'RENEWING THE CONNECTION': ACOUSTICS AND PHONOLOGY OF TWO LEXICAL TRISYLLABIC TONE PATTERNS IN ZHENHAI

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Introduction This paper describes some aspects of the tonal acoustics and phonology of trisyllabic words in Zhenhai, a Wu dialect of N.E. Zhejiang. The particular variety described is typical of the speech of the rural area around Qingshuipu, some 10 kilometers S.W. of the provincial town of Zhenhai. The acoustics and phonology of disyllabic Zhenhai words were described in detail in Rose (1990). This paper reports a small part of the results of a similar analysis of trisyllabic lexical sandhi. The material presented is limited to just two tonal shapes: on trisyllabic words beginning with unstressed tones 1 and 3. The acoustics of these shapes are presented and it is demonstrated how they can be accounted for by the rules proposed in Rose (1990) for Zhenhai disyllabic words.

Isolation Tones Zhenhai has six isolation tones displaying the normal co-occurrences, for Northern Wu, of pitch onset height, phonation type, phonation offset, rhyme duration and consonantal manner. A minimal set of six contrasting citation tones is given in table 1 below, together with their tonological representation as argued in Rose (1990: 5,6). [..] = whisper; [..] = growl.

Table 1 Zhenhai citation tones

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Figure 1 shows the F0 and duration of the citation tones of the female speaker (NYS) who is used in this study. F0 is plotted as a function of absolute (i.e. unnormalised) duration. Numerical values (means and standard deviations) for this speaker's citation tones can be found in Rose (1987:346). The two tones that condition the shapes to be discussed are the high falling tone 1 and the low convex tone 3.

**Trisyllabic data.** Two tone patterns on trisyllabic words will be discussed, both conditioned by unstressed tones - tones 1 and 3 - on the first syllable. These tones differ synchronically in register: tone 1 is [+Upper, HL]; tone 3 is [-Upper, HL]. The two types will be discussed with respect to their pitch; their general F0 shapes; intrinsic F0 effects; and their tonological derivation.

**Words with tone 1 on unstressed first syllable.** Trisyllabic words with unstressed tone 1 on the first syllable have a [33 44 31] pitch profile, with stress on the second syllable. Examples are (permuting voicing on the initial consonants of the non-initial syllables): [ khzj `dzpj tsi ] 'empty town strategy'; [ thz 2ej m`n ] 'Gate of Heavenly Peace'; [ teju `se ta ] 'the Zhou Shan islands'; [ taj `de wej ] 'reception'.
The F0 and duration of trisyllabic words with unstressed tone 1 on the first syllable are shown in figure 2. (The F0 and duration measurements of trisyllables depicted in this paper are arithmetical means spectrographically derived from a corpus of 453 words recorded by the female native speaker NYS. The words all had C1V1C2V2C3V3 structure, where Cn = obstruent or sonorant consonant and Vn = rhyme belonging phonologically to the nth syllable. Apart from the exclusion of syllables with apical (or 'buzzed' or 'strident') vowels, the corpus was uncontrolled for segmental effect on F0 and duration.) The procedure used for sampling F0 and duration is essentially that described in Rose (1990: 9-17).

Figure 2. F0 & duration for words with unstressed tone 1 on the first syllable.

Figure 2 has been plotted to show the effect on F0 and duration of the voicing on intervocalic consonants. Thus two F0 shapes are shown on the first syllable vowel (V1). These show the effect of the second syllable-initial voiced/voiceless consonant (C2). Likewise the two F0 shapes on the last syllable vowel (V3) show the effect of the third syllable-initial voiced/voiceless consonant (C3). Four F0 shapes are plotted for the vowel on the middle syllable (V2). These show the effect of voicing of the adjacent prevocalic C2 and postvocalic C3. The short vertical bars in figure 2 indicate the consonantal boundaries/onset and offset of the rhymes.

Figure 2 shows a mildly falling F0 between about 240 and 220 Hz on the first syllable vowel, followed by a step up of about 30 Hz onto the second syllable.
the second syllable vowel. F0 on the stressed second syllable vowel is located between about 250 and 230 Hz, and again shows an overall slightly falling trend. Declination is apparent in the mildly falling F0 shapes on the first two syllables. F0 on the final syllable vowel falls abruptly from just below S2 offset values to offset at about 150 Hz.

The intervocalic consonants have the same clear and expected intrinsic effects on duration and F0 as observed for the disyllabic data in Rose (1990). Rhymes are a few centiseconds longer before voiced consonants. A post-vocalic voiceless consonant causes more abrupt F0 decay in the 5 centiseconds or so before onset. Prevocalic consonants are associated with differences in F0 onset height, with F0 onsetting about 10 Hz higher after voiceless consonants. The resulting difference equalises much quicker in the third syllable than the second, where the perturbation takes about 10 centiseconds to disappear.

Figure 2 shows the duration of the initial voiceless consonant in the third syllable (C3) to be clearly much greater than that of the second syllable. This is the reason why the F0 of the third syllable vowel appears to start much later after a voiceless than a voiced initial consonant.

Disyllabic words with unstressed tone 1 on the first syllable have a [33 441] pitch, e.g. [ tshing 'thi ] 'spring'; [ ka da ] 'grand'. In Rose (1990) I showed that this tonal shape could be analysed as resulting from the following generative rules. The mid level pitch on the first syllable is the result of a contour simplification rule which levels all contours before a stressed syllable, the height of the level being determined by the register of the tone: mid on upper register tones; low on low register tones (Rose 1990:20). The high falling pitch on the second, stressed syllable results from a more complex set of changes - a register shift and a tone copy - again conditioned by stress. In Zhenhai the register of all stressed second syllable tones becomes +Upper (or in traditional terms, yin), and the tone of the first syllable is copied onto the stressed second syllable (Rose 1990:28). In this case the tone on the first syllable (tone 1) is HL. When copied onto the (now) upper register of the stressed second syllable, the tone becomes [+Upper, HL], which is the representation of a high falling pitch.

In trisyllabic words beginning with unstressed tone 1 it is clear that the mid level pitch on the first syllable is the result of the same
contour simplification observed in disyllables. However, trisyllables differ from disyllables in the pitch shape of the stressed second syllable: high level [44] in trisyllables; high falling [441] in disyllables. The derivation of this [44] pitch is also clear from consideration of the rules for disyllables, however. This is because a stressed [+Upper] HL tone becomes high level word-initially (Rose 1990: 20, 21). This rule is needed to account for the [44 31] pitch on disyllables with stressed tone 1 on the first syllable, like [ 'tjæju kau ] 'noon', or [ 'tha wu' 'lake Tai'. It appears, therefore, that the [44] pitch on the stressed second syllable of these trisyllabic words instantiates the same rule, operating on the output (+Upper, HL) of the register shift and tone copy rules already discussed. The trisyllabic case makes it clear that the correct environment for this rule is stressed non-final position (not stressed word-initial position, as predicted from the disyllabic data).

The final explicandum is the falling pitch [31] on the final syllable. This, again, is the same phenomenon as observed in disyllables after stressed syllables ([44 31]), and is accounted for by the insertion of a 'default' pitch shape on (probably underspecified) unstressed final syllables (Rose 1990:31).

Words with tone 3 on unstressed first syllable. Trisyllabic words with unstressed tone 3 on the first syllable are very similar to those with unstressed tone 1 just described, with stress on the second syllable, a (low) level first syllable pitch, and falling pitch on the final syllable. Unlike the tone 1 examples, however, they have two audibly different pitch shapes for the second syllable, depending on the voicing of the initial consonant of the second syllable. With voiceless C2 the pitch is [11 44 31], e.g. [ nje']tsz ' hej 'a real man'; [ jìj 'tjìj dàñ ] 'administrative power'. With voiced C2, the shape is [11 34 31], e.g. [ wu 'miñ tsz ' ring finger'; [ jìj 'zë 've ] 'criminal').

The F0 and duration of trisyllabic words with unstressed tone 3 on the first syllable are shown in figure 3. Figure 3 shows a mildly falling F0 between about 180 and 160 Hz on the first syllable vowel. The F0 on the second syllable vowel is either level (after a voiceless syllable-initial C2), or rising (after a voiced C2). F0 on the final syllable falls from just below F0 offset on S2 to offset at about 150 Hz. With the exception of the F0 onset value of the third vowel after a voiced C3, the third syllable F0 shapes are the same as in figure 2.
The relatively higher F0 onset of S3 vowels after voiced C3 may be caused by inertial effects of the rising phonation on the previous syllable.

Declination is also evident in figure 3, in the sense that the gradual slope of F0 values on the first syllable seems to point to the offset value on the third syllable. This is confirmed by regression: an extrapolated least squares line regressed linearly on the F0 values on the first syllable vowel predicts F0 offset values on the third syllable to within 6 Hz. The slope of this base line on which the S1, and S3 offset values lie is -0.34 Hz/csec..

The same intrinsic conditioning of duration and F0 offset by post-vocalic consonants occurs in figure 3 as in figure 2, *q.v.*. The difference in the F0 of the second syllable vowel as a function of voicing on the syllable-initial C2 appears to be more drastic than in figure 2. The difference in F0 at vowel onset of about 30 Hz is slightly less than double that observed after the higher V1 F0 in figure 2, and the effects of the perturbation persevere longer: they do not disappear until some 5 csec. before the end of the syllable.

The S2 data in figure 3 also differ from figure 2 in an overall shift downwards in F0 onset values. Thus the F0 offset value of the vowel with the voiceless C2 after low level pitch in figure 3 is about the same as that of the vowel with the *voiced* C2 after mid level pitch in figure 2. These intrinsic effects are also observed in the disyllabic...
data (Rose 1990: 23 fig. 6) and are presumably to be referred to the twin factors of voicing on the C2 and phonation rate on the first syllable. Note that the pitch descriptors for the second syllable incorrectly imply that the effect of the voiced C2 and first syllable phonation rate are only manifested after the low level pitch of the V1 (i.e. [34] with voiced C2 after low level pitch; [44] elsewhere). A longer voiceless C3 is also observed, as in figure 2.

The tonal derivation of trisyllabic words with unstressed tone 3 on the first syllable mostly involves the same rules as for the unstressed tone 1 words. The low level pitch on the first syllable results from contour simplification on an underlying unstressed low register tone. The falling pitch on the final syllable is, as with the tone 1 example, a typical default shape. The only difference in the derivation between the two types of word is in the pitch of the middle syllable, which requires lowering the onset of a high level [44] pitch to [34] after a voiced C2. Thus the derivational history of the [34] pitch on the second syllable is rather complicated. It occurs as an intrinsic lowering of a high level target, itself the result of a rule changing a stressed high register falling tone to high level. It will be recalled that this tone is itself the result of register shift and tone copy. It is worth noting that the interpretation of the [34] pitch as a phonologically relatively low level rule is made easier by identification of intrinsic effects in the acoustic phonetic data.

Summary The two tone patterns determined by unstressed S1 tones 1 and 3 on Zhenhai trisyllabic words have been discussed with respect to the tonological and tonetic factors involved in their observed acoustics. Tonetic factors were: intrinsic pro- and regressive assimilatory effects of the voicing of the syllable-initial consonants; progressive assimilation of phonation rate, both of S1 on S2, and S2 on S3; greater voiceless C3 duration; and declination. Tonologically, the same stress-conditioned rules were seen to apply as in Zhenhai disyllabic words, with, however, a resulting more complex derivation for the S2 pitch.


P.J.Rose (1990) 'Acoustics and Phonology of Complex Tone Sandhi'  *Phonetica* 47/1: 1-35.
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