55 '53], [24 '53], [24 53] in Chongming; [55 '52], [24 52], [24 53] in Old Shanghai; [5 42] in Changzhou; [24 41], [23 21] for Old Suzhou; and [23 21] for New Suzhou. The impression from the available data is that the S2 defaults constitute values on a tonicity cline, going from fully tonal e.g. Old Shanghai [55 '52] or Chongming [24 '53] to nearly atonic, e.g. Hangzhou [55 '21] or New Suzhou [23 21]. Different degrees of reduction can also be found within one dialect. In Zhenhai, for example, some speakers have ['33 21] & ['5 21], with effectively atonic S2, corresponding to other speakers' ['34 51] & ['5 51], where the S2 has a more audible pitch shape. Such a range of values recalls the so-called negative effects of destressing on the S2 described for Modern Standard Chinese by Kratochvıl (1968:42-44).

In the phonological literature, e.g. Zee and Maddieson (1979), shapes like [44 21] are generally considered as examples of tone spreading: the L tone of a HL sequence is delinked from the S1 and associated with the TBU on the S2. Rose (1990:31) pointed out that a more realistic analysis of these shapes is one (suggested by his term 'default') where they do not constitute extrinsic tone targets, and are accounted for in the phonology by pitch insertion rules. Toda (1990) has criticised the conventional spreading analysis on both phonological and phonetic grounds using data from Daishan, which has both Contour Spreading (i.e. ['53 21] pitch), and default realisation (i.e. ['44 21]), both related to the same falling tone. It is likely, therefore, that some kind of interpolation over a toneless S2 is a more appropriate representation for defaults than spreading, c.f. Pierrehumbert and Beckman's analysis of Japanese tones (1988:13-16).

**Contour Leveling.** A third process which has been attested acoustically is the leveling of the pitch contour of unstressed S1 before stressed S2. In Zhenhai, all unstressed S1 tones become level, with the height of the level pitch determined by the register: mid [33] on +Upper (or yin) syllables; low [11] on -Upper (or yang) syllables (Rose 1990:20). Figure 4 shows the F0 shapes for these level pitches on S1 Shu tones in combinations of [33 '441] ("1a") and [11 '441] ("1b"). Each shape is the mean of at least 16 tokens. For each combination two F0 shapes are plotted, each differing
in the voicing of the intervocalic consonant ("+/−V"). Short vertical lines indicate the boundaries of the intervocalic consonant.

**Figure 4. Contour leveling and categorical shift in Zhenhai**

<table>
<thead>
<tr>
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<th>a+V F0</th>
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<td>1a</td>
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<td>1b</td>
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<td>2a</td>
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<td>2b</td>
<td>120</td>
<td>105</td>
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Corresponding leveling in Daishan is noteworthy because of an additional incipient change, whereby the F0 on the low level tone is assimilating to the high F0 on the following syllable (Toda 1989b:61,62). This is an indication that the unstressed low and mid levels are in process of merging to mid before a stressed high fall Shu ([51]), although interestingly the coarticulation is not occurring in Daishan before stressed Ru tones ([5?]) (Toda 1989b:80,81).

Ballard (1988:113) notes that several N.Wu dialects (Shanghai, Suzhou, Shaoxing, Tangsic, Zhoushan) display a type of sandhi, called "narrow" in the descriptive literature, which is characterised by '... left reduction and right stress' and '...shifts most of the tones in first position before most all other tones to mid level...'. This is obviously the same contour leveling phenomenon as described above for Zhenhai and Daishan.

**Citation Target** It is frequently the case that a tone on a syllable in a sandhi group can be identified as one of the citation tones, once allowance is made for the intrinsic influence of various conditioning factors like stress. Figure 5 (after Rose 1990: 21) shows the mean F0 of Zhenhai upper and lower dipping tones 2 ("2a") & 4 ("2b") in citation ("cit", 12 tokens each), together with the F0 of the corresponding stressed tones on S1 ("S1", 44 and 49 tokens respectively). The abrupt drop after peak in the citation tones is a reflex of the syllable-final glottal stop on these tones in citation form. The main effect of the stress here is to uniformly raise the tones' F0 peak values, changing their shape from concave to rising.

The literature contains many examples of citation targets on initial syllables. This reflects the left dominant N.Wu pattern, where most of the citation tone contrasts are realised on the initial syllable. All shapes except high falling are common.
Categorical Shift In Zhenhai there is neutralisation of all four Shu tones in favour of a high falling pitched tone after unstressed tones 1 or 3 on S1. The acoustics of such combinations have already been given in figure 4 in conjunction with contour leveling. The relevant point here is the F0 shapes of the high falling tone on the second syllable (as explained above, the unstressed tones on S1 have undergone contour leveling). Comparison of these S2 acoustic shapes with those of Zhenhai high falling citation tone 1 shows that they are best considered as allotypes of a citation tone 1 target, conditioned by voicing on the syllable-initial consonant, and phonation rate on the S1 (Rose 1990:22,23). Identifying the S2 tone as an allotype of citation tone 1 allows us to stipulate that it represent a neutralisation of all stressed Shu tones in favour of tone 1 after unstressed tones 1 and 3. In order to account for the S2 shape, therefore, we must make use of two notions: citation target, and a tonal shift from all Shu tones to tone 1. This latter is what Ballard (1980; 1989) calls categorical shift. It is an important notion in accounting for tone sandhi in Wu, not only because of its explanatory power, but because certain areas tend to be characterised by certain shifts.

Categorical shifts in Wu are also of theoretical significance in phonology, because they appear to offer counter evidence to the belief (Hyman 1986:116,117) that natural classes should be definable by features. Since the individual dialects can differ considerably with respect to their tonal phonetics, the natural classes defined by the categorical shifts do not always appear to have a phonetic basis (Ballard 1980;1989). It may sometimes be the case, however, that one has simply to look harder for the phonetic bases. The Zhenhai neutralisation just mentioned is a case in point. Recall that all Shu tones are neutralised to the high falling tone 1 on stressed S2 after tone 1 (high falling), and tone 3 (low convex). Interpreting the pitch of Zhenhai tones as resulting from the interaction of an independent tonal and register component allows us to see that, firstly, the natural class of tones 1 and 3 is defined by their tone specification (HL, or +Fall). Secondly, the tone on the S2 is the result of a change to the +Upper register (or yin ), in conjunction with a copy of the tone on the S1. In Zhenhai there is also a parallel neutralisation of all Shu tones to tone 2 (high concave) after an unstressed tone 4 (low concave). Again, decomposing the tones in question into their register and tonal components reveals the same processes as involved in the previous example, namely a shift to yin on the S2 and a tone copy this time of the HLH on the S1 tone. This example is important for showing that some categorical shifts in Wu may be examples of more basic processes like register shift or tone copying.
Summary This paper was motivated by the thesis that it is more difficult to understand what is happening in Wu dialect tone sandhi than in segmental phonology in general, or tonal behaviour in other tone languages. The paper set out five ways in which N. Wu dialect citation tone shapes relate to forms in disyllabic words. The problematic examples cited at the beginning of the paper can now be examined in the light of these demonstrated relationships. The Zhenhai and Shaoxing \([33 \ '441]\) pattern is an example of contour leveling on S1 and a categorical shift to a citation tone 1 target on S2. The Daishan \([53 \ 21]\) pattern is the result of a categorical shift from tone 2 \([335]\) to tone 1 \([51]\) on the S1, followed by contour spreading of the \([51]\) over both syllables. The Suzhou \([44 \ 21]\) is the result of a categorical shift from tone IIIa \([513]\) to tone Ia \([44]\) on the S1, with default realisation on the S2.

Needless to say, there are examples in the literature which cannot be understood in terms of these proposed types. Nevertheless, this paper has demonstrated that Wu tone sandhi may not be quite as phonetically opaque as previously thought, especially when the notions of Contour Spreading and Leveling; Default Realisation; and Citation Target are combined with a theory of representation that includes register and tone. In fact the only process to obscure the nature of the relationship is Categorical Shift, which, as already pointed out above, closer inspection may reveal to be phonologically motivated by tone copying and register shift.

This paper has also demonstrated the indispensability of acoustics in tonological investigations - an insight that is no longer novel, since the inception of 'Laboratory Phonology'. Without acoustic measurement, for example, it would not be possible to demonstrate the presence (or absence) of contour spreading. More importantly, acoustic data permit correlation of F0 shapes and values with variables like position in utterance, stress, and intrinsic effects of surrounding consonants, thus allowing us to judge identity of targets. Hopefully more research - especially based on detailed auditory and acoustic description - will continue to illuminate this fascinating area of tonal behaviour.

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