THE DIFFERENTIAL STATUS OF SEMIVOWELS IN THE ACOUSTIC PHONETIC REALISATION OF TONE

Phil Rose

Phonetics Laboratory, Department of Linguistics (Arts), Australian National University

ABSTRACT

The distribution of tonal fundamental frequency is determined on syllables differing with respect to semivowels in their segmental structure for three of the contrasting tones from the Chinese Wu dialect of Zhenhai. Comparison with mean F0 and duration measurements from CV syllables demonstrates differential distribution of tonally relevant F0 with respect to the semivowel, conditioned by the absence or presence of a syllable-initial consonant. A functional explanation for the difference is proposed by relating it to a previous finding on the relationship between syllable-initial glides and intrinsic F0 transitions. Implications of the finding are explored for the phonological integration of semivowels into metrical syllable structure.

1. INTRODUCTION

The most basic dichotomy in the production of speech exists between the activity that occurs at the larynx and in the supralaryngeal vocal tract. In the former, voicing (including voicelessness), phonation types, and linguistic pitch for tone, intonation and stress are generated; in the latter the gestures that result in different vowel and consonantal quality. Speech sounds result from the precise timing of supralaryngeal and laryngeal events. This paper examines one aspect of the relationship between the supralaryngeal and laryngeal strands -- phonetic mapping between tone and segmental material. Previous studies of tone languages (Kratochvíl 1968:36 Howie 1974, Sauvian 1977, Rose 1982:47,48) have claimed on the basis of compared duration that the fundamental frequency (F0) on syllable-initial sonorants can be discounted from the domain of phonetic realisation of tone. This hypothesis is supported by the fact that F0 transitions between different tones on successive syllables take place over the syllable-initial sonorants, or indeed any voiced syllable-initial unit, like a glide or obstruent (Rose 1989).

Up to now, only the status of syllable-initial sonorants has been systematically investigated with respect to this feature. Many tone languages also have other voiced segmental constituents at syllable onset that are thus potentially tonally relevant. This paper examines the role of prevocalic semivowels ([j w œ]), and asks whether they can be said to constitute part of the material over which tonal F0 is distributed.

The tone language chosen for this investigation is Zhenhai (Zhènhǎi) -- a variety of Wu dialect spoken in northern Zhejiang province in China. In Zhenhai, as in most Wu dialects, there is an indeterminacy with respect to number of tonemes. This results from co-occurrence relationships between the number of surface tonal contrasts possible and both the segmental structure of the rhyme, and the manner of the syllable-initial consonant, which in turn is related to a possible depressor effect (Rose 1994). For the purposes of this paper, a 4 toneme solution will be assumed, the citation allotones of which have the following pitch shapes: high falling (tone 1), mid concave (tone 2), low convex (tone 3), and low rising (tone 4). Figure 1 shows mean F0 shapes for the allotones of these 4 tonemes on syllables consisting of a voiceless syllable-initial obstruent, followed by a long monophthong. F0 is plotted as a function of absolute duration. Values are from the speaker used in this paper and are taken from Rose (1982:12-16). It can be seen from figure 1 that the tonal F0 shapes resemble their pitch shapes closely, except for abrupt falls at the end of tones 2 and 4. These F0 perturbations are caused by a prosodic syllable-final glottal stop which is part of the realisation of tones with rising pitch in Zhenhai.

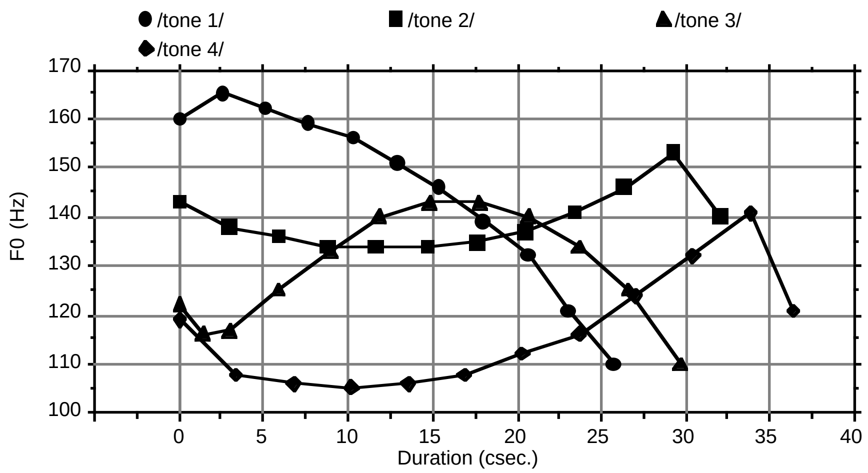

Figure 1: F0 values for 4 Zhenhai tonemes on syllables with voiceless initial obstruent and monophthongal vowel.

$$\text{syllable} = (\mathrm{C})(\mathrm{G})\left\{\begin{matrix} \mathrm{V:} \\ \mathrm{v}\left\{\begin{matrix} \mathrm{G} \\ \mathrm{N} \end{matrix}\right\} \end{matrix}\right\}$$

Figure 2: Segmental structure of Zhenhai syllables.

These four tonal pitch shapes can occur on syllables with the segmental structure shown in figure 2. That is, a Zhenhai syllable can consist segmentally of an optional initial consonant "C", followed by an optional semivowel (or glide) "G", followed by either a long monpththong "V:", or a short vowel followed by either a glide "vG" or a velar nasal "vN". Exponents of the set C of initial consonants are (voiceless) obstruents, or (voiced) sonorants. The prevocalic semivowel G can be /j/ /w/ and / œ /.

In order to investigate the way in which tonal F0 is distributed with respect to semivowels, the acoustical correlates of tone (F0, duration) were determined on syllables differing with respect to semivowels in their segmental structure. Four different syllable-structures were examined: unaspirated voiceless obstruent and monophthongal vowel ("CobsV") e.g. /ka 3/ eggplant; unaspirated voiceless obstruent followed by rising diphthong ("CobsGV"), e.g. /kwa 3/ bosom; rising diphthong ("GV") e.g. /wa 1/bad, and sonorant syllable-initial consonant and monophthongal vowel ("CsonV") e.g. /N a 4/ outside.

Tone	CobsV	CsonV	CobsV	GV
1	14	6	12	9
3	14	9	9	10
4	11	18	11	12

Table 1: Number of tokens measured per syllable type.

2. PROCEDURE

Syllables with the above four segmental structures were selected from a list of some 300 Chinese characters recorded at several sittings by a 25 year old male native speaker. Recordings were made in the phonetics laboratory of the Department of Linguistics at the University of Manchester. Tone 2 morphemes with CsonV and GV structure are lexically rare in Zhenhai, and there were too few recorded examples to be of use. Tone 2 was therefore not further analysed. The number of tokens analysed is given in table 1. F0 was measured with the method described in Rose (1982:7-9), which involved sampling at a rate high enough to resolve details of its time course over the whole voiced portion of the syllable.

3. RESULTS

Mean F0 values for the four different syllable types on the three tones are shown in figure 3. F0 is plotted as a function of absolute duration, and the F0 shapes are aligned at phonation offset in tones 1 and 3, and F0 peak in tone 4. The boundary between syllable-initial sonorant and syllable Rhyme in $C_{son}V$ syllables is shown by a vertical line.

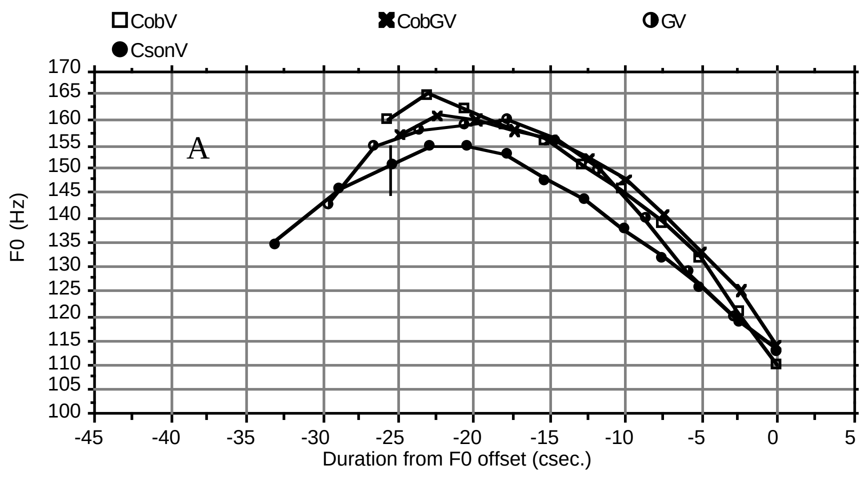

Figure 3: Mean F0 shapes for different syllable types in Zhenhai tone 1.

It can be seen from figure 3A that the mean F0 shapes of the four tone 1 syllable types all show the same contour for a duration of ca. 25 csec. before F0 offset. The shared contour consists of a short (ca. .3 csec.) rise, followed by a fall from an F0 peak located between 155 and 165 Hz to offset within a narrow 5 Hz range between 110 and 115 Hz. Over the first part of the fall, the shapes of the CobsV, GV, and CobsGV syllables are fairly tightly grouped, with the F0 of the CsonV type lying slightly lower. This duration over which the shared contour distributes corresponds to the Rhyme in CobsV, CobsGV and CsonV syllables. The 4 syllable types can be seen to form 2 groups with respect to duration of their F0 shape: CobsV and CobsGV syllables constitute one group, which is shorter by 5 - 10 csecs. than the CsonV and GV types. This is confirmed by a 90% significance level ANOVA on the duration values of the 4 types followed by post-hoc Scheffé tests, which shows no statistically significant difference in duration between CobsV and CobsGV syllables, or between GV and CsonV syllables, but that GV type syllables are significantly longer than CobsV syllables. During the extra duration of the CsonV and GV types, the F0 rises from an onset value some 20 Hz below peak F0 value.

These data show that in tone 1 the presence of a prevocalic semivowel makes no difference to the duration of the Rhyme nor the F0 shape if the semivowel is preceded by an obstruent consonant: CobsGV syllables are the same as CobsV syllables in this respect. In the absence of an initial obstruent, however, the presence of a prevocalic semivowel correlates with a longer duration, and a lower F0 onset, so that GV syllables resemble CsonV syllables in overall F0 and duration values.

A very similar pattern to tone 1 can be seen in the distribution of F0 shapes for convex pitched tone 3 in figure 3B. The mean F0 shapes of the 4 tone 3 syllables all show the same convex contour for a duration of ca. 30 csec. before F0 offset. This duration over which the shared contour distributes corresponds to the Rhyme in CobsV, CobsGV and CsonV syllables. Effectively the same two groups as in tone 1 emerge with respect to overall duration: CobsV and CobsGV, vs. GV and CsonV syllables. ANOVA shows no significant durational difference between CobsV and CobsGV syllables, both of which are significantly shorter than the GV and CsonV syllables. However, unlike in tone 1, CsonV syllables are significantly longer than GV syllables.

The grouping of CobsV and CobsGV syllables against GV and CsonV syllables can be seen once again for the concave pitched tone 4 data in figure 3C. ANOVA shows that CobsV and CobsGV syllables do not differ significantly in duration at 90%; neither do GV and CsonV syllables, but the two groups of sonorant- and glide-initial types and CobsV and CobsGV types remain significantly different.

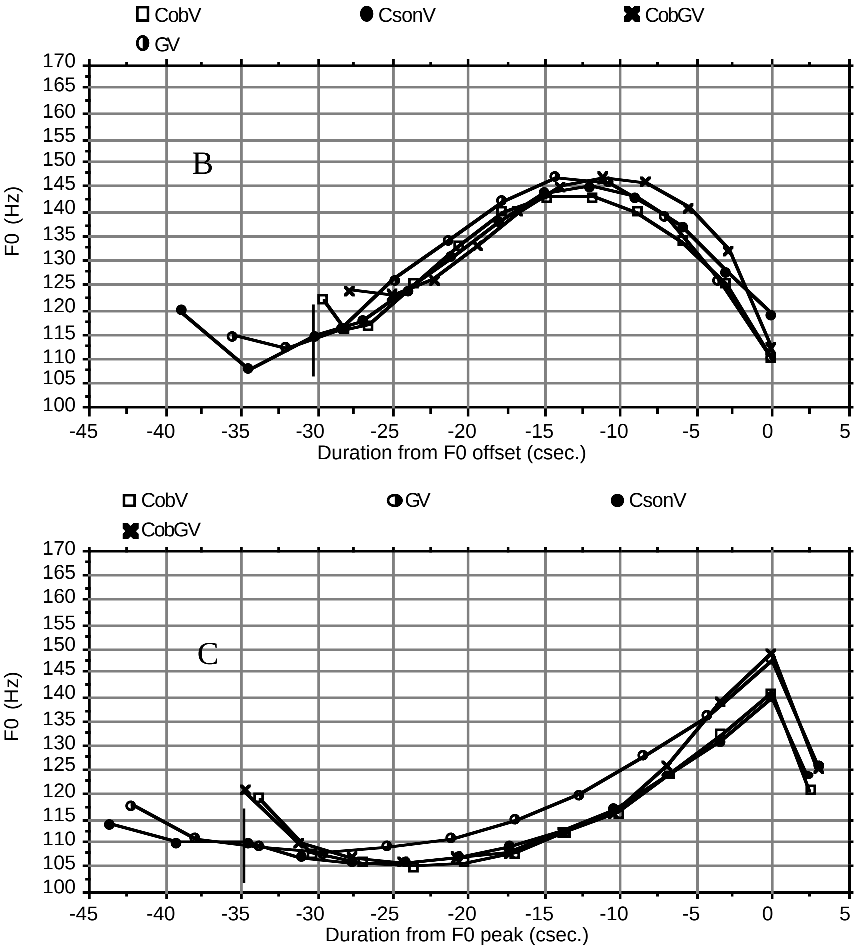

Figure 3 (con't) : Mean F0 shapes for different syllable types in Zhenhai tone 3 (B), and tone 4 (C).

4. DISCUSSION

It is the similarity of the F0 contour of CsonV syllables and CobsV syllables over the duration of the Rhyme, together with the fact that the Rhymes of these two types do not differ significantly in duration, which prompted the view expressed by Howie (1974) and Kratochvíl (1968:36) for Modern Standard Chinese, Sauvain (1977) for Yangzhou and Rose (1982:47,48) for Zhenhai that the F0 on syllable-initial sonorants is not tonally relevant. Despite its phonological discreteness, there is, of course, no corresponding acoustically discrete segment corresponding to the glide in GV syllables that can be "discounted" from tonal relevance in the same way as the syllable-initial sonorant. Nevertheless, since it has been claimed that syllable-initial sonorants are not tonally relevant, it can be concluded from the parallel demonstrated above between CsonV and GV types that (1) neither are syllable-initial semivowels, and (2) semivowels behave differentially with respect to phonetic mapping depending on whether they are preceded by a syllable-initial obstruent. (Syllables with CsonGV structure were not analysed, so it is not possible to say if it is simply the presence of a syllable-initial consonant, rather than an obstruent consonant, which determines this. For reasons to be discussed below, the latter is likely.)

Why is the semivowel part of the tonal F0 carrier in syllables with an initial consonant, but not part of the tonal F0 carrier in syllables without one? The significant extra duration at the onset of glide-initial syllables is itself phonetically unexpected, since the typical close articulation of the glide should actually hinder a quick restoration of the transglottal pressure difference necessary for phonation (the same reason why VOT is often longer before high vowels). A shorter, not longer, duration for glide-initial syllables should result. The problem of the differential distribution of the glide with respect to tonally relevant F0 can be answered by focusing first on the glide-initial case, where the behaviour of syllable-initial glides with respect to phonetic mapping of tonal F0 is one of the ways relevant F0 values are signalled.

When an F0 contour realises extrinsic tonal and intonational targets, intrinsic transitions must occur on voiced segments between them. Rose (1984:61-79) used the segmental and suprasegmental acoustics of a minimal (Zhenhai) tonal contrast between falling and rising-falling pitch, where intrinsic changes in tonal F0 must not be perceived as pitch, to show that one of the ways of signalling an intrinsic F0 change is to time it to overlap syllable-initial consonants. For example, the contrast between Zh. [wei 'lE 11 41] come back, and [wei 'lE 11 131] will come, is signalled by a falling vs. convex pitch on the second syllable (p.65). Both words have very similar level-rising-falling F0 shapes, the small differences between which are not enough to cue the difference between falling and rising-falling pitch. The difference in the falling vs. rising-falling pitch percept depends in fact on where the rise in the F0 takes place. In the [level-fall] example, it starts just before the onset of the second syllable-initial [l], so that by the onset of the vowel, the F0 has completed most of its intrinsic rise to its high pitch target. In the [level-convex] example, the F0 does not start its extrinsic L H rise until just before the onset of the vowel. Of relevance to this paper is the fact that in cases with glide-initial syllables, the glide, although not acoustically discrete, behaves analogously to a syllable-initial consonant as a landmark for timing intrinsic F0 changes. This behaviour, which is part of the segmentally mediated perception of F0 as pitch, assures the minimal contrast between such Zhenhai forms as [iN 'jiN 11 41] circumstances vs. [iN 'jiN 11 131] to take shape.

This finding has relevance for the measurement of tonal acoustics in connected speech. Maximum consistency in the descriptive statistics of tonal and intonational F0 will be obtained if the short (ca. 10 csec.) stretches of F0 distributed over syllable-initial glides are excluded from measurement, in the same way as stretches over any other Onset constituent. This also guarantees a better correspondence between F0 and tonal pitch, since without such indications there is no way to distinguish from a visual inspection tonally and intonationally relevant extrinsic F0 changes from intrinsic transitions.

Caution is advised when drawing phonological inferences from the productional side of phonetics in the absence of supporting phonological arguments. However, the demonstrated phonetic parallelism between syllable-initial glides and sonorants naturally invites the phonological analysis of a syllable-initial glide as one of the fillers of the Onset slot, with the glide being phonotactically equivalent to the other Onset consonants. Under this analysis, the syllables in the Zhenhai morphemes [wa 1] bad, [jO 3] shake [œfl$] distant have the same Onset-Rhyme metrical structure as [ma 1] mother, [NO 3] tooth, [lfl$ 3] penis, or indeed [ta 1] belt, [tsO 3] snake, [pfl$ 3] tray.

The analysis of the glide-vowel sequence in syllables with a consonant in the Onset slot, e.g. in forms like [ju 1] noon, [œyN 3] skirt, [kwa 3] bosom, is not so clear. The phonetic parallelism with CobsV (or CsonV) syllables suggests that the glide is part of the Rhyme. However, another interpretation that is perhaps even more consistent with the phonetics is that the glide is simply not there phonologically as it can be predicted from the syllable-initial consonant. (This approach has been proposed by Ian Maddieson (pers. comm.) for Mandarin palatal glides). The Zhenhai labial-velar glides in forms like [kwa 3] would then have to be part of an extra labial-velar stop series /kh^w, k^w/ etc. Taken together, these proposals would obviate the need for a separate glide position in Zhenhai syllable structure, resulting in an increase in phonological simplicity.

5. REFERENCES

1. Howie, J. "On the domain of tone in Mandarin", Phonetica 30: 129-148, 1974

2. Kratochvíl, Paul The Chinese Language Today Hutchinson University Library, London, 1968

3. Rose, P. "Acoustic Characteristics of the Shanghai-Zhenhai syllable-types", in D.Bradley, ed. Tonation. Pacific Linguistics Papers in South-East Asian Linguistics 8: 1-53, 1982

4. Rose, P. "On the non-equivalence of fundamental frequency and pitch in tonal description", in D. Bradley, E. Henderson and M. Mazaudon, eds. Prosodic Analysis and Asian Linguistics: to Honour R.K.Sprigg. Pacific Linguistics: 55-82, 1989

5. Rose, P. "Acoustics and Phonology of Complex Tone Sandhi", Phonetica 47: 1-35, 1990

6. Rose, Phil, "Wenzhou Tonal Acoustics: Depressor and Register Effects in Chinese Tonology", in Roberto Togneri (ed.) Proc. 5th Australian Intl. Conf. on Speech Science and Technology. Australian Speech Science and Technology Association, Canberra: 138-143, 1994.

7. Sauvain, D. L., "An Acoustical Analysis of Selected Yangchow Syllables", thesis submitted for Ph.D. degree, University of Cambridge, 1977