INDEPENDENT DEPRESSOR AND REGISTER EFFECTS IN WU DIALECT TONOLOGY: EVIDENCE FROM WENZHOU TONE SANDHI

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ABSTRACT

This paper presents an analysis based on new acoustic data from tones and tone sandhi in Wenzhou dialect. The data provide evidence for the independent existence of a Depressor as well as the Tonal Register and Tonal melodic component in the tonology. For example, a convex [343 or 342] pitch is shown to result from a depressor effect on a tone with high falling pitch. Comparisons are drawn with acoustics of other Wu dialects and Zulu. It is suggested that 'murmur' in many Wu dialects is actually Depression, but that Depression is not associated with non-vocalic segments, as it typically is in some African tone languages.

1. INTRODUCTION

This paper describes some tonologically interesting phenomena in the Chinese dialect of Wenzhou (Wz). Wenzhou dialect belongs to the Oujiang subgroup of Wu, and has highly complex tone sandhi of the so-called right dominant type found in the southern Wu area. In this type of sandhi the tones on syllables towards the end of a word determine the sandhi shape and are said to show values similar to citation forms; and contrasts on syllables towards the beginning of the word tend to be neutralised (Ballard 1988a: 43).

Wenzhou has a certain notoriety for unintelligibility among speakers of more northern Wu dialects, e.g. Shanghai or Zhenhai, possibly because it is the Southern Wu variety they commonly hear. In a conversation about other Zhejiang dialects during an elicitation session in 1978, one of my Zhenhai informants jokingly observed about Wenzhou:
After a short pause he added:

It is perhaps not surprising that a degree of unintelligibility could arise in a Wu dialect where Proto Wu * fat 45 put forth 2 has become [huː 3312], and proto Wu * jang 31 wave has become [i 331]. But the main interest of Wenzhou is synchronic and tonological: it provides evidence for the existence of a Depressor as well as the expected Tonal Register and Tonal Melodic component in Wu tonological representation. The aim of this paper is to present the evidence.

The Wz citation tones are described first. This is followed by the description of some tone sandhi changes that, it is subsequently argued, point to the coexistence of Depressor and Tonal Register effects. The analysis is broadly generative, relating the citation tones to sandhi tones by rules. It diverges slightly from generative practice in the assumption, usual in Chinese linguistics, that the citation forms are also underlying. Use is also made of Rose and Toda's (1994) typological framework for tone sandhi in Wu, which in turn adopts ideas from Ballard's (1988a, 1988b) work, in particular the notion of categorical shift.

The auditory descriptions and acoustic analyses reported here constitute new data and are based on my analysis of extensive recordings of a male native Wz speaker.
2. PREVIOUS WORK.
2.1 Auditory Descriptions and Analyses.

Several descriptions of the auditory characteristics of Wz tones exist, the earliest of which (Parker 1883/84) dates from before the turn of the century. Most of these are summarised in Zhengzhang (1995: 358-359); other descriptions are in CH (1964: 9), ZH (1962: 6, 1989: 21) and Nakajima (1983). The earliest linguistic description is Chao Yuen Ren's (1928) pioneering monograph on the Wu dialects, which contains a musical description of the tones of a female speaker from Yongjia, a site about 10 kilometers almost due north of Wenzhou city. To commemorate the sixtieth anniversary of Chao's study, Qian Nairong retraced Chao's steps and redid the investigation (Qian 1992). In addition to the material covered in Chao 1928, Qian included extra data on di- and polysyllabic tone sandhi. Zhengzhang (1964a) contains detailed descriptions of the phonology of two Wenzhou sites: Yongzhong, a S.E. suburb variety, and the Wenzhou city dialect. Zhengzhang is a native speaker of the former. His (1964b and 1980) studies contain detailed descriptions of Wz tone sandhi. His descriptions have been cited as evidence of tonological phenomena of various kinds, e.g. arguments for and against a spreading tone contour node (Yip 1995: 481), or examples of a contour tone surfacing on a stopped syllable (Yip 1995: 494). Ballard's (1988a, 1988b) phonological analyses of Wz tone sandhi are also based mainly on Zhengzhang's work. Chen (2000: 475ff.) also includes an extensive analysis of Wz tonological behaviour.

The above authors do not differ very much in their descriptions of Wz citation tones, and these are also in general agreement with the descriptions in this paper. It will be shown, however, that there is one very important difference between the existing sandhi descriptions and those documented here.

2.2 Acoustical Descriptions

It is surprising, given that auditory descriptions of Wz data have been adduced in support of important phonological arguments, that little acoustical work has actually been done on Wz tones, and especially tone sandhi, to verify them.
Cao and Maddieson (1992) did an acoustic and aerodynamic analysis of the Wz high falling and low level tones. More extensive investigation was carried out by Ballard (1989) and (1994), who made acoustical measurements of F0 and duration with two different extraction devices. Ballard sampled F0 only at inflection points, which is inadequate for the kind of descriptive and analytical work necessary in this paper: it does not give a sufficiently detailed picture of the F0 time course, and, without auditory transcription, does not permit differentiation between intrinsic and extrinsic effects on tonal F0. The data presented in this paper are the results of a complete remeasurement of Ballard's data, therefore, as well as its necessary precursor of a careful narrow auditory analysis. The procedure used to extract the tonal acoustic features is not of direct relevance to the phonology, and can be found in Rose (1994). Acoustic and auditory descriptions of another subset of disyllabic Wz lexical sandhi, with Ru tones on the first syllable, are presented in Rose (2000).

3.0 CITATION TONES.
3.1 Phonetic Description.
Traditionally, Wz is described as having eight tones (where 'tone' has its commonly encountered, but phonologically imprecise sense of 'different pitch shape'). My transcriptions of the auditory characteristics (pitch and length) of this speaker's eight tones are given below.

**Tone Ia** (yin ping): **mid-level.** This tone has level pitch in the speaker's mid pitch range, and average length. Examples are [sei 33] 西 west; [ka 33] 間 to close.

**Tone Ib** (yang ping): **mid-falling.** The pitch of this tone starts at about the same pitch as in tone Ia, has a short initial level component and then falls; length is average: [mai 331] 梅 plum; [ni 331] 年 year.

**Tone IIa** (yin shang): **high-rising.** This tone rises abruptly within the upper pitch range. Length is notably short, but the phonation offset is gradual, and
not truncated by a glottal stop. Examples are: 風 45 草 arm; [ts* 45] 草 grass.

**Tone IIb** (yang shang): low-rising. This tone has a short initial low level component, and then rises abruptly into the upper pitch range. It has average length, and non-abrupt phonation offset is as for tone IIa: [pai 114] 被 blanket; [tse 114] 胃 stomach.

**Tone IIIa** (yin qu): high-falling. This tone falls abruptly from high in the upper pitch range into the lower pitch range. Length is somewhat shorter than average: [tei 51] 麵 paste; [tie 51] 跳 jump.

**Tone IIIb** (yang qu): low-level. This tone has a level pitch in the mid-low pitch range. Length is notably longer than average. Examples are: [mi 222] 面 face; [tei 222] 地 ground.

**Tone IVa** (yin ru): mid-dipping. The pitch of this tone falls after a short initial level component in the mid pitch range, then rises slightly. Length is much longer than average: [pai 3312] 北 north; [ts* 3312] 作 make.

**Tone IVb** (yang ru): low-dipping. This tone has similar prosodic characteristics to tone IVa, but its pitch onset lies slightly lower: [pa 2212] 白 white; [wu 2212] 學 learn.

The eight Wz tones thus comprise upper ("a") and lower ("b") values of the same four pitch shapes: level (tones Ia and IIIb); rising (tones IIa and IIb); falling (tones IIIa and Ib); and dipping (tones IVa and IVb). Length also appears to be an important auditory dimension for some tones. Thus the high-rising tone IIa is notable for its shortness, and the low-level and dipping tones IIIb, IVa and IVb sound overlong.

The upper and lower Wz citation tones are distributed in typical Wu fashion with respect to several segmental and suprasegmental features of the syllable,
in particular the manner of articulation of syllable-initial obstruents, and phonation type. Like other Wu dialects, Wz has three morphophonemically separate sets of syllable-initial stops (voiceless aspirated; voiceless unaspirated; and voiced), and two sets of syllable-initial fricatives (voiceless and voiced). The first two sets of stops occur on syllables with the upper ("a", or Yin) tones and are realised by voiceless aspirated and voiceless unaspirated allophones. The third set of stops, which co-occurs with the lower ("b", or Yang) tones, has different realisation depending on position in the word. Word-initially, the third series of stops is realised in this corpus predominantly by voiceless, coincident VOT articulations, but there is a small amount of free variation with VOT lead tokens, although not in the citation monosyllables. So for example three consecutive tokens for the word stomach 肚皮 were read [təy bei dəy bei dəy bei 342 21], with the alveolar stop in the first syllable of the word having coincident VOT in the first token, and very clear voice onset lead in the second two. Word-internally the realisation of the third morphophonemic series of stops is usually modally voiced, although this is also somewhat sensitive to stress placement.

The same applies mutatis mutandis to the two morphophonemic sets of fricatives: voiceless in upper, "a" tones; voiced word-internally, and voiceless in free variation with voiced word-initially in lower, "b" tones. (Unlike stops, in this corpus, some monosyllabic citation forms have a fully voiced realisation). So for example the three consecutive tokens for the word sin 罪過 were read [sai ku zai ku zai ku 343 1], with the alveolar fricative in the first syllable of the word being voiceless in the first token, and voiced in the second two.

In this paper, the morphophonemically voiced series of obstruents are phonologically transcribed with voiced symbols.

In Northern Wu dialects, it is well known that phonation type is an additional feature correlating with tone, and the term 'murmur' is often encountered in this connection. This refers to a different, usually whispey-voiced phonation type, which occurs at the onset of the low (Yang) tones. Phonation-type differences
of this kind are also audible in the present data, although they are very much less salient than the phonation types I have encountered in the North, especially in Zhenhai dialect (Rose 1989). Cao and Maddieson (1992) were also able to find aerodynamic and acoustic evidence for a different, more breathy, mode of phonation in the Wz low-level tone than in the high falling tone. It seems to be generally assumed (e.g. Cao & Maddieson 1992) that this breathy phonation is a property of the syllable-initial stops. This view, however, is incorrect. As explicitly pointed out for Zhenhai (Rose 1989), and Shanghai (Sherard 1972: 87), the breathy phonation occurs on all lower tones, irrespective of what, if anything, fills the onset slot. The same applies to Wenzhou.

Figure 1 shows the mean F0 values of the speaker’s citation tones plotted as a function of absolute duration. It can be seen that the tonal F0 shapes generally reflect my transcribed pitch and length shapes well (the short falling offset perturbations observable on tones with final rising pitch (IIa, IIb, IVa, IVb) and the low level tone IIIb are not audible as pitch contour).

![Figure 1. Mean F0 shapes for the eight Wenzhou citation tones.](image-url)
3.2 Citation Tones: Tonological Representation.

Tonological representation in Asian languages using a combination of tonal register and tonal melody Yip (1980) is now widely accepted. The Wz data presented above, with their upper and lower versions of the same four pitch/F0 shapes, seem a particularly clear instance of the realisation of this framework. Thus the high falling and mid falling tones IIIa and Ib would be represented as upper [+U(pper)] and lower [-U] register versions of the same HL tonal sequence; the high rising and low rising tones IIa and IIb would be upper and lower register versions of a LH sequence; the dipping tones IVa and IVb would be [+U, HLH] and [-U, HLH], and the mid and low-mid level tones Ia and IIIb would be [+U, L] and [-U, H] respectively. However, evidence from morphotonemic alternations in Wz tone sandhi points to another interpretation of the difference between the high and low register tones. These alternations will now be described.

4. TONE SANDHI

The Wz tone sandhi phenomena that are of importance in this paper concern the changes that take place on the tone of the first syllable in disyllabic words with these six first syllable input tones: high falling (IIIa), low level (IIIb), high rising and low rising (IIa and IIb respectively), mid level (Ia), and mid falling (Ib). In the case of the input tones IIIa, IIIb, IIa, and IIb, these changes take place before all input tones on the second syllable except the two dipping tones IVa and IVb. In the case of Ia and Ib, the changes take place only before second syllable input tones IIa and IIb.

It is worth pointing out here that the natural class of IIa and IIb -- the set of second syllable tones which condition the changes in tones Ia and Ib -- is readily definable as rising (or LH). It is also possible to use Yip's (1989: 155) notion of 'extra-complex tone' (called here complex tones) to define, albeit negatively, the natural class of IIIa, IIIb, IIa, IIb, Ia and Ib -- the class of second syllable tones which condition the main changes that take place -- as [-complex]. It is not possible to define the natural class of Ia and Ib, -- the class of first syllable tones which change before LH (i.e IIa and IIb). Neither is it possible to define the natural class of IIIa, IIIb, IIa and IIb, -- the class of first
syllable tones which change before [- complex] second syllable tones. These groupings immediately highlight some typical problems for Wu that have to do with the phonetic definition of natural tone classes.

The sandhi affecting the first syllable tones will be dealt with in order of complexity. This means the high register tones come first, starting with the high falling IIIa. The low register tones follow.

Table 1. Examples of Wenzhou tone sandhi in combinations with high falling input tone IIIa on the first syllable, and non-complex input tones (Ia, Ib, Ia, IIb, IIIa, IIIb) on the second.

<table>
<thead>
<tr>
<th>Tone Combination</th>
<th>Example 1</th>
<th>Example 2</th>
<th>Example 3</th>
<th>Example 4</th>
<th>Example 5</th>
</tr>
</thead>
<tbody>
<tr>
<td>IIIa + Ia</td>
<td>quick + ts'ho 33 vehicle -&gt; k'h ts'ho 53 22 express train</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>IIIa + Ib</td>
<td>great + ben 331 peace -&gt; t'a ben 32 12 peace</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>IIIa + IIa</td>
<td>to report + tsei 45 paper -&gt; pa tsei 53 23 newspaper</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>IIIa + IIb</td>
<td>to report + zei 114 agency -&gt; pa zei 53 23 newspaper office</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>IIIa + IIIa</td>
<td>to act + tou 51 struggle -&gt; feŋ tou 52 1 struggle</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>IIIa + IIIb</td>
<td>to explode + da 222 bomb -&gt; tso da 53 22 bomb</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

4.1 Changes to High Register Tones IIIa, IIa, Ia.
4.1.1 Input high falling tone (IIIa) on first syllable. In combinations with the input high falling tone IIIa on the first syllable, and any tone except IVa and IVb on the second, the first syllable has a high falling pitch, unless the second
syllable has input tone lb, in which case the first syllable tone has a lower falling pitch. Examples are given in table I, which shows for example that when the high falling IIIa tone is combined with the mid level la tone in a word like [kʰa tsʰo] 乘客 express train, the resulting pitch is [53 22]. Most examples in table I are compound words with morphological structure of the semantically defined 'synonym' or 'modifier-head' type (Kratochvil 1968:7(t ff.).

From table I it can be seen that all first syllables except before input tone lb have high falling pitched tone, with a lower pitch offset before input tone IIIa. On the second syllable, contrasts between level tones Ia and IIIb appear to be neutralised and realised as a low level [22] pitch. Tones IIa and IIb are neutralised to a short low rising pitch tone [23], and tone lb sounds a little lower: [12]. The short and low realisation [1] of IIIa looks as if it may be atonic, and as such may be part of a spread first syllable tone, as is commonly found in Northern Wu. This looks especially plausible given the [52] fall on the first syllable. However, comparison with data to be presented shows that it is better considered as the realisation of a low falling pitch target, the onset of which has been truncated by its voiceless syllable-initial consonant.

All the second syllable tones are rather narrowly realised in the lower third of the speaker's range. This is undoubtedly due to the effect of the falling contour on the preceding syllable, and possibly to utterance-final intonation and/or stress effects as well.

Figure 2 shows the mean F0 shapes corresponding to these high (and low) falling pitches on the first syllable. For comparison, the mean F0 shape for high falling citation IIIa is also shown. Seven shapes are shown - one for the low falling allotone before input tone lb; five for the high falling allotones before input tones Ia, IIa, IIIb, IIIa, and IIIb; and one for the high falling IIIa citation tone. All second syllable b tones have a voiced syllable-initial consonant (see 3.1 above).
Figure 2 shows that the high falling allotones and the high falling citation tone $F_0$ form one group clearly separate from the lower $F_0$ shape of the lower falling allotone before $Ib$. The former group displays the same level-falling $F_0$ contour which onsets at about the same position in the speaker's $F_0$ range, but which is truncated at different durations, yielding slightly different $F_0$ offset values.

As expected, $F_0$ before voiceless consonants lasts slightly shorter than before voiced, *ceteris paribus*. However, it can be seen that the $F_0$ is longer and offsets lower on syllables before the short low [1] pitch of input IIIa on the second syllable. (Subsequent data will show that this is also the case before the short low [2] realisation of $Ib$ on the second syllable.) I do not know why these low pitch targets should differentially condition first syllable rhyme duration in this way.

![Figure 2](image)

Figure 2. Mean $F_0$ and duration for high falling citation tone IIIa, and first syllable input tone IIIa before non-complex second syllable tones.

Since the input tone on the first syllable is high falling, the obvious tonological interpretation for all of the cases above except before $Ib$ is one of a citation high falling tone target, with allotones conditioned by voicing on the following consonant, and pitch target on the following syllable. 'Citation target' is one of the categories of relation between citation tones and tones in sandhi, and refers
to cases where a tone in sandhi 'can be identified as one of the citation tones, once allowance is made for intrinsic influence of various conditioning factors...' (Rose and Toda 1994: 271). Tonologically, then, no change to the high falling input tone IIIa is involved in these combinations. The tonological interpretation of the low falling F0 shape that occurs before input tone Ib appears to involve a kind of assimilation in tonal register:

(1) [+Upper, HL] \rightarrow [-Upper] / ___ [-Upper, HL].
(The Upper register falling tone IIIa changes to low falling before the low falling tone Ib.)

However, the phonetic motivation for this change is not clear. Because the change does not occur before all low register tones the environment has to specify [HL], yet Ib actually surfaces, as shown in table 1, as low rising [12]. An interpretation of the change in terms of categorical shift appears to be clearer, viz: tone IIIa \rightarrow Ib / ___ Ib, although the change is still phonetically unmotivated.

4.1.2 *Input high rising tone (IIa) on first syllable.* In combinations with the input high rising tone IIa on the first syllable, and any tone except the complex IVa and IVb on the second, the first syllable has a high falling pitch. This is therefore just like the previous \textit{example} with input IIIa, except for combinations with input Ib on the second syllable. In these combinations, there is no separate lower falling pitch on the first syllable, and the second syllable, with input Ib, has a short low falling pitch, and thus merges with input IIIa (the difference in pitch between [21] for input Ib and [1] for input IIIa is conditioned by the voicing on its syllable initial consonant). This means that contrasts between the six input tones on the second syllable appear to be neutralised to three tones: level (merged Ia & IIIb), rising (merged IIa & IIb) and falling (merged IIIa & Ib). Examples are given in table 2. Note that all first syllables have high falling pitched tone, with lower offset before [1] and [21].
Figure 3. Mean F0 and duration for first syllable input high rising tone IIa before non-complex second syllable tones.

Table 2. Examples of Wenzhou tone sandhi in combinations with upper rising input tone IIa on the first syllable, and non-complex input tones (Ia, Ib, IIa, IIb, IIIa, IIIb) on the second.

| IIa + Ia | pʰu 45 | common | tʰʊŋ 33 | general | → | pʰu tʰʊŋ | common |
| IIa + Ib | pʊŋ 45 | root | nʊŋ 33 | ability | → | pʊŋ nʊŋ | instinct |
| IIa + IIa | kə 45 | draft | tseɪ 45 | paper | → | kə tseɪ | manuscript |
| IIa + IIb | ʃə 45 | small | mei 114 | rice | → | ʃə mei | millet |
| IIa + IIIa | tie 45 | do | pa 51 | to dress | → | tie pa | makeup |
| IIa + IIIb | tsz 45 | particle | da 222 | bomb | → | tsz da | bullet |
The acoustics corresponding to the first syllable input IIa forms just discussed are shown in figure 3. It can be seen that the mean F0 shapes of these input IIa tones do not differ in any systematic way from that of the IIIa input tones in figure 2, except that there is no separate lower F0 corresponding to the F0 of input IIIa before input tone Ib. It can also be seen that F0 shapes before the [1] and [21] reflexes of IIIa and Ib are about 10 csec. longer than the rest.

The near identity in acoustic values between the input IIa and input IIIa tones confirms the auditory impression that the input high rising tone IIa changes to high falling tone IIIa before all except the complex tones IVa and IVb. Structurally, this results in a neutralisation of the high rising and high falling tones IIa and IIIa in favour of the high falling tone IIIa before tones other than IVa and IVb. Given the tonological representation outlined in section 3.1, this change is in the tonal melodic component, with the tonal register constant, thus:

(2) [+Upper, LH] -> [HL] / _ ~ HLH  
(The upper register rising tone changes to falling before any non-complex tone.)

This also does not appear to be a very well motivated rule phonetically: it is difficult to see why the presence of any following non-complex tone (comprising rising, falling and level pitch shapes) should induce a change from rising to falling tone on the preceding syllable. Perhaps it is (just) possible to see here some kind of assimilation in complexity: a change to a less complex (i.e. falling) tone before non-complex tones?

4.1.3 Mid level Input tone Ia on the first syllable. As pointed out above, a mid level input tone also changes to high falling on the first syllable, but only before the rising pitch tones IIa and IIb. Examples are given in table 3, and figure 4 shows the mean F0 of these tones.
Table 3. Examples of Wenzhou tone sandhi in combinations with mid level input tone Ia on the first syllable, and rising input tones (IIa, IIb) on the second.

<table>
<thead>
<tr>
<th>Ia + IIa</th>
<th>tsz 33</th>
<th>money</th>
<th>pwj 45</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>capital</td>
<td>-</td>
<td>capital</td>
</tr>
<tr>
<td>Ia + IIb</td>
<td>?y 33</td>
<td>peaceful</td>
<td>zuj 114</td>
</tr>
<tr>
<td></td>
<td>quiet</td>
<td>-</td>
<td>quiet</td>
</tr>
</tbody>
</table>

Once again, the near identity in acoustic values between the input Ia and input IIIa tones (in figures 2 and 4) confirms the auditory impression that the input mid level tone Ia changes to high falling tone IIIa before the rising tones IIa and IIb. Structurally, this results in a neutralisation of the mid level and high falling tones Ia and IIIa in favour of the high falling tone IIIa before IIa and IIb. Given the tonological representation outlined above, this change is again in the tonal melodic component, with the tonal register constant, thus:

(3) [+Upper, L] -> HL / _ LH

(The upper register level tone changes to falling before any rising tone.)

Figure 4. Mean F0 and duration for first syllable input mid level tone Ia before rising second syllable tones.
Again, it is not easy to see any phonetic motivation here. An assimilation in offset, whereby the offset of the level tone is lowered in anticipation of the low onset of the following tone would make sense only if the representation of la were \([+U, H]\), instead of \([+U, L]\) viz: \(H \rightarrow HL /_LH\). Perceptually and acoustically, however, la is clearly a mid tone, not high.

4.1.4 Summary: high register tones. The sections above looked at the upper register tones IIIa, IIa, and Ia, and showed how high-rising tone IIa and mid-level tone Ia change to the high-falling IIIa before different subsets of tones on the following syllable. IIIa also changed to an unspecified low falling tone before input tone Ib. Since, as was pointed out, it is difficult to motivate these changes phonetically, they can be best summarised using the tone categories as follows:

\[
\begin{align*}
1. & \text{ IIIa } \rightarrow \text{ Ib } /_Lb \\
2. & \text{ IIa } \rightarrow \text{ IIIa } /_L\text{Ia, Ib, IIa, IIb, IIIa, IIIb} \\
3. & \text{ Ia } \rightarrow \text{ IIIa } /_L\text{IIa, IIb}
\end{align*}
\]

Previous descriptions of Wz disyllabic tone sandhi (Qian 1992: 655; Zhengzhang 1964b, 1980; Chen 2000: 478), are generally in good agreement with the changes to the high register first syllable tones described above, and show changes to a high falling tone with the same pitch as citation IIIa ([42] or [52]). The main difference is that Zhengzhang does not show the changes occurring before Ila/b, which he shows as grouping with the complex IV tones in evincing different changes on the first syllable\(^8\). As in the present data, Qian, Zhengzhang and Chen all show a separate change for IIIa before Ib, but with different realisations: Qian shows a change to Ia [44], Zhengzhang and Chen to [22]/[11]/L. Zhengzhang (1964b) also mentions that the [42] realisation of IIa and IIIa is in between-speaker free variation with a lower [31] fall.

The following sections will examine changes to the corresponding non-complex lower register tones IIIb, IIb, and Ib in the same environments as the upper register tones.
4.2 Changes to the Lower Register Tones IIIb, IIb, Ib.

When considered in conjunction with the changes just described to the upper register tones, the behaviour of the low register input tones IIIb Ib and IIIb on the first syllable indicates that the tonological representation is best augmented in Wz with a component indicating a depressor effect (abbreviated as D), with a feature composition to be discussed below. This manifests as a lowered onset to an otherwise unchanged F0/pitch contour. The changes will be presented in the same order as for the upper register tones, viz: IIIb, IIb, and Ib, but tonological interpretation will be deferred until all relevant data have been presented.

Table 4. Examples of Wenzhou tone sandhi in combinations with high falling input tone IIIa on the first syllable, and non-complex input tones (Ia, Ib, IIa, IIb, IIIa, IIIb) on the second.

<table>
<thead>
<tr>
<th>IIIb + Ia</th>
<th>locality + xwo 33</th>
<th>place -&gt;</th>
<th>place 343 22</th>
</tr>
</thead>
<tbody>
<tr>
<td>IIIb + Ib</td>
<td>the earth + dzau 331</td>
<td>ball -&gt;</td>
<td>earth 342 21</td>
</tr>
<tr>
<td>IIIb + IIa</td>
<td>character + ti 34</td>
<td>scholarly book -&gt;</td>
<td>dictionary 343 23</td>
</tr>
<tr>
<td>IIIb + IIb</td>
<td>apparent + i 24</td>
<td>likeness -&gt;</td>
<td>phenomenon 343 23</td>
</tr>
<tr>
<td>IIIb + IIIa</td>
<td>va 222</td>
<td>rice + ti 51</td>
<td>shop -&gt;</td>
</tr>
<tr>
<td>IIIb + IIIb</td>
<td>va 222</td>
<td>outside + dei 222</td>
<td>locality -&gt;</td>
</tr>
</tbody>
</table>

4.2.1 Input lower level tone (IIIb) on first syllable. The lower level input tone IIIb changes to a convex pitch before all tones except the complex IVa and
IVb. There is one exception: if the input tone on the second syllable is IIIa, the convex pitch on the first syllable tone is lower. These changes thus largely parallel those for the upper register tone IIIa in conditioning environment in that they take place before all tones except IVa and IVb. They differ from the IIIa data in that a lowering effect takes place before an input IIIa, instead of an input lb tone (note that both of these are falling, however). Changes on the second syllable are the same as those for input IIa tones described above, that is, apparent neutralisation to a three-tone system of Ia and IIIb (level), IIa and IIb (rising), and IIIa and lb (falling). Examples are shown in table 4.

Figure 5 shows the acoustics corresponding to these convex pitch shapes on the first syllable with input tone IIIb. A set of convex F0 shapes can be seen, the offset and duration of which are conditioned in the same way as in the previous examples. The lower convex F0 shape of the IIIb tone before input IIIa is also clear.

Figure 5. Mean F0 and duration for first syllable input low level tone IIIb before non-complex second-syllable tones.

4.2.2 Input low rising tone (IIb) on first syllable. In combinations with the input low rising tone IIb on the first syllable, and any tone except IVa and IVb on the second, the changes are the same as with input tone IIIb on the first
syllable, except that there is no lower convex pitch before input tone IIIa on
the second syllable, the pitch of which merges with that of input IIIa. This
parallels the behaviour of the high rising tone IIa on the first syllable.

Second syllable tones are as for the previous example with IIIb on the first
syllable. Examples are given in table 5. Note that all first syllables have a
convex pitch tone. Figure 6 shows the acoustics corresponding to these first
syllable convex pitch shapes.

| Table 5. Examples of Wenzhou tone sandhi in combinations with lower
level input tone IIb on the first syllable, and non-complex input tones (Ia,
Ib, IIa, IIb, IIIa, IIIb) on the second. |
<table>
<thead>
<tr>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>IIb + Ia</td>
</tr>
<tr>
<td>vu 114</td>
</tr>
<tr>
<td>IIb + Ib</td>
</tr>
<tr>
<td>dey 114</td>
</tr>
<tr>
<td>IIb + IIa</td>
</tr>
<tr>
<td>vu 114</td>
</tr>
<tr>
<td>IIb + IIb</td>
</tr>
<tr>
<td>dey 114</td>
</tr>
<tr>
<td>IIb + IIIa</td>
</tr>
<tr>
<td>zai 114</td>
</tr>
<tr>
<td>IIb + IIIb</td>
</tr>
<tr>
<td>dei 114</td>
</tr>
</tbody>
</table>

4.2.3 Input mid falling tone on first syllable. Table 6 shows that the mid
falling input tone Ib changes to convex on the first syllable, but only before the
input rising tones IIa and IIb (which are neutralised to a low rise). This change
is therefore parallel to the change to the upper register mid level tone Ia.
Figure 7 shows mean F0 of these tones.
Figure 6. Mean F0 and duration for first syllable input low rising tone lb before non-complex second syllable tones.

Figure 7. Mean F0 and duration for first syllable input mid falling tone lb before rising second syllable tones.
Table 6. Examples of Wenzhou tone sandhi in combinations with lower falling input tone Ib on the first syllable, and rising input tones (IIa, IIb) on the second.

<table>
<thead>
<tr>
<th>Combination</th>
<th>Example</th>
<th>Transcription</th>
<th>Transcription</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ib + IIa</td>
<td>door + pa</td>
<td>办 + 帮</td>
<td>办 + 帮</td>
</tr>
<tr>
<td></td>
<td>board</td>
<td>板</td>
<td>板</td>
</tr>
<tr>
<td></td>
<td>(removable)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ib + IIb</td>
<td>form + i</td>
<td>形 + i</td>
<td>形 + i</td>
</tr>
<tr>
<td></td>
<td>likeness</td>
<td>形象</td>
<td>形象</td>
</tr>
<tr>
<td></td>
<td>image</td>
<td>形象</td>
<td>形象</td>
</tr>
</tbody>
</table>

4.4.4 Summary: changes to the lower register tones. The sections above have shown that a convex pitched tone emerges from word-initial morphemes that have the lower register non-complex input tones IIIb (low level), IIb (low rising), and Ib (mid falling). The changes take place before second syllable non-complex input tones in the case of IIIb and IIb, but only before the rising tones IIa and IIb in the case of Ib. A lower convex tone emerges from a IIIb input tone when followed by an input IIIa tone. These environments are comparable to the upper register tones where there is a change to the high falling tone IIIa. Structurally, the changes result in widespread neutralisation, on the first syllable, of the three low register tones in favour of a convex pitched tone. They can most conveniently be summarised using the tone categories as follows:

(5)

1. IIIb -> [high convex] / _ Ia, Ib, IIa, IIb, IIIb
2. IIb -> [high convex] / _ Ia, Ib, IIa, IIb, IIIa IIIb
3. Ib -> [high convex] / _ IIa, IIb

In contrast to the upper register tones, there is an important discrepancy between the published sandhi descriptions (Zhengzhang 1964b, 1980; Qian 1992; Chen 2000: 478) and the present data in the descriptions of the lower register tones. Changes to a convex pitch tone for input tones IIIb IIb and Ib
are not shown in any of the published sandhi descriptions, all of which show high falling pitch values that are exactly the same as those used to notate the corresponding upper register falling tones, and which therefore imply merger with the upper register high falling tone IIIa. A separate lower value for IIIb before IIIa is not noted in any of the descriptions either.

5. Disyllabic Shapes

In the sections above, it was pointed out that, from their pitch shapes, apparent neutralisation was taking place between subsets of second syllable tones defined by their Tonal Melody (Fall, Rise, Level). This section briefly examines the acoustic characteristics of these second syllables in the disyllabic combinations with the high falling and convex pitched tones on the first syllables, and describes the associated tonological changes.

![Figure 8a](image)

Figure 8a. Mean F0 shapes for high falling pitch on first syllable and input rising tones IIa and IIb on the second syllable.

5.1 Disyllabic shapes with high falling pitch on first syllable

Figure 8a shows the mean F0 shapes for combinations with a high falling pitched tone on the first syllable, and input rising tones IIa and IIb on the second; figure 8b shows high falling plus falling input tones Ib and IIIa on the second syllable; figure 8c shows high falling plus level input tones Ia and IIIb on the second. In figure
8c the F0 for the combination IIIa + lb has been omitted, because it does not involve a high falling shape on the first syllable. F0 shapes have been aligned at the onset of the Rhyme in the first syllable. Recall that the combinations with `a` tones on the second syllable have voiceless intervocalic segments, and those with `b` tones voiced intervocalic segments. The onset and offset of these voiced segments are shown by vertical lines.

\[ \text{Figure 8b. Mean F0 shapes for high falling pitch on first syllable and input falling tones lb and IIIa on the second.} \]

Figures 8a b and c show clearly how the absence or presence of voicing on the intervocalic segment conditions the first syllable rhyme duration and F0 offset. However, their most important feature is the F0 shapes on the second syllables. In figure 8a it can be seen that the F0 shapes of the input rising tones IIa and IIb on the second syllable are very similar. The F0 shape for IIb lies about 10 Hz lower than IIa at onset, after which the shapes converge until there is a smaller difference of 8 Hz at peak. T tests show the former difference to be significant (p = .015), but the latter not (p = 0.23).

The most important feature in figure 8a is that the difference between the F0 values of the input `a` and `b` tones on the second syllable is now small enough to be accounted for by the difference in modal voicing on the syllable-initial
consonant. (The same effect may be seen in Zhenhai (Rose 1990: 23 fig.6).) This finding is nicely in agreement with all sources (Zhengzhang 1964b: 108; 1980: 248; Qian 1992: 655; Chen 2000: 478), who show the same pitch values ([34]/[35]/MH) for both IIa and IIb input tones in this environment. The tonological inference for these data, therefore, is that the Tonal Register difference between IIa and IIb on the second syllable has been lost, and the result is a low rising pitch tone. (This tonal merger does not result in confusion of IIa and IIb morphemes, because the identity of most will still be guaranteed by the voicing specification on their initial consonant.)

Figure 8c. Mean F0 shapes for high falling pitch on first syllable and level input tones Ia and IIIb on the second syllable.

Figure 8b shows what looks like the same thing happening when input falling tones IIIa and Ib occur on the second syllable. It can be seen that there are very small differences indeed between the F0 of these two tones. In this case the falling input tones IIIa and Ib are merged by loss of register to a low falling pitch. This merger, with the pitch of the second syllable tone transcribed as [21]/[1]/ML, is also found in the published descriptions. An exception is that for the input tone combination IIa + IIIa, two sources note rather different shapes: Qian (1992: 655) has [44 24]; Zhengzhang (1964b: 108; 1980: 248) has [11 13], or [22 2].
The same pattern is again visible in figure 8c with the F0 shapes of the second syllable input level tones Ia and IIIb. There is a significant difference of about 10 Hz at onset, and subsequent convergence to a non-significant difference of 5 Hz by mid duration. In contrast to the case with the second syllable rising and level tones, however, coalescence of Ia and IIIb on the second syllable is not found in the published descriptions. The transcriptions of Zhengzhang (1964b: 108; 1980: 248), Qian (1992: 655) and Chen (2000: 478) imply that Ia still has a higher pitch ([33/44/M]) than IIIb ([11/22/L]).

5.2 Disyllabic shapes with convex pitch on first syllable  Figures 9a, 9b and 9c show the acoustic characteristics for combinations with a convex pitch tone on the first syllable. Figure 9a shows combinations with rising input tones IIa and IIb on the second syllable; figure 9b shows combinations with input falling tones IIIa and IIIb on the second syllable, and figure 9c shows combinations with input level tones Ia and IIIb on the second syllable.

![Diagram](image)

**Figure 9a.** Mean F0 shapes for convex pitch on first syllable and rising input tones IIa and IIb on the second.

It is clear that figures 9a and 9b show the same merger patterns on the second syllable that were observed for the combinations with the high falling pitched tones in the previous section. This speaker appears therefore to be showing
(for once!) a phonetically based merger of the rising and falling input tones on the second syllable, the result being a simple contrast between a (low) rising and (low) falling pitched tone.

Figure 9b. Mean F0 shapes for convex pitch on first syllable and input falling tones Ib and IIIa on the second.

Figure 9c. Mean F0 shapes for convex pitch on first syllable and level input tones Ia and IIIb on the second.
It is not clear whether this merger has also happened to the level input tones Ia and IIb. Although the amount of difference between the F0 of Ia and IIb after the high falling pitch (in figure 8c) is comparable to that for rising input tones IIa and IIb, and falling input tones IIIa and Ib, figure 9c shows a somewhat greater separation between the F0 values of level input tones Ia and IIb after the convex pitched tone. The ca. 13 Hz difference between the F0 values of the two second syllable shapes in figure 9c is not great, but is clearly significant (p = .011). A rather large F0 difference is also observable on the first syllable shapes.

Neither the second syllable nor the first syllable F0 differences in figure 9c are referrable to between-sample differences in intrinsic vowel F0, because both samples, for both syllables, are comparably constituted with respect to vowel height. The most plausible interpretation of the difference on the second syllable is, therefore, that it reflects an extrinsic tonal difference, and that the F0 difference on the first syllable reflects some kind of anticipatory assimilation of the F0 height on the second. It should be noted that this putative assimilation goes against expectation: the F0 of a tone on a preceding syllable usually dissimilates in height from that of a following syllable (Gandour et al. 1994; Xu 1997). It is possible therefore that this speaker is in the process of merging the two level tones on the second syllable, in parallel with the other two mergers of the rising and falling tones.

Irrespective of what is actually the case with the second syllable level input tones, however, the demonstrated mergers of IIa and IIb, and IIIa and Ib, are tonologically important, since they reflect a loss of tonal register (i.e. +/- Upper) on the second syllable. This is important, because at least one model for the geometry of tonological representations - Yip's (1989) 'dominance' model - has the Tonal Melodic component dependent on the Tonal Register. These Wenzhou data, however, evidence deletion of register with tonal melody intact, which shows that the tonal melodic component in Wz cannot depend on it in feature geometry. This is why I have not shown this dependency in the tone rules above.
6. DISCUSSION

In the sections above, I have described how upper register tones Ia, IIa, and IIIa change to high falling, and lower register tones Ib IIb and IIIb change to convex in parallel environments. Ila and IIIb also change to lower falling and convex pitches in restricted environments. In the following sections I shall propose an analysis of these changes. Two main points will be demonstrated:

• That the convex pitch of the first syllable low register input tones is accounted for by a depressor effect on a falling tone; and therefore all the first syllable tone sandhi phenomena described above involve a change in the tonal melodic component to a falling or [HL] tone.

• That tonal register changes, both from high [+Upper] to low [-Upper] and vice versa, are involved independently of the depressor effect.

6.1 Depressor Effect and Uniform Change to a Falling Tone.
There are several indications that the convex pitch/F0 sandhi tone which is associated with first syllable low register tones in Wenzhou is the result of a depressor effect on a falling tone.

6.1.1 Evidence for Depressor There is both phonetic and phonological evidence pointing to the involvement of a Depressor. As far as phonetic evidence is concerned, the Wenzhou data described above are very similar to non-controversial depressor effects in other languages. In Zulu, for example, a convex pitch results from the interaction of a falling tone and a depressor consonant (Rycroft 1963: 46ff).

Figure 10 shows examples of the F0 of a Zulu falling tone on a syllable with and without an initial depressor consonant. The words are induku *handkerchief* with depressor consonant and underlying falling (HL) tone on du, and umkakhe *wife* with a non-depressor consonant k and falling tone on ka (i and um are noun class prefixes; the speaker is a male). It can be seen that the undepressed falling tone on ka has a clearly falling F0, and the depressed falling tone on du has a convex F0 shape similar to the Wenzhou examples. The magnitude of
depression is also comparable. In the Wenzhou data, the mean difference between the onset of the convex F0 and its peak is 40Hz. This is rather large, representing between a third and a half of the speaker's effective F0 range. Comparable values can be seen in the Zulu tokens. The typical lack of voicing on the depressor consonant d can also be seen from the lack of periodicity in the audio. (It can be seen from comparison with the audio, and can be heard, that F0 on ku has been poorly extracted: it should lie around 100 Hz.)

Similar phonetic effects involving depression have also been observed in Tibetan (Kjellin 1976; Rose, in press), although this language is not usually analysed with depressor consonants.

![Figure 10](image_url)

**Figure 10.** Two Zulu words illustrating the F0 of a falling tone on the middle syllable (A) with, and (B) without, depressor consonants.

A = iduku [41 131 1]; B = umkakhe [4 41 1].

Recent tonetic research has shown that a depressor effect is commonly involved in distinguishing the upper and lower (Yin/Yang) reflexes of Middle Chinese tones in Wu. Zhu and Rose (1998), for example, give mean F0 shapes for the tones of four central Zhejiang Wu dialects which show historical pairs
of tones differing in the lowering of pitch, and F0, at onset. In addition to examples very similar to Wenzhou, e.g. Pujiang [51] and [231] (Ia/b), there are examples of depressors on tones with other shapes, e.g. Pujiang [323] vs [2323] (IVa/b), shown in figure 11a, and Tonglu [43] vs. [133] (Ia/b), shown in figure 11b. The six citation tones of Zhenhai (Rose 1990) also clearly factor

![Figure 11. Mean F0 shapes of depressed and non-depressed onset tones in the Zhejiang Wu dialects of Pujiang (A) and Tonglu (B). (From Zhu & Rose 1998).](image-url)
into three pairs distinguished by depression. Multispeaker acoustic data on Shanghai (Rose 1993: 194,195) also show that the lower tones are not overall lower as is described in nearly all the literature, e.g. Yip (1992: 251), but actually have very similar peak F0 values -- like Wenzhou tones IIa and IIb -- and are better described as having a lower, i.e. depressed, onset. It seems possible therefore that what has been generally referred to as murmur in Wu dialects might be better phonetically described as depression.

Indirect evidence that the rising part of the convex pitch may not be tonal is also suggested by the native speaker transcriptions. It was pointed out above that no mention is made of a convex pitch on input IIb and IIb either in Zhengzhang's (1964b; 1980), Qian's (1994) or Chen's (2000) description of Wz tone sandhi, where generally no differentiation between input b tones and input a tones on first syllables is shown. This may point to a differential perception of pitch features on the part of native speaker transcribers (Qian and Zhengzhang are in addition native Wu speakers). It is also possible, of course, that the effect was for whatever reason simply not present in the data that they transcribed.

The simplest piece of phonological evidence for the Depressor is that, according to Yip (1989:154-5) there is a tendency for extra-complex tones in Chinese and African languages to be restricted to domain-final position. The word-initial occurrence of clear convex pitch in Wenzhou would be an exception to this, were the pitch to realise exclusively tonal features.

Positing a depressor also makes sense phonologically. It has been shown above in section 4.1 that a change to a falling tone is demonstrably involved in the sandhi in the high register tones. Since the environments that condition the convex pitch in the lower register tones are almost identical to those that condition the fall in the upper, it is possible, by positing a depressor, to factor out the rising component of the convex pitch and capture the simplifying generalisation that the discussed sandhi changes all involve a change to a fall.
6.2 Phonological Integration of Depression

The sections above have presented evidence for the involvement of a Depressor in Wenzhou. Certain aspects of its phonological integration can now be briefly discussed.

6.2.1 Feature composition. Depression is characterised by local low F0, which results in lowered pitch onset; noise from some kind of direct current component in the glottal flow, which is responsible for the breathy voice percept; and usually voicelessness under conditions of increased supraglottal resistance resulting in predominantly voiceless obstruents word-initially. These can be described, although not to complete satisfaction, with the Halle-Stevens features. These features account for laryngeal activity in terms of the two parameters of glottal aperture and vocal cord tension. The direct current airflow could be represented by a [+spread] value for aperture. Direct evidence of this for Shanghai comes from Ren (1995) who demonstrated with glottal transillumination that Shanghai has increased glottal aperture co-occurring with syllable-initial stops in murmured syllables. It might also be the case that the sensitivity to increased supraglottal resistance which results in voiceless obstruents is in part caused by the higher airflow resulting in quicker equalisation of transglottal pressure. To provide a low tension which would account for the low F0, [+ slack cords] might be appropriate, and indeed [+slack] was suggested by Keating for murmur (Yip 1992: 253 fn 10).

The representation of depression as [+slack, +spread] is not quite satisfactory, however, since this is also the Halle-Stevens representation for the Hindi 'breathy voiced' stops, and, as pointed out above, Wenzhou depressed obstruents are generally voiceless. To represent this, it would be necessary to assume a value of [-slack]. This, together with [-stiff] and [+spread] is how Halle and Stevens represent the Korean voiceless 'lenes' stops, which also have in common with Wu the fact that they become modally voiced word-internally. Thus a feature representation for Depression of [-/+slack, -stiff] and [+spread] would be appropriate, with the variation in voicing being shown by variation in the feature [slack].
6.2.2 Location in the prosodic hierarchy Presumably the same arguments as to where murmur belongs in the prosodic hierarchy will also apply to Depression. Murmur has, however, been the subject of considerable debate. Ren (1992:11) claimed for Shanghai that murmur was a property of the initial stop consonant, and Duanmu (1988) of the Onset slot, while for Yip (1992: 250) it is a property of the syllable. Zhu (1994: 29-34, 1999: 24-28) gives arguments for rejecting all these positions, and points to the fact that, since murmur only occurs word-initially -- or effectively word-initially as in the case of citation tones -- it is a property of the word, and is to be associated higher up in the prosodic hierarchy. This was also suggested to me by Ian Maddieson in 1991.

Implications of this analysis clearly need to be explored in greater detail, (although as a Chinese linguist I am reluctant to abandon the (syllabic) morpheme as the focus of all-important phonological information!). It has been shown for example that depression does not occur on non-initial syllables. If depression is considered a morphemic property, absence on non-initial syllables must be accounted for by deletion. But if depression were a word-level effect, deletion would obviously not be necessary. Since Depression has been shown to underlie the difference between many tonal pairs in Wu, the radical implication of a word-level interpretation of Depression is that there are many less tones in Wu than is traditionally assumed.

Although this would result in a considerable reduction, it would not necessarily result in a halving of Wu tonal inventory, because tonal register remains in some cases. The difference between the Wz high-falling and mid-falling tones IIIa and Ib, for example, cannot be accounted for in terms of a Depressor effect, since it will be shown below that the depressed version of the high falling tone is different from Ib. However, since tonal register contrasts are also restricted to the initial syllable of a word in Wz, acceptance of the word-level analysis of Depression would make it necessary to regard tonal register as a word-level property too.

Against the word-level analysis is the fact that it would make the intimate and obvious connection between word-initial depression and word-internal
obstruent voicing appear random. There would be no straightforward way to account for the fact that morphemes with voiced obstruents word-externally have depression word-initially, and morphemes that have voiceless obstruents word-externally lack depression. In addition, we need to know more about the phonological properties of less controversial edge effects, in order better to identify the more problematic cases. It still seems better to say, almost as Yip (1992: 249) does for Shanghai, that there are two types of morpheme in Wz: one which is associated with word-initial depression and (when they are present) word-medial voiced syllable-initial obstruents, and one that is not. This seems to identify depression (and Tonal Register) as a property of morphemes, which then has to be deleted on non-initial syllables.

6.2.3 Surface attachment Another important question concerns where precisely the Depressor is attached in the surface representation. It is initially attractive, given the existence of non-vocalic depressor segments (e.g. the Zulu depressor consonants), to see it attached to an onset segment. However, there are problems with this. As the examples in the tables above suggest, e.g. [i 222] 現 apparent, [i 114] 象 likeness, the Wz syllable does not necessarily have a segment in the onset slot. Other examples are the initial syllables in the words [i sz 343 22] 上司 boss; [e duoŋ] 343 23 行動 movement; [uŋ sz 343 23] 洪水 flood. To be sure, morphemes like these are traditionally transcribed in Wu with the voiced glottal fricative 'curly h' symbol, e.g. fî fê fîuŋ. However, as Sherard (1972: 42-58) and Zhu (1994: 32,33; 12-14) point out for Shanghai, and Rose (1982: 64-66) for Zhenhai, these morphemes clearly pattern phonologically as if they had zero initials, and not as if they had the voiced counterpart to the /h/ in the upper tones. This means that the only evidence for an onset phonological segment to associate the depressor to is the presence of the depressor effect itself. It appears therefore that the Wu dialects show a depressor that is not a property of a non-vocalic onset segment, and that the Depressor would simply have to attach to the first segment in the syllable.

Yip (1992: 252-254, 266) points out that murmur in Shanghai has a closer affinity to tonal than to laryngeal properties of the onset because it deletes, like
INDEPENDENT DEPRESSOR AND REGISTER EFFECTS

Tone, on non-initial syllables. To reflect this she proposes a double attachment of murmur to laryngeal and tonal root nodes. Whether this is an appropriate analysis of the feature-geometrical position of Depression depends on its level in the prosodic hierarchy. This is because, as pointed out above, a word-level analysis would imply no deletion, which is Yip's main argument for the double attachment of murmur.

6.3 Tonal Register Changes

We now turn to the analysis of Wz tonal register. It will be argued that the convex pitches [343, 342], which are the sandhi forms of the low register tones in the vast majority of cases, are part of the manifestation of a depressed falling tone with high register, that is [+D, HL, +U]. In other words, there must also be a change in word-initial syllables, not only in the tonal melodic component to HL, as demonstrated in sections 4.1 and 4.2 above, but also in the tonal register to +U.

The evidence for this is as follows. Firstly, tonal register is assumed by most researchers to be binary. It was demonstrated above that two convex tones -- a lower [232] and a higher [343/2] -- result from the sandhi (the lower is the sandhi tone of IIIb before IIIa.) This requires the higher convex tone to be upper register.

The second phonological argument for a change to a high register is also from logical necessity. If the low register specification of low register input tones were not changed in sandhi, forms would result that would not be distinguishable from the low register convex tone. For example, the lower level tone IIIb is represented as a low register high tone with depressor: [-U, H, +D]. A change only in the tonal specification to HL would result in [-U, HL, +D]: a low register falling tone with depressor. This is, however, the representation of the lower convex tone, which is the sandhi tone of IIIb before IIIa. In order to derive the appropriate surface form for the sandhi tone of IIIb -- the higher convex pitch -- the register must be changed to +U.
6.4 Lower pitches of IIIa and IIIb before Ib and IIIa.

One more problem remains to be addressed: the lowered pitches that occur in combinations of input tones IIIa and IIIb before input tones Ib and IIIa. Recall that when followed by input tone Ib, IIIa on the first syllable is realised by a low falling [32] pitch (table 1), and IIIb on the first syllable is realised by a low rise-fall [232] pitch before IIIa on the second syllable (table 4). The first change was interpreted in section 4.1.1 as an assimilation in register. The second appears to be the usual change to a falling (HL) tone, but without the change to high register, thus:

(The low level tone IIIb changes to a fall before the high falling tone IIIa)

Note that the depressor is not deleted, and stays the same as for the input first syllable tone. The result is that a depressed low falling tone surfaces.

6.5 Conclusion

It has been shown above that what is happening structurally in the portion of Wz tone sandhi described in this paper is a neutralisation on the first syllable of the tonal melodic and register components in both upper and lower tones II and III, and tone I in certain environments, in favour of an upper register falling tone, with unchanged depression specification. This could be described by a rule affecting the tonal root node, thus:

(7) tone -> HL, +U /_ ~HLH

Such a rule will change, for example, the high rising tone IIa to a high fall, and the low rising tone IIb to convex. Since tone IIIa is [+U, HL], in terms of categorical shift (Ballard 1988a/b; Rose and Toda 1994) this could be interpreted as a change of all non-complex tones to tone IIIa before all non-complex tones.

The changes associated with tones IIb and IIIb, and Ib before II, are different from those which occur with their upper counterparts IIa, IIIa and Ia in that the
surfacing low convex tone is not a citation target. However, the coherence of the sandhi behaviour lies in the fact that the convex tone and the high falling tone IIIa differ in the +/- depressor effect, which is revealed in the emergence of a new, non-citation tone.

The change to an upper register falling tone, together with the depressor, accounts for about half of the sandhi changes that occur on the first syllable in Wz disyllabic lexical expressions. Although there is no space to document the changes affecting the non-complex tones before complex tones IVa and IVb, it will be of interest to note that they appear to be equally simple, and involve a change to an upper register rising tone -- in categorical terms, to tone IIa. As far as the tones on the second syllable are concerned, the changes are simple: tones sharing the same contour merge, reflecting loss of Depression and tonal register.

Despite the simplicity of the first syllable sandhi changes, it should not be forgotten that, as has been continually pointed out, they show a typical lack of phoneticity. It is not possible to phonetically define the several important natural classes that are involved, for example the class of tones that condition the changes of II and III to high falling (section 4.0), or the class of tones (Ia and Ib) that change to high falling only before II. In intriguing contrast to this, of course, are the clearly phonetically motivated changes that occur on the second syllable tones, where patterns of merger are based on contour.

7. SUMMARY

The paper has presented an analysis based on new auditory and acoustic data from Wenzhou dialect which demonstrates the existence of a Depressor. It has shown how, in conjunction with changes to tonal register and melody, the presence of a Depressor elegantly accounts for observed complex word-initial morphophonemic alternations, and renders the tone sandhi somewhat simpler than has been previously assumed. The paper has also suggested that what has previously been called murmur in Wu is actually Depression. Previous work (Yip 1992) has already demonstrated the independence of Tonal and Phonation Registers in Wu, but in separate varieties. The Wenzhou data,
however, constitute language-internal evidence for the independence of Phonation and Tonal Register in Wu. Most importantly, they show that depression can occur with high register tones.

The paper has also briefly examined some of the phonological problems associated with Depression: its place in the prosodic hierarchy; its feature composition; and where it associates on the surface. It has shown that, despite phonetic similarity to other languages with depression, the Wenzhou, and possibly Wu, depressor is neither associated with, nor a property of, a non-vocalic segment.

NOTES

1. This is a much expanded version of my paper (Rose 1994) given at the 5th Australian International Conference on Speech Science and Technology (SST 94). I should like to thank my anonymous reviewer for giving their time to make it a better paper, and William Ballard for making available his Wenzhou recordings.


3. Tonal register, which divides the speaker's phonological pitch range into two, is one of the three senses of the word register identified by Yip (1993: 245). Yip also recognises a Phonation Register: a phonation type which behaves tonally, and which is created by the double attachment of laryngeal features to laryngeal and root nodes (p.266). It may be better to reserve the term Phonation Register for languages with contrastive phonation types independent of tone, and use, after Bradley (1982: iv), the term Tonation Register for this tonally related phonation.

4. The recordings were made by Ballard in China in 1988.

5. Simultaneously transcribing detailed differences in both tonal length and pitch contour is a problem, and I have adopted the following method. Relative length is indicated in level pitch tones conventionally by the number of integers. Thus two integers, e.g. [33], imply a default average length. For contour pitch tones, I have followed conventional usage in underscoring to indicate shorter duration, thus [45] sounds shorter than [45]. It seems useful,
however, to extend these conventions by assigning explicit timing values to the integers, making each integer equal to half a beat, and underscoring equal to a quarter beat. Thus [321], or [114], indicate a pitch which sounds to have the same duration as a two integer level tone, e.g. [33]; [51] sounds a little shorter than [33]; and [222], with underscoring arbitrarily marked on the last integer, a little shorter than [3312].

6. Cao & Maddieson (1992) crucially failed to examine syllables without an initial consonant, and so logically cannot claim a causal relationship between stop and phonation type.

7. One discrepancy is in the length of the (idiosyncratically short) upper rising tone IIa, which sounds shorter than the upper falling tone IIIa, but which is only a little shorter in acoustic duration. This is presumably because of perceptual allowance for intrinsic variation, cf. perceptual allowance for intrinsic differences in vocalic F0 (Hombert 1978: 99). The F0 in rising tones is known to generally have longer duration, ceteris paribus, than in falling tones (Ohala 1978: 31), therefore the Wz high rising tone sounds shorter, relative to the falling tone, than is warranted by its acoustic duration.

8. Zhengzhang notates the sandhi tones before II and IV as high falling [53] (1980: 248) or [43] (1964b:108). Fortunately, Zhengzhang (1980:247) emphasises that the [53] before II and IV is glottalised and short, and sounds very different to the [42] before I and III, otherwise it would be very difficult to sort out the various high falling shapes [53, 43, 42] he describes. In the present data, and Qian (1992), there is a change of all non-complex tones to a high rising pitch (i.e. IIa) before complex tones. I suspect therefore that Zhengzhang's glottalised [53]/[43] corresponds to this high rising tone.

9. The Halle-Stevens features might not be sufficient to capture additional correlates of depression in other Wu dialects, e.g. strong medial compression and epiglottalisation in Zhenhai (Rose 1989).

REFERENCES


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INDEPENDENT DEPRESSOR AND REGISTER EFFECTS


ZHENGZHIANG S. 鄭張尚芳 1995. 溫州方言近百年來的語音變化


從温州方言變調看吳方言聲調學中互相獨立的壓抑機制和域域作用

摘要：本文是根據在對溫州方言的聲調和連讀變調觀察中獲得的新
的聲學數據所作的分析。這些數據證明壓抑機制，根據域域構 一
樣，是聲調學中一個獨立的成分。例如，本文顯示一個高聲的音
調會由於壓抑機制的作用而變為先昇後降[343 或 342]。本文將溫州
方言聲調的聲學特征與若干吳方言和祖魯語作了比較。本文建意
許多吳方言中所謂的murmur ("濁氣流")實際上是壓抑機制的結果，
但這種壓抑機制並不象在一些非洲聲調語言中常見的那樣與非元
音性成分有關。