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Non-contrastive Features or Enhancement by Redundant Features?

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In Mandarin Chinese, when the suffix -r is added to syllables ending in -n and -ŋ, both consonants are dropped but the vowel is nasalized in the case of ŋ. It has recently been argued (Zhang 2000) that this is because in the unsuffixed forms there is already a greater degree of nasalization in the case of -ŋ than in the case of -n and that this merely allophonic contrast becomes distinctive when the suffix is added. It is here claimed that there is already a phonemic distinction present in the unsuffixed forms, namely pharyngealization of the velar nasal, and that furthermore there is a pharyngeal glide /ɑ̯/ coda in the case of so-called 'open' syllables ending mid and low vowels. This is supported by comparison with the Changli dialect in which both nasal finals are deleted before -r but the distinctions are uniformly preserved. Further evidence for the need to recognize the pharyngeal glide /ɑ̯/ as a possible phoneme and for replacing the dorsal feature [±low] with the tongue-root feature [±RTR] in distinctive feature theory is adduced from the history of Chinese as well as from other languages, including English, where it takes the place of the traditional tense/lax contrast in short and long vowels. This supports the concept of featural contrasts that are strictly speaking redundant according to the standard test of minimal pairs but that serve to enhance distinctions that would otherwise be easy to confuse.

Key words: non-contrastive features, redundant features, pharyngeal glide, r-suffixation

1. Introduction

In a recent paper, Jie Zhang (2000) argues that in Mandarin Chinese the nasality induced on the preceding vowel by the /ŋ/ coda is perceptually more salient than the nasalization induced by the other nasal coda /n/ and that this is the explanation for the fact that when the retroflex diminutive suffix is added, resulting in loss of both preceding nasal consonants, the distinction between -Vn and -Vŋ is preserved by nasalization of the vowel in the case of the latter but not the former. Since degree of nasalization is not normally recognized as a possible distinctive feature, this requires the assumption that a surface phonetic contrast can emerge as distinctive in a morphological process. In the case in question, however, I shall argue that before adding the suffix there is already a featural contrast in the quality of the vowel preceding /ŋ/ as compared to /n/, namely pharyngealization, that is to say, secondary articulation of /ŋ/ by the pharyngeal glide /ɑ̯/. This featural contrast serves as an enhancement to the distinction between the two nasal phonemes and is preserved when the suffix is added.[1] The pharyngealization of /ŋ/ means that it has a uvular rather than a velar point of articulation, relatively close to the velum, which can also account for the spread of nasalization to the preceding vowel in the unsuffixed form, preserved along with the pharyngeal glide when the suffix is added.

As I shall show, this apparently small detail in the morphophonemics of Mandarin involves several issues of wider importance for phonological theory, including the role of redundant features in enhancing phonemic contrasts and also the role of tongue root as the articulator for low vowels. These questions were addressed in a preliminary way in a 1994 conference paper read in Hong Kong,[2] but further discussion is clearly necessary.

2. R-suffixation in Changli

Zhang supported his argument by a wide-ranging survey of northern Chinese dialects. He did not, however, refer to the dialect of Changli, a county northeast of Beijing, which was the subject of a very thorough study, *Changli fangyan zhi*, first published in 1960 and reprinted in 1984. In this dialect both -ŋ and -n are completely lost when the retroflex suffix is added, but the words in question remain distinct in their vocalism as shown in the following table.

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1 On the concept of enhancement by redundant features see Stevens, Keyser and Kawasaki 1986.

2 'Pharyngeal Glides and Zero Initials in Chinese', presented at the Third International Conference on Chinese Linguistics, City Polytechnic of Hong Kong, July 1994, published as Pulleyblank 1998.

-ɑ, -ɑŋ + r → -ɑr[3]	-ai, -an + r → -ar
-iɑ, -iɑŋ + r → -iɑr	-ian[4] + r → -iar
-uɑ, -uɑŋ + r → -uɑr	-uan + r → -uar
	-yan + r → -yar
-ɤ, -əŋ + r → -ɤr	-ən, -ei + r → -ər[5]
-uo, -uŋ, -əŋ[6] + r → -uor	-uei, -uən + r → -uər
-ie, -iŋ + r → -iɜr	-i, -in + r → -iər
-ye, -yŋ + r → -yɜr	-y, -yn + r → -yər

Table 1: Products of *érhuà* in the Changli dialect

The anonymous authors of the report who were working in the tradition of structural phonemics, set up two low vowels, /a/ and /ɑ/, as distinct phonemes in the dialect, though they continued to treat the vowels in Pekingese [an] and [ɑŋ] as allophones of a single phoneme /a/. As we see in the above table, their treatment of the mid vowels was not consistent with this. They posited the same phonemic vowels in /ən/ and /əŋ/ in spite of the fact that, for them, /ən + r/ gives [ər], while /əŋ + r/ gives [ɤr], like /ɤ + r/. According to Y. R. Chao (1968:24), /əŋ/ in Pekingese has a lower and backer vowel than /ən/. He transcribes it as [ʌŋ]. Though this kind of phonetic detail is

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[3] The authors remark that in all cases -r signifies retroflexion of the preceding vowel rather than a distinct segment. They further state that the retroflexion of -ɑr and -ɜr is weaker than that of -ar and -ər, and that -ɑr and -ar have the (more precise) phonetic values [Ar] and [ɐr] respectively. This auditory contrast may reflect the fact that there is pharyngealization as well as retroflexion in the former but not in the latter. This may correspond to the two degrees of retroflexion of vowels in Badaga as reported by Emeneau (1939) which Lindau (1978) took as evidence for considering rhotacization to be a multivalued feature. Clements (1989) suggests that the half-retroflex vowels of Badaga combine radical articulation with coronal, while the fully retroflexed vowels combine dorsal, radical and coronal. Assuming that the two degrees of retroflexion in Badaga correspond to those in Changli, we should expect to find that the fully retroflex vowels simply have the coronal feature [-front] combined with dorsal articulation, while the half-retroflex vowels, corresponding to the 'weaker' retroflexion in Changli, have radical articulation as well.

[4] Though the report does not say so explicitly, this final is presumably phonetically [jɛn] or [jæn] like the corresponding final in Beijing, since other differences from Beijing are remarked upon.

[5] The tongue position in -ər, -iər, -uər, and -yər is reported to be quite high, 'close to ɘr'. On the symbol [ɘ] which, according to Pullum and Ladislaw (1986:47) was never formally adopted by the IPA but was proposed as a more precise sign for a half-close (upper-mid) central unrounded vowel of the same height as Cardinal 2, see now the 1999 edition of the *Handbook of the International Phonetic Association*.

[6] After labial initials. The report notes that after labial initials there is a more pronounced labial glide before the vowel [o] in this dialect than in Beijing.

not available for Changli, one can assume that the same is true in that dialect and that this so-called ‘allophonic’ difference is relevant to the maintenance of a distinction between the reflexes of the finals in -n and -ŋ after r-suffixation. Finals corresponding to standard Mandarin *-ing*, *-ong*, *-iong*, which Chao (1968) transcribes phonetically as [iŋ] [ɷŋ] [iɷŋ], also drop the velar nasal and give the same retroflex finals as the syllables with ‘open’ mid vowels: *-ie*, *-uo*, *-ue*. (Note that in these transcriptions the high vowels [i], [u] and [y] as the first element in vowel clusters must be interpreted as the nonsyllabic glides [j] [w] [ɥ]).

My proposal is that in both Changli and Beijing the finals in so-called ‘open’ mid and low vowels actually have a pharyngeal glide, that is, non-syllabic /ɑ̯/, as coda and that the velar nasal also has such a glide as a secondary articulation, thus: -əɑ̯ [ɤ], -jəɑ̯ [je], -wəɑ̯ [wo], -ɥəɑ̯ [ɥe]; -aɑ̯ [ɑ], -jaɑ̯ [jɑ], -waɑ̯ [wɑ]; -əɑ̯͡ŋ [ʌŋ], -jəɑ̯͡ŋ [jʌŋ], -wəɑ̯ [wo], -ɥəɑ̯ [ɥe]; -aɑ̯͡ŋ [ɑŋ], -jaɑ̯͡ŋ [jɑŋ], -waɑ̯͡ŋ [wɑŋ]. This is redundant as a way of distinguishing the vowels in the finals spelled *a, -an*, *-ang* if one strictly applies the principle of minimal pairs, but it plays a role synchronically in enhancing contrasts that would be easy to confuse in rapid speech. As I shall argue below, -ɑ̯ as coda for finals with mid and low vowel nuclei also fills a necessary requirement in terms of syllable structure. Diachronically non-syllabic pharyngeal /ɑ̯/ has played an important role throughout the history of the Chinese language both as an independent coda and as a secondary articulation of velars in contrast to palatalization, labialization and palato-labialization.

Another relevant phonetic detail is that the velar nasal in Beijing Mandarin has a more retracted, uvular, point of contact than the velar stops /k/ /k^h/ and fricative /x/. Jerry Norman reports: “In the speech of many Peking speakers the final *ng* in *ing* has a uvular articulation” (1988:143). In the accompanying table he writes uvular -ɴ instead of velar -ŋ in all three high vowel finals, -iɴ, -ɷɴ, -yɷɴ. He informs me (p.c.) that this is based on notes of a personal communication from the late Y. R. Chao. It seems highly unlikely that there is in fact a backer articulation of the final velar nasal after high vowels than after mid or low vowels and Chao’s observation probably simply reflects the fact that the uvular articulation is less expected and therefore more noticeable after a high vowel. Chao’s auditory impression is confirmed by x-ray photographs which include samples of [ŋ] both as the final consonant in words rhyming in *-ang* and as the initial consonant of the following syllable [ŋa], formed when final -ŋ links as onset of the enclitic particle -a (Zhou and Wu 1963:21, 27, 40, 53, 91, 106).[7] The contrast with

[7] The authors also give the second syllable of the place name Chang’an as an example of initial [ŋ]. According to Chao (1948), in one style of pronunciation the velar continuant that is the normal onset of so-called vowel initial words (see below) assimilates to a preceding velar nasal, though it resists liaison with a preceding alveolar nasal.

the velar stops [k] and [k^h] and even with the fricative [x], which Chao (1968:21) considered to be uvular but which appears in these photographs to differ little in place of articulation from the stops, is very apparent. I shall argue below that the proper way to define uvular consonants in terms of articulator theory is as combining the action of the Dorsal and Radical articulators, so that Beijing Mandarin [ɴ] can be interpreted not as [-high, -low] as in the feature system of *Sound Pattern of English* (Chomsky and Halle 1968, hereafter *SPE*) but as the resultant of simultaneous raising of the body of the tongue required by velar /ŋ/ and retraction of the tongue root required by nonsyllabic /ɑ̯/ attached to the same skeletal slot.

3. What is a pharyngeal glide?

There are a number of problems of a general kind that are implied by the hypothesis of a pharyngeal glide as a possible syllable closure and as a secondary articulation of velar nasals in Mandarin. In *SPE* pharyngeal consonants are defined in terms of place of articulaton as [-high, +low, +back,], in contrast to velars [+high, -low, +back,], uvulars [-high, -low, +back] and glottals [-high, +low, -back] (p.307). In Chapter 9 in which the feature [±vocalic] is replaced by [±syllabic] the high glides, *y* and *w*, are treated as nonsyllabic forms of the high vowels *i* and *u* but the glottals [ʔ] and [h] are treated as the glides corresponding to non-high vowels (p.354). No evidence is offered, however, to support the idea that a low vowel can be replaced by [ʔ] or [h] in a nonsyllabic position. Moreover, although in the *SPE* scheme it remains necessary to characterize laryngeals as [-back] in order to distinguish them from pharyngeals, in this context it does not have any obvious relationship to the contrast in place of articulation between a velar and a palatal consonant that defines the contrast [±back] for consonants.

More recently it has been recognized: (a) that the older flat model in which all features operated independently needs to be replaced by a hierarchical tree in which some features are located at the root and others branch off from subordinate nodes, (b) ‘place of articulation’ for both vowels and consonants is to be defined not as a continuous series of positions along the passive upper surface of the oral tract but in terms of a limited number of active articulators, now usually defined as Labial (the lower lip), Coronal (the tip and blade of the tongue), Dorsal (the tongue body) and Radical (the tongue root), which can act independently or together. (See, among others, Clements 1985, Sagey 1986, Halle 1983, 1992, Ladefoged and Halle 1988.)

In such a scheme laryngeal features of segments are defined by a separate laryngeal node attached to the root. This will account for the phenomenon of debuccalization by which in many languages an oral stop is replaced by a glottal stop. Thus final or intervocalic *t* is frequently replaced by [ʔ] in English regional dialects and this can affect *k* and *p* as well. Similarly final /p, t, k/ of the Middle Chinese Entering Tone are replaced by [ʔ] in Mandarin dialects that have not lost the consonantal closure altogether. An oral voiceless fricative can be replaced by [h] as in the change of Indo-European *s- to h- in Ancient Greek. In initial position debuccalization of Middle Chinese initial /t/ to [ʔ] and /t^h/ to [h] is typical of the Siyi group of Yue dialects in South China and in one of them, that of Kaiping, it has spread also to Middle Chinese /p/ and /p^h/ (Yue-Hashimoto 1972:33-34). In the Wu dialects of Chinese, the velar fricatives /x/ and /ɣ/ of Early Middle Chinese have been replaced by /h/ and /ɦ/ respectively.

Traditionally, nonsyllabic forms of the high vowels, *i* and *u*, are called semivowels, for which the English alphabet provides the special consonantal forms *y* and *w*. The phonetician Peter Ladefoged admits that efforts to define the syllable in experimentally measurable terms have not been successful and that syllables "may be considered to be abstract units that exist at some higher level of mental activity of the speaker" (1982:223). The International Phonetic Alphabetic treats [j] and [w] as palatal and labial-velar approximants, to which it now adds [ɰ][8] and [ɥ] as non-syllabic velar and labial-palatal approximants corresponding to the high vowels [ɯ] and [y] respectively. A space is provided for a pharyngeal approximant but it is left empty.

A regular role for semivowels/glides is that of secondary articulations of consonants. In his textbook, *A Course in Phonetics*, Peter Ladefoged defines this as 'an articulation with a lesser degree of closure occurring at the same time as another (primary) articulation'. He symbolizes palatalization, labialization, and labiopalatalization in a familiar way by raised [ʲ], [ʷ] and [ᶣ]. In the first two editions, 1975 and 1982, he proposed raised [ᵚ] for velarization, perhaps harking back to the time before there was a special symbol, [ᶭ] in IPA for a velar semivowel/glide, and raised [ᵅ] for pharyngealization, with the comment "… since cardinal vowel-(5)—[ɑ]—has been defined as the lowest, most back possible vowel without producing pharyngeal friction" (1982:211). This seems to be very close to an admission that nonsyllabic [ɑ] is a pharyngeal approximant even though no such sound is provided for in IPA.

In the third edition of the same work (1993), however, in accordance with the latest version of the IPA, Ladefoged proposes without comment raised [ˠ] for velarization and raised [ˤ] for pharyngealization. I do not know what has prompted this

8 At least until 1963 the IPA did not provide a separate sign for a velar semivowel and the sign ɣ was made to serve for both a voiced velar fricative and a frictionless continuant or semivowel (*The Principles of the International Phonetic Association*, London: Department of Phonetics, University College, 1949, reprinted 1963). See Henderson (1985) for the need to recognize such a consonant in the Sgaw dialect of Karen, where the letter *g* in the name stands for such a phoneme. In some other Karen dialects she writes the corresponding sound as uvular R.

change by the International Phonetic Association. It probably has to do with the claim that in the case of the pharyngeal fricatives of Arabic, [ħ] and [ʕ], "For many speakers there is little or no actual friction, so that these sounds may be more like approximants than fricatives" (Ladefoged 1982:149). According to Butcher and Ahmad, who have made a thorough instrumental study of the pharyngeals of Iraqi Arabic, both [ħ] and [ʕ] "could be regarded as approximants, formed in a region of the vocal tract where true fricatives are very difficult to produce" (1987:156). Against this one must point out that, unlike approximants, these Arabic pharyngeals appear as a voiced/voiceless pairs and, according to Maddieson (1984), there are several languages such as Tama, Atayal, Nootka and Lak, that have voiceless [ħ] but no corresponding voiced [ʕ]. This is a pattern that is typical of fricatives at other places of articulation and unlike that of approximants. Thus, Maddieson lists 135 languages with labiodental [f], as against 67 with labiodental [v]. On the other hand, he lists six languages with a voiced labiodental approximant [ʋ], but has no example of a language with a voiceless counterpart. Another circumstance that argues for [ħ] and [ʕ] being obstruents phonologically even in Arabic is that in some dialects they are subject to final devoicing and voicing assimilation rules that otherwise apply to obstruents (McCarthy 1991:36).

I shall return below to the difficulties of reconciling the proposal that Radical (i.e., Tongue Root) must be recognized as an oral articulator on the same level as Labial, Coronal, and Velar with the special characteristics of the class of guttural consonants in Arabic and other Semitic languages. It will be argued that, because of the difficulty of making a stop or even a fricative occlusion by retracting the Tongue Root towards the wall of the pharynx, in most languages the Radical articulator is separately responsible only for the vowel features [±RTR]. This includes non-syllabic [+RTR] [ɑ̯] as a glide in the same way that the Dorsal articulator is responsible both for the high central or back unrounded vowel [ɯ] and its nonsyllabic counterpart [ɰ]. True pharyngeal consonants are comparatively rare and probably require concomitant support of the epiglottis and perhaps also larynx raising.

4. Approximant or voiced fricative

It seems that the distinction between an approximant and a voiced fricative, like that between syllabic and nonsyllabic, is sometimes difficult to define in measurable phonetic terms and may be part of the mental organization of phonological contrasts. To illustrate the difficulty of making a clear-cut distinction between a voiced fricative and an approximant one may refer to Mandarin /r/, which, as an initial consonant, is often transcribed by phoneticians as a retroflex fricative [ʐ], the voiced counterpart of initial [ʂ], and which in former times was often romanized in such a way as to imply a fricative pronunciation, e.g. as *j* in the Wade-Giles system, implying [ʒ] as in French. Maddieson (1984:346) lists it as a voiced fricative. Yet it is undoubtedly a sonorant in its phonological behaviour. If one were to insist that it is a fricative, it would be the only voiced obstruent in the language. Of course, it may be argued that, though it is an approximant underlyingly, it is strengthened phonetically in syllable onset position. Initial [j] in Mandarin is also said to sometimes have a 'slightly more consonantal articulation' in syllable onsets and initial [w] is commonly replaced by the labiodental approximant [ʋ], without, however, acquiring any friction (Chao 1968:20). On the other hand, German [ʝ] in *ja*, which Maddieson (1984:265) lists as an approximant and which is historically related to English [j] in *yes* is treated phonologically as a voiced fricative. It patterns in German as the voiced counterpart of the non-strident palatal fricative [ç] and has minimal contrasts with non-syllabic [i̯] (or [j]). It may or may not be pronounced with audible friction (Moulton 1962:6, 14 n.1, 65). Until 1989 the IPA chart did not provide a separate symbol for a voiced palatal fricative distinct from an approximant.[9]

5. Pharyngeal semivowels in other languages

The use of the symbols for pharyngeals in Interior Salish languages, which are not included in Maddieson's sampling constitutes an apparent exception to his generalization about pharyngeal fricatives. Typically these languages are described as having four voiced pharyngeals, transcribed with the symbols for voiced pharyngeal fricatives as /ʕ, ʕʷ, ʕ', ʕ'ʷ/ but with no voiceless counterparts (Bessell 1992). Moses-Columbian has voiceless /ħ/ and /ħʷ/ in addition, but this is an innovation peculiar to that language. According to Kinkade (1967:231) voiceless allophones probably originally occurred only initially, or before another consonant finally, or in word-final position; while the voiced allophones occurred only after the root vowel and before a vowel or a suffix. Though this is still the most usual distribution, /ħ/ and /ʕ/ now contrast before certain suffixes. The development of a voiceless allophone which eventually became phonemic is interesting for the light it may throw on other cases where a pharyngeal glide has developed less sonorous surface realizations, especially in onset position, but it does not support the contention that [ħ] and [ʕ] in other languages should always be regarded as sonorant approximants rather than fricative obstruents.

[9] The *Handbook of the International Phonetic Association* (1999) interprets the initial of German *ja* as an approximant. Ladefoged and Maddieson (1996:165) remark: "Phonological contrasts involving voiceless palatal fricatives are fairly rare; less than 5% of the languages of the world include **ç** in their inventory (Maddieson 1984a). The voiced palatal fricative **ʝ** is even more rare." They illustrate the contrast between fricative and approximant by the Chadic languages Margi and Bura.

According to Bessell the Salishan languages, generally speaking, lack voiced obstruents, but they have voiced pharyngeals that pattern with the other sonorants which are found in glottalized and unglottalized pairs and include: m, m', n, n', r, r', l, l', y (=IPA j), y', ɣ, ɣ', w, w'. All these sonorants syllabify in certain contexts. The nasals and liquids either become syllabic or are followed or preceded by an epenthetic schwa: m̩ ~ ᵊm ~ mᵊ, etc.; /y, y', w, w'/ vocalize to [i, iʔ, u, uʔ]; /ɣ, ɣ'/ vocalize to [ʌ, ʌʔ]. In parallel circumstances /ʕ, ʕ'/ vocalize to [a/ɑ, a/ɑʔ] and /ʕʷ, ʕʷ'/ vocalize to [ɔ, ɔʔ]. As Bessell (1992:147) remarks, "There is no real phonetic evidence for distinguishing /ʕ/ from the so-called semi-vowels /y, w/ in this respect. In fact the inclusion of the pharyngeals in the class of semi-vowels would contribute to an explanation of the extreme difficulty in perceiving them as distinct from an [a/ɑ] vowel in certain positions, paralleling the difficulty in distinguishing /y, w/ from their vocalic counterparts in the same positions." Our conclusion must be that, although in the absence of a recognized symbol for a pharyngeal approximant and unfamiliarity with the IPA symbol [ɰ] for a velar approximant, the symbols for voiced fricatives have been used, these phonemes in Salishan languages are phonologically approximants, i.e., 'glides' in the usual terminology of generative phonologists.

Another language in which the vowel /a/ can become nonsyllabic in certain contexts is Axininca Campa. Payne reports that in Axininca Campa the vowel /a/ is replaced by a 'velar glide' [ɣ] (presumably [ɰ] in current IPA practice) when it becomes non-syllabic between two vowels, in the same way that /i/ is replaced by [j] and the third vowel /o/ is replaced by the bilabial approximant [β]. (Note that the symbol for a bilabial fricative is used in the absence of a special IPA symbol for a bilabial approximant.) According to Payne's description the articulation of the velar glide 'involves very little tongue movement from the neutral /a/' (1981:71). From this Yip (1983) infers that, though he calls it velar, "it should more properly be called a pharyngeal glide." While the exact phonetic properties of this glide require further investigation, it seems clear that Payne heard some velar approximation, if not friction. Desonorization of glides in syllable onsets is a very widespread phenomenon in languages, no doubt because it strengthens the CV contrast, and it is probably such a universal tendency that is at work. Velar [ɯ] is like [a] or [ɑ] in being neutral as far as front [i] or back-rounded [u] colouring is concerned but is less sonorous. As we shall see below, I assume that desonorization of pharyngeal [ɑ̯] to [ɰ] in onset position was a stage in the development of the shift from *kaikou* to *hekou* in Early Mandarin in words like *shuang* 霜 'frost'.

In Axininca Campa the same tendency to reduce sonority when a vowel becomes nonsyllabic is illustrated by the treatment of intervocalic [o], which instead of giving labiovelar [w], loses its dorsal component altogether and becomes bilabial [β]. Another case in which a non-syllabic /ɑ̯/ replaces its tongue root articulation by a dorsal glide in a syllable onset is found in Maxacalí. This language has processes of glide formation which produce palatal [j] after /i/, nasalized [j̃] after /ĩ/, labial [w] after /o/, nasalized [w̃] after /õ/, velar [ɣ] (more properly [ɰ]?) after /ɨ/ and /a/, and the velar nasal [ŋ] after [ɨ̃] (Gudschinsky, Popovich, and Popovich 1970).

6. Tense/lax and tongue root advancement/retraction

In the *SPE* system the feature [±tense] is used to accommodate the difference between the English high-front and back-rounded vowels [i] and [ɪ] or [u] and [ʊ] as in *peel* vs. *pill* and *pool* vs. *pull*, which also extends to the mid vowels [e] vs. [ɛ], as in *bale* vs. *bell* and [o] vs. [ɔ] as in *coat* vs. *cot*. According to the article, 'Tenseness and Laxness' (Jakobson and Halle 1962), this contrast was first discussed by Alexander Melville Bell (1867), who ascribed it to differences in the behavior of the pharynx. Other nineteenth century phoneticians had different solutions to the problem. Sweet, who used the terms 'narrow' and 'wide', later changed to 'tense' and 'lax', emphasized the shape of the tongue. Others claimed that laryngeal positions and air pressures were involved.

Jakobson and Halle (1965) noted a parallel between the tense/lax contrast in English and the pairs of high and mid vowels, [i] vs. [ɪ] and [e] vs. [ɛ], that contrast in many African vowel harmony systems. A phonetic study of West African languages by Ladefoged (1964) demonstrated that the higher and more forward high and mid vowels in such systems that seem to correspond in auditory terms to the so-called tense high and mid vowels of English, were characterized by enlargement of the pharynx by pushing forward the root of the tongue, apparently confirming Bell's hypothesis. This led to the introduction of a new feature, Advanced Tongue Root [ATR].

For a brief period this coincidence between the phonetic exponents of [±ATR] and [±tense] for high and mid vowels led some linguists to suggest equating the two features, but the idea was abandoned when it was realized that for low vowels it did not work (at least not in the same way). In many languages with [ATR] vowel harmony the contrast is neutralized for low vowels. Where this is not the case, however, it turns out that the [+ATR] vowel, as one might expect, is articulated farther forward and somewhat raised compared to the [-ATR] vowel. This is true, for example in Kalenjin, a Nilotic language of northern Kenya (Stewart 1971). According to Tucker (1964) the Nandi-Kipsigis dialect of Kalenjin has the following ten vowels, long and short, falling into two sets labelled Open (= [-ATR]) and Close (= [+ATR]): Open — ɪ, ʊ, ɛ, ɔ, ɑ; Close — i, u, e, o, a. The low Open vowel [a] is said to be a central vowel midway between cardinal [a] and [ɑ]. This mimics phonetically the contrast between the short/lax and long/tense, low vowels of German in words like *Lamm* 'lamb' and *lahm* 'lame', transcribed phonetically as [ɐ] and [aː] in Maddieson 1984 based on Moulton 1962 and Phillipp 1974.

It has therefore been felt necessary both by phonologists and phoneticians to treat the tense/lax contrast and [±ATR] as independent (Halle 1977). From a phonetic point of view Lindau (1978) argues that there is no unique articulatory correlate for tenseness and suggests the opposition peripheral/central for the auditory contrast it represents. Ladefoged and Maddieson (1990) bypass even this and treat contrasts between the English front vowels [i], [ɪ], [e], [ɛ], [æ] as definable solely in terms of tongue height and that between IPA [a] and [ɑ] as an unrelated front-back contrast in the horizontal dimension, with mid as a third possibility at all heights. Even from a strictly phonetic point of view, however, this does not explain the centralization that is also a feature of the "lax" alternants of English high and mid vowels, especially [ɪ] as compared to [i], as shown in Figures 2 and 3 of Lindau's paper, which show, respectively, averaged and normalized positions of the highest point of the tongue and averaged and normalized formant frequencies of American English vowels of five speakers. In Figure 1 the lax high vowel [ɪ] is actually lower than the tense mid vowel [e] and only slightly higher than [e] in Figure 2, as well as more centralized in both cases.

A point that purely phonetic discussions fail to address is that the prototypical tense/lax contrast in languages like English and German reflects a feature of syllable weight. Accented syllables are necessarily heavy, that is, bimoraic, which in these languages means that they are minimally either CVC or CVV(C). Tense (i.e., long) vowels link to two V slots and can therefore stand alone. Lax (i.e., short) vowels require a coda which can either be a consonant or a semivowel. Long or tense vowels in open syllables can be treated as ending in a semivowel, as is sometimes recognized even in phonetic descriptions. Thus *bee* [biː]/[bij], *beet* [biːt]/[bijt] and *bit* [bɪt] are possible English words but *[bɪ] is not. So also *bay* [bej], *bait* [beːt]/[bejt] and *bet* [bɛt] but not *[bɛ]. My hypothesis is that the difference in vowel quality, though apparently redundant if the length distinction is taken into account, serves a function in enhancing the auditory contrast and making it more robust. The difference in vowel quality cannot be dismissed as an automatic adjustment to the shortness of the vowel. In unaccented syllables either the tense or the lax alternants can occur. There are dialect differences in usage, as in *pity*, which is [ˈpɪtɪ] in British Received Pronunciation but [ˈpɪti] in most types of North American speech. Or consider *taxis*, which in RP is [taksɪz], not [taksiz], merging with *taxes*, in distinction from *taxers* [taksəz].

In languages like English and German with a tense/lax contrast, the tense vowel [i] can be considered the resultant of simultaneously raising the coronal blade of the tongue and the dorsal back of the tongue resulting in an approach to the traditional 'palatal' point of articulation which is optimal for creating the formant pattern of a high front vowel. For the lax vowel [ɪ] the same actions on the part of the coronal and dorsal articulators are accompanied by retraction of the tongue-root towards the wall of the pharynx causing lowering and centralization. This enhances the contrast in cases like *beat* [biːt] vs. *bit* [bɪt]. The same applies to the mid front vowels [eː] and [ɛ] in *bate* and *bet*. The optimal low vowel, however, as remarked in the quotation from Ladefoged cited above is low-back [ɑ], articulated by approaching the tongue-root to the back of the pharynx. The corresponding lax vowel in German, [a] or [ɐ], is fronted and somewhat raised, corresponding to the low [+ATR] vowel in African vowel harmony systems. The corresponding vowel in English is not the low front vowel [æ], which has acquired the coronal feature [+front]. Instead the lax vowel corresponding to tense [ɑ] in 'father' is the vowel in *cut*, which although transcribed as lower-mid back unrounded [ʌ] is described by the British phonetician, A. C. Gimson, as a centralised and slightly raised cardinal [a] (1970:107). Compare also the short and long low vowels of Cantonese, transcribed as [ɐ] and [Aː] by Yue-Hashimoto (1972).

7. Tongue-root enhancement in front/back harmony

Unlike the role of the tense/lax distinction to enhance differences in vowel length in accented syllables in Western Eropean languages, vowel harmony serves to link together two or more syllables—a root and its affixes—that form a word. In languages like Turkish which use front/back harmony, this is achieved by requiring that affixes agree with the stem in the feature [±front], while in African languages the feature used is tongue-root advancement or retraction. The two types of harmony can even be combined or turn into one another. Enhancement of palatal/non-palatal harmony by tongue-root features is found in Kirghiz, a Central Asian Turkic language with typical palatal/non-palatal vowel harmony. The high front vowels of Kirghiz are transcribed as [i] and [y] but the corresponding back vowels are transcribed as lowered central unrounded [ɨ̞] and back rounded [ɷ] by Maddieson (1984) based on Herbert and Poppe (1963). In Tatar the corresponding phonemes /ï/ and /u/ are similarly described by Poppe as: (a) "[ə̂] mid (mid-high) back, wide, lax, greatly reduced, the back correlate of /e/; … (b) [u] high back, close, more or less identical with English <u>oo</u> in <u>book</u>" (1963:9-10). In these and other Central Asian Turkic languages, such as inscriptional Old Turkish of the eighth century, there is also an alternation between velar and uvular consonants before the front and back vowels: /ki/ /ky/ *vs.* /qɨ/ /qu/, etc. This is consistent with the evidence from other languages that a contrast between uvular and velar articulation can be interpreted as pharyngealization. One may assume that the vowels /ɨ/ and /u/ were lowered in Old Turkish as they are in the present-day Turkic languages cited above. In contrast, Osmanli Turkish, which does not have the velar/uvular contrast, has palatalized velars before front vowels and plain velars before back vowels. In some Mongolian dialects the front-back harmony of the classical language has been replaced by tongue-root harmony. That is, the redundant feature has taken over and become distinctive. The same thing seems to have happened in Korean (Pulleyblank 1999).

In Modern Standard Chinese the role of the pharyngeal glide as a coda for mid and low open vowels is again different. It is a feature of syllable structure related to the monosyllabicity that has been a feature of Chinese morpheme structure throughout its history. Its role as a secondary articulation of the velar nasal, which synchronically helps to preserve the distinction between the only two consonantal codas that have survived at the present day is a relic of the situation in Middle Chinese in which final velars were all either palatalized, or labialized, or pharyngealized. I shall return to this question below but first let us look in a more general way at the question of replacing the feature [±low] under the Dorsal articulator by the feature [±RTR] under the Radical node.

8. Replacing [±low] with [±RTR] — A new theory of articulator features

A basic premise of Roman Jakobson's theory of universal distinctive features that was adopted as the phonological foundation of generative grammar was the principle of binarism. That is, a given feature should have at most two values symbolized as either plus (+) or minus (-). Why this should be so was not, however, made very explicit and it has remained controversial ever since. The advent of the digital computer and the revolution it has created in the last half century has, I would suggest, made this concept more easily understandable than it was in Jakobson's time. To put it briefly, I would argue that language, the most important characteristic that distinguishes humans from all other animals, is basically a new, digital, add-on to the analogue, sensory-based forms of communication that we inherit from our animal background and still use. Its internal role in cognition, as a basis for thought and understanding of ourselves and the world we live in, is at least as important as its role in communication.

Perhaps the simplest illustration of what one means by the digital nature of language is the fact that any language can be written down using a strictly limited number of alphabetic symbols. How is this possible? It is because the words in a language are made up of combinations of a strictly limited set of vowels and consonants that are meaningless in themselves, but when combined according to definite rules can be assigned arbitrary meanings. These meaningful combinations, words, can in turn be manipulated by rules of syntax to make statements or suppositions, ask questions or perform any of the other multifarious tasks that humans have found for this unique evolutionary achievement. This is what lies behind Wilhelm von Humboldt's famous remark that language uses finite means to achieve infinite ends. More recent linguists have found other terms in which to express it. Martinet referred to it as ‘double articulation’ and Hockett called it ‘duality of patterning.’

In an electronic digital computer, a single binary on-off contrast symbolized as 0/1 is used to create a vocabulary of “bits” (0 or 1) combined into sets of eight, called “bytes”, a set number of which, typically two or four, is called a “word”. In spoken language the units corresponding to 0’s and 1’s are consonants and vowels. To be restricted to using a single consonant, say [p], and a single vowel, say [a], combined into contrastive sequences such as [papapapa], [appappaa], [paapapaa], would place an intolerable strain on memory. Instead human languages use a variety of consonants (C) and vowels (V), constituting (“bits”), organized into syllables (“bytes”), which combine to form “words” to which meanings are arbitrarily assigned, and are then combined by syntactic algorithms into sentences and longer discourses.

The less than ideal characteristics of possible phonations from the point of view of creating a digital system of contrasts that can be successfully used for communication, determined by the nature of the human vocal apparatus, are responsible for the great surface variety in the structure of human phonological systems. They are also responsible for the fact that the phonological systems of languages are forever in a state of diachronic flux. Distinctions that are relatively difficult to maintain in the flow of speech or to perceive by the ear, but the loss of which may not be crucial to understanding because of contextual redundancy, tend to disappear as language passes from one generation to the next; but this happens in unpredictable ways and in different ways in different speech communities, giving rise to dialects and eventually to mutually unintelligible languages.

Jakobson’s analysis of distinctive features was partly based on the generalizations about phonemic systems of the world’s languages studied by Trubetskoy and other linguists of the Prague School, but also on studies of the developmental stages in the acquisition of language by infants and the stages by which distinctions were lost in patients suffering from aphasia. He argued that the first distinction to which meaning could be attached that children made was between /pa/ and /a/ or /pa/ and /ap/, that is, between closing the oral tract at the lips or leaving it open, a maximal opposition between consonant and vowel. Another opposition that was acquired early was that between oral and nasal, adding /ma/, etc. to the list of contrasts.

Jakobson next went on to describe what he called the primary triangle, in which the single stop, /p/, is split into two, /p/ and /t/, distinguished in tonality as grave/acute, together contrasting with the compact vowel /a/; splitting again into two triangles, consonantal and vocalic by adding the diffuse vowels, /u/ and /i/ corresponding respectively with the grave and acute consonants /p/ and /t/, and adding /k/ to the consonantal triangle as a counterpart of the compact vowel /a/. (Jakobson and Halle 1955, as reprinted in 1962:493).

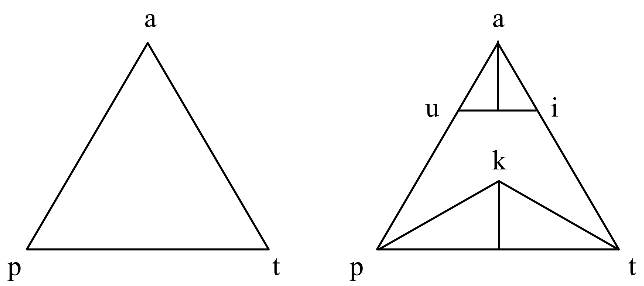


Fig. 1

A more fully worked out set of distinctive features was presented in *Preliminaries to Speech Analysis* (Jakobson, Fant and Halle 1965). Consonants and vowels were both specified in terms of a limited number of oppositions, including: vocalic/consonantal, compact/diffuse, grave/acute, nasal/oral, tense/lax. A questionable assumption was that opposite values of the same feature could be combined in the same phoneme. Thus, English *l* was characterized as ±vocalic.

By the time of *Sound Pattern of English* (Chomsky and Halle 1968, hereafter *SPE*), the acoustic features were largely replaced by features based on the traditional concept of place of articulation and the combining of opposite values of the same feature was no longer allowed. As far as consonants were concerned, the principle of binary distinctions was maintained by defining overlapping regions along the upper surface of the oral tract from the lips to the larynx. In the case of vowels, however, awkward problems arose. According to the standard analysis, even with the addition of the feature [±tense], one could not avoid the necessity of recognizing at least three degrees of tongue height. The solution was to set up two linked features [±high] and [±low], it being assumed that while [-high, -low] was available to allow for an intermediate mid vowel, the combination [+high, +low] was excluded as self-contradictory.

Whether this is really a legitimate way of preserving the concept of binarism is questionable. In the *SPE* system the features [±high], [±low], and [±back] assume a neutral position of the body of the tongue, approximating the position of the vowel *e* in English *bed*, that is IPA [ɛ], from which [+high] means upward movement of the tongue to the position of [i], and [-high] means downward movement to the position of the vowel [æ] in *bad*. The assumption that [ɛ] is in a neutral position would seem to imply that it does not require specification (p.384). This seems quite arbitrary. There is, however, a vowel in many languages that can be considered to be completely unspecified by a movement of the tongue, namely *schwa* [ə], placed as mid central on the IPA chart.

This is the phonetic value to which other vowels are commonly reduced in unaccented syllables in English. It has also played a role throughout the history of Chinese as a default vowel in the absence of lexical specification. The vowel [ɛ] in *bed* in English, on the other hand, is the lax counterpart of the [-high] front vowel [eː] or [ej] in *bait*. Phonologically it is therefore quite highly marked and from the point of view of articulation one would expect to have to specify it in a positive way.

If [-high] is to mean, as I think it should, a definite action on the part of the Dorsal articulator, it should surely mean movement away from the place of articulation of a velar consonant on the roof of the mouth and not simply maintenance of a neutral position of the tongue. Combined with the Labial feature [+round] it specifies the vowel [o] in contrast to [+high] [u]. Combined with the Coronal feature [+front] it specifies the vowel [e] in contrast to [+high] [i]. In both cases the [+high] vowels are more nearly universal among the world's languages and the [-high] alternants must be considered to be more marked. By the same token, the feature [+low] should mean movement towards a target, and the feature [-low] should mean movement away from that target, but no such target is specified. On the other hand, pharyngeal consonants are specified as [+low] in *SPE*, and if Tongue Root is recognized as an articulator on the same level as Dorsal, to redefine [+low] as movement of the Tongue Root towards the wall of the pharynx (i.e., as [+RTR]) would make it quite parallel to [+high] as an articulatory gesture towards the Dorsum. The feature [-low] will then be replaced by [-RTR] or [+ATR] and this seems to fit very well with the attested values of [RTR] and [ATR] vowels in African languages that have such contrast in their harmony system.

As has been proposed elsewhere, the features [±back] and [±round] of the *SPE* system, which are packed together in the [-anterior] half of the oral tract, need to be redistributed to involve the Coronal and Labial articulators (Pulleyblank 1989). More on this below.

9. Mismatch between the primary features of vowels and consonants

The primacy in human language of the vocalic triangle [i, a, u] and the three quasi-universal consonants [p, t, k] seems well established. But, while the three consonants correspond to points at which it is easiest to make a complete closure of the oral passage by closing the lips, pressing the blade of the tongue against the back of the teeth or the alveolar ridge, and raising the back of the tongue to make contact with the roof of the mouth, the three optimal vowels are defined acoustically in terms of the formants (overtones) in the soundwave made by vibration of the vocal cords by narrowings of the passage between the larynx and the lips. The vowel [i], which acoustically combines low first formant with high second formant, is articulated by an approach of the blade of the tongue to the hard palate, a point at which it is possible to make a palatal stop [c] but relatively difficult to make a firm contact so that there is a strong tendency towards affrication. This has the effect of dividing the oral passage into a relatively large posterior section between the larynx and the front of the tongue and a shorter section between the tongue and the lips. The vowel, [u] which combines relatively low first formant with low second formant, is articulated by raising the body of the tongue towards the roof of the mouth while protruding the lips so as to enlarge the front section while shortening the back section. The vowel [ɑ], which combines high first formant with low second formant, is articulated by drawing the root of the tongue back towards the wall of the pharynx, leaving an unobstructed passage from there to the lips. The lowering of the body of the tongue that also takes place may be regarded as an automatic reaction to the pharyngeal retraction.

Thus, the correspondence that Jakobson postulated between [p] and [u] was correct in that the consonant and the vowel both involve actions of the lips but the actions are not the same. The consonant requires lip closure while the rounded vowel requires lip protrusion accompanied by raising of the back of the tongue. The correspondence between [t] and [i] is less immediately obvious. The consonant is articulated by advancing the front of the tongue to make contact with the alveolar ridge or the back of the teeth while the vowel is made by simultaneously raising the blade of the tongue and pulling it back so as to approach without touching the hard palate. From the point of view of articulation, the correspondence between [k], made by raising the back of the tongue to make contact with the roof of the mouth, and [ɑ], made by approaching the root of the tongue towards the wall of the pharynx, is even less immediately obvious. Acoustically, however, a high central or back unrounded vowel, IPA [ɨ] or [ɯ], has much in common with a low [ɑ]. As secondary articulations of consonants, IPA has traditionally used the same diacritic for velarization and pharyngealization and only recently made an official distinction between them (Ladefoged 1982:211, 1993:231-32). Such a distinction is necessary, but the acoustic closeness can play an important role in both synchronic phonological alternations and diachronic changes in various languages.

10. Articulator-based place features of consonants and vowels

Figure 2 below offers in outline a proposed new theory of place features, positing four articulator nodes with binary terminal features that apply differently to consonants and vowels. I assume that the primary distinction between consonant and vowel is determined by the feature [±consonantal] at the root, but that vowel roots can be attached to non-syllabic X-slots, onsets or codas, either alone or as secondary articulations of consonants. Less commonly consonants can also occupy syllabic positions.

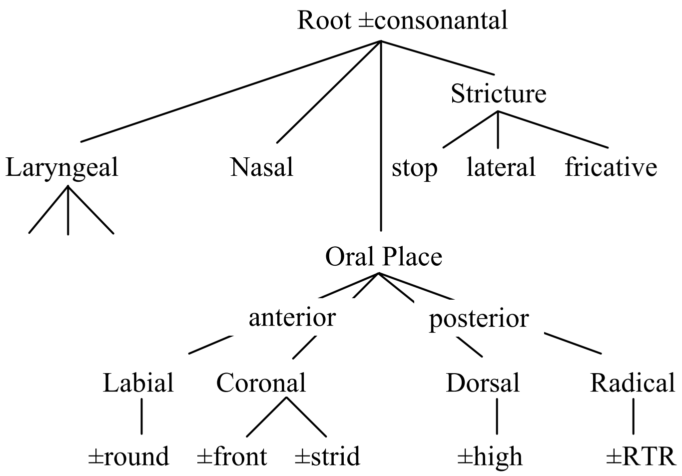


Fig. 2: Articulator-based Features of Place

In this scheme, anterior and posterior are not features but classificatory terms replacing the *SPE* place feature [±anterior]. They distinguish the Labial and Coronal articulators that fall outside the vowel space from the Dorsal and Radical articulators that fall within it. The difference between consonant and vowel from an articulatory point of view is determined at the root by the feature [±consonant], meaning presence or absence of complete or partial closure in the oral passage between the larynx and the lips. Nasal consonants, though inherently voiced and therefore sonorant, are consonantal in that they involve a closure in the oral passage. Lateral consonants are also typically voiced sonorants, but voiceless fricatives and affricaters are by no means rare. Laterals are typically coronal and [+lateral] is often treated as a subordinate feature under that place node, but velar laterals also occur in some languages, and I therefore tentatively assign the feature [lateral] to the Root. Lateral labials and pharyngeals are presumably ruled out on physical grounds. Nothing in my present discussion depends on this.

Labial and Coronal vowels require the concomitant action of one or both of the anterior articulators. In the absence of such concomitant posterior articulation, Labial and Coronal non-nasal sonorants are approximants, which are most commonly found in consonantal positions in syllable margins, but can also sometimes occur as [+syllabic] in syllable nuclei.

The terminal features under the four articulators apply differently to vowels and consonants. While consonants are typically (though not necessarily) singly articulated, Labial and Coronal, vowels require the concomitant action of one or both of the posterior articulators.

In the case of Dorsal and Radical the terminal values apply only to vowels. That is, [-high] (which means separation of the dorsum from the roof of the mouth), and [-RTR] (or [+ATR], which means movement of the tongue root away from the wall of the pharynx) are used to make vowel distinctions, but are not available to distinguish consonantal articulations. Uvular consonants, which are treated as [-high, -low] in the *SPE* system, are assumed to be doubly articulated by Dorsal and Radical. The features [±high] under Dorsal distinguish what are traditionally called high and mid vowels, while [±RTR] distinguishes the traditional back/front dimension for low vowels, but typically also involves small differences in height, higher for [-RTR] and lower for [+RTR]. The role of [±RTR] under Radical in combination with [±high] under Dorsal in harmony systems and as enhancement for length distinctions has already been outlined above.

There is a lack of symmetry between the articulation of vowels and consonants, even though the same articulators are involved. The optimal consonants [p, t, k] are singly articulated by the first three articulators: Labial, Coronal and Dorsal. The optimal vowels [ɑ, i, u] are articulated by Radical, Coronal-Dorsal, and Labial-Dorsal. Palatal stops and nasals [c, ɟ, ɲ] are doubly articulated by Coronal and Dorsal. Doubly articulated Labial-Dorsal consonants [k͡p] and [ŋ͡m] are also found in some languages. While the pharyngeal vowel /a/ is universal, it is difficult to make a consonantal occlusion by pressing the root of the tongue against the wall of the pharynx. The voiceless and voiced pharyngeal fricatives [ħ, ʕ] recognized in the IPA are comparatively rare. It will be argued below that they typically, perhaps always, involve concomitant action of the epiglottis and raising of the larynx. Uvular consonants [q, ɢ, χ, ʁ], which have a place of articulation between velar and pharyngeal, combine the actions of Dorsal and Radical, a conclusion that is supported by the fact that in Arabic they are treated as the 'emphatic' (i.e., pharyngealized) counterpart of the velars.

11. The terminal features of labial

The terminal feature [±round] distinguishes [+round] lip protrusion required for rounded vowels from [-round] lip closure required for bilabial stops and fricatives. Labiodental fricatives typically involve some protrusion of the lower lip. In a language like English that combines bilabial stops with labiodental fricatives, one may assume that the contrast is created by default. That is, the stops [p/p^h, b] are bilabial, biased towards [-round], while the fricatives [f, v] are labiodental, biased towards [+round], but without significant phonological effects. There are, however, languages like Ewe that use this contrastively and oppose [-round] bilabials to [+round] labiodentals.

Ladefoged (1993:269) notes that in Ewe, unlike English, the upper lip is actively raised in the production of labiodentals in order to maximize the contrast with bilabials.

Even where there is no minimal contrast in the feature composition of phonemes, a differential contrast between [+round] labiodentals and [-round] bilabials can emerge as significant in phonological rules. In Cantonese, which has only labiodental [f] and no contrasting bilabial [ɸ], labiodental [f] patterns phonologically with labiovelar [k^w, k^{wh}, w] as [+round] as opposed to bilabial [p, p^h, m] which behave as [-round]. Cantonese has historically undergone a process of diphthongization, whereby the long open high vowels, -iː, -uː, -yː, have become -ej, -ow, -øɥ respectively, except after palatalized initials (in the case of -iː and -yː) or labialized initials (in the case of -uː), where the feature [+round] is doubly linked to the onset and the nucleus. In accordance with this rule, contemporary Cantonese has pow, p^how, mow to the exclusion of *puː *p^huw, *muː; but fuː, wuː, to the exclusion of *fow, *wow. That is, labiodental [f] is treated as [+round] along with the labiovelar [w], while the bilabial stops are treated as [-round]. Initial f- in Cantonese is derived historically partly from earlier f- and partly from labiovelar x^w- and k^{hw}- (Pulleyblank 1997).

The default value for a Labial vowel is [+round] as combined with Dorsal [+high] in the cardinal high back rounded vowel [u] that occupies the top right hand corner of the IPA vowel triangle. The opposite value [-round] can also occur, however; for example, in Swedish [ʉ], which is said to involve lip compression in contrast to the lip protrusion in [u] (Lindau 1978:548). The high back unrounded vowel [ɯ] of Japanese is another example of a Labial vowel that surfaces phonetically as [-round]. Its labial character is shown by the fact that initial /h/ is realized as bilabial [ɸ] in front of it: /hu/ = [ɸɯ] in contrast to /ha/ [ha], /he/ [he], /ho/ [ho] and /hi/ [çi].

Although a purely Labial vowel with no Dorsal or Radical component is not possible, labiovelar [w] (that is, the nonsyllabic form of [u]) can lose its Dorsal component in onset position, giving the [+round] approximant [ʋ], which is a common variant of initial [w] in Mandarin, and which can also appear as syllabic [ʋ̩] in the Bai language of South China and in some Chinese dialects. The IPA does not provide a special symbol for a bilabial approximant corresponding to the fricative [β], but (as noted above) it is said to occur in Axininca Campa.

Assuming that the basic distinction between consonant and vowel is determined at the root, one can account for the difference between a doubly articulated labial velar stop [k͡p] or nasal [ŋ͡m] and a velar stop or nasal with labial secondary articulation [k^w] or [$ŋ^w$]. This can be done by assuming that, in the one case, there is a single, doubly articulated, consonant; while in the other, the consonantal articulation and the vowel articulation are on separate tiers, linked to the same timing slot. Typically in syllable initial position one will expect the semivowel to remain audible after the release of the stop, and in coda position to be audible before the closure of the stop (Pulleyblank 1984, 1989).[10]

According to Henderson (1966:170-71), the syllables written -*oc*, -*ong*, -*ôc*, -*ông* in Vietnamese are pronounced [auk͡p], [auŋ͡m], [əuk͡p], [əuŋ͡m] with a labial onglide followed by a doubly articulated velar-bilabial stop or nasal. If one assumes that these actually have underlying labialized velar endings, /kʷ/ and /ŋʷ/, in which the glide, though linked to the same timing slot as the stop, is indepedent of it, one can account both for the surface spreading of the glide into the preceding nucleus and for the double articulation of the stop as phonetic features of coärticulation. That is, the vocalic constrictions at the lips and the dorsum corresponding to [w] have an audible effect before the complete occlusion at the velum is accomplished. On the other hand, there is an assimilatory effect on the stop from the labial articulation of the glide, so that the occlusion takes place at the lips as well as the velum. This is a coärticulation effect of the glide on the stop and does not imply that the stop is underlyingly specified as combining velar and labial closure. It shows, however, how a consonant with secondary articulation could change to a single complex consonantal articulation. According to Henderson (1966), the so-called final palatals of Vietnamese, spelt -ch and -nh, are also strictly speaking palatalized velars, in which the oral or nasal stop, besides being fronted, is preceded by an overt palatal glide.

12. The terminal features of coronal

In the case of Coronal, the terminal feature [±front] replaces the *SPE* feature [-back], as well as the feature [±distributed], to distinguish the laminal approach of the blade of the tongue to the palate (combined with raising of the dorsum) in the case of a high front vowel [i] or a palatal stop [c] from the [-front] apical approach in the case of a singly articulated alveolar or dental [t], or when combined with Dorsal retroflex [ʈ]. The contrast between [+front] laminals and [-front] apicals for consonants is more fully utilized in many Australian and Dravidian languages, which contrast [+front] laminal interdentals with [-front] apical alveolars and [+front] laminal palatals with [-front] apical retroflexes, the first pair being simple coronal articulations, and the second pair being doubly articulated coronodorsals (Pulleyblank 1989). The feature [±strident]

[10] Clements (1990) deals with this problem by providing for a uniform set of place features for consonants and vowels, but partially segregating them by assigning the place features of vocoids to a secondary V-place node under the primary consonantal or C-place node.

under Coronal is required for fricatives and affricates to distinguish strident /s, z/ from non-strident /θ, ð/.[11]

Doubly articulated Corono-dorsal stops with laminal [+front] contact are the palatals [c, ɟ] found in some languages such as Hungarian, but commonly replaced by strident postalveolar affricates [tʃ, dʒ] as in English. Presumably this is because it is more difficult to maintain a complete closure at the palatal place of articulation, which is defined by the combined approach of the blade and back of the tongue to the roof of the mouth required for the cardinal high front vowel [i]. In Cantonese, [tʃ, dʒ, ʃ] are treated as non-distinctive variants of singly articulated purely coronal [ts, dz, s], with which they have merged for most speakers (Yue-Hashimoto 1972:89 and 120 n.8). In these languages the terminal coronal features [±front] are not used. Mandarin, on the other hand, distinguishes [+front] alveolopalatal [tɕ, tɕʰ, ɕ] from [-front] retroflex [tʂ, tʂʰ, ʂ]. German has the non-strident palatal fricative [ç] in addition to strident palatoalveolar [ʃ, ʒ]. To an English speaker, Mandarin retroflex [ʂ] sounds more like palatoalveolar [ʃ] than does alveopalatal [ɕ] which accounts for the fact that in the old Wade-Giles system of romanization the former was transcribed as *sh* while the latter was distinguished as *hs*. In the case of the affricates, the retroflex and palatal consonants were transcribed in the same way and the distinction was shown only in the following vowel.

The doubly articulated nature of palatal or palatalized consonants is illustrated by the way in which the dorsal component may be lost diachronically, as when the velar initial of Latin *centum* 'hundred' first palatalized to proto-Romance [tʃ], preserved in Italian *cento* [tʃɛnto] before becoming alveolar [ts] in Old French and simplifying further to give modern French *cent* [sã]; in the change of *pj- to pt- in Ancient Greek (Pulleyblank 1989). Less commonly, the coronal component of the articulation can be lost as in Spanish, where palatalveolar [ʃ, ʒ] of the sixteenth century later merged as the velar fricative [x], as in Juan [xwan] (compare Italian *Giovanni*) and *Don Quixote* [kixote], for which French *Quichotte* [kiʃɔt] preserves the earlier pronunciation.[12]

It will be noted that the provision that the terminal features [±high] and [±RTR] of Dorsal and Radical (which take care of the traditional dimension of vowel height) apply only to vowels and not to consonants obviates the need for the more complicated

[11] Although labio-dental [f] is assigned the Labial articulator and the dental fricative [θ] is assigned to the Coronal articulator, the two sounds undoubtedly have an affinity as we find in Cockney English [fɪŋz] for *things* and in the Russian treatment of Greek *θ-* in names like Fyodor for Theodore. It is unclear to me whether this is because they share the same dental place of articulation or whether it is because of acoustic similarity.

[12] Penny 1996:86-88.

structures proposed by Clements (1993), who finds it necessary to set up vowel place and aperture as separate nodes under C-place.

The coronal feature [-front] for [-consonantal] roots, with or without concomitant Dorsal or Radical articulation, defines various types of rhotics. As far as Chinese is concerned, I assume that Mandarin *r* is an approximant combining Coronal [-front] with Dorsal [+high]. The assumption that it has a dorsal component is consistent with the fact that in some dialects (including some districts of Changli county, as well as Wuhan) final -*r* is replaced by velar [ɯ].

The dorsal articulation of Mandarin /r/ contrasts with English retroflex *r* which has been shown phonetically to involve tongue-root retraction. I assume that in English, instead of Dorsal [+high] and Coronal [-front], it combines Radical [+RTR] and Coronal [-front] articulation. In r-dropping dialects the coronal articulation is deleted before another consonant or a pause leaving the pharyngeal glide: *far* [faɻ] > [faɑ̯]. Before a vowel onset the coronal articulation is restored. The fact that typically in such dialects unetymological [r] is inserted also in a case like *India Office* [ˈɪndɪəˈɹɔfɪs] suggests that [ɪə] does not constitute two syllables but is a monosyllabic diphthong /ia/ in which the second (low) vowel does not reach its target. Before a following vowel onset, final /a/ spreads as nonsyllabic /ɑ̯/ to the empty onset of the following word, where it is reinforced by the addition of Coronal [-front] as if it came from a word like *dear*.

Non-strident retroflex affricates for which there is no IPA symbol are also possible. Such a phoneme is found in Vietnamese as *tr*, which (according to Henderson 1966:166) is a "retroflex affricate" which she transcribes as [tɹ] in the southern dialect. Thompson calls it a retroflex stop, but adds "it is usually slightly affricated" (1965:89). Daniel Jones calls English *tr*, in which the place of articulation of the stop is assimilated to the retroflex continuant that follows, an affricate (1972:159). See also Gimson (1975:171-78). In English, unlike Vietnamese, there are other initial clusters of stop + *r* so that it may seem best to treat *tr* also as a cluster from a phonological point of view. On the other hand, I have observed a tendency in English for *tr*- to merge with the affricate *ch*- [tʃ] in child language, that paralleling the dialectal merger of *tr*- and *ch*- in Vietnamese and that of *shéshăng* initials tr-, tr^h-, trɦ- of Late Middle Chinese with the *zhèngchǐ* initials tʂ̻-, $tʂ̻^h$-, tʂ̻ɦ- that took place in the evolution of Early Mandarin.

13. Terminal features of dorsal and radical

As mentioned above, I assume that the terminal features, [±high] and [±RTR], of the posterior articulators apply only to vowels and not to consonants. The unspecified vowel schwa [ə] (which in Chinese and many other languages is inserted by default to fill an empty syllable nucleus) does not require either active raising or lowering of the dorsum, or active retraction or advancement of the tongue root. Other vowels require active gestures of one or other or both of these articulators, which may be combined with gestures of the lips or the blade of the tongue. The following table will illustrate major contrasts that have to be accounted for in the various languages around the world. I use the less familiar IPA symbol [ɘ] instead of schwa [ə] for a specified close-mid central vowel, contrasting as +ATR with open-mid -ATR [ɜ] in vowel harmony, in Kpokolo (Kaye, Lowenstamm and Vergnaud 1985). [ɨ̞] is the lowered high central vowel of Kirghiz referred to above. Omitted are the Labial [-round] high and mid vowels [ɯ] or [ʉ] and [ɵ] of Japanese and Swedish.

	Labial	Coronal	Dorsal	Radical
ə				
i		+front	+high	-RTR
ɪ		+front	+high	+RTR
e		+front	-high	-RTR
ɛ		+front	-high	+RTR
æ		+front		-RTR
u	+round		+high	-RTR
ɷ	+round		+high	+RTR
o	+round		-high	-RTR
ɔ	+round		-high	+RTR
ɒ	+round			+RTR
y	+round	+front	+high	+RTR
ʏ	+round	+front	+high	+RTR
ø	+round	+front	-high	+RTR
œ	+round	+front	-high	+RTR
ɶ	+round	+front		+RTR
ɨ			+high	-RTR
ɨ̞			+high	+RTR
ɘ			-high	-RTR
ɜ			-high	+RTR
ɑ				+RTR
a				-RTR

Table 2

The values that the vowels specified by these featural contrasts will take in different environments and different languages will not necessarily correspond exactly in IPA terms to those given in this table. For example, the long and short low vowels of Cantonese, which I assume to be respectively [+RTR] and [-RTR], are usually interpreted phonetically as low central [A] and higher mid low [ɐ] and, as noted above, Changli [ɑ] in open syllables and before [ŋ] and [a] before [n] are said by the investigators to have similar values to those in Cantonese. The IPA contrast between central-unrounded [ɨ] and back-unrounded [ɯ] seems to be a distinction without a difference. I know of no language in which they are used contrastively; and in descriptions of Vietnamese, for example, the same vowel is interpreted by some phoneticians as [ɨ] and by others as [ɯ]. Compare also the difference noted above in the interpretation of the English lax vowel in *cut* as raised low central [ɐ] or lower mid back unrounded [ʌ].

14. Syllable structure in Chinese

Syllabicity as the way to distinguish the high vowels [i], [u], [y] from the corresponding semivowels/glides [j], [w] [ɥ] was introduced as an afterthought in *SPE*, but full recognition of the syllable as an essential concept in phonological analysis had to await the advent of non-linear phonology in the mid seventies and eighties (Kahn 1976, Clements and Keyser 1983, among others). It is particularly important in the case of Chinese languages, in which morphemes have been typically monosyllabic from the earliest times.

Dividing syllables into two complementary parts, onset and rhyme, corresponds to the traditional Chinese method of *fanqie* spelling that was used in the absence of an alphabetic script by commentators on classical texts to identify the pronunciation of logograms from the second or third century onwards. Dictionaries were compiled classifying words by rhyme and, within each rhyme, by homophone groups having the same onset. After the recognition and naming of the four Middle Chinese tonal categories, Level, Rising, Departing, and Entering, tone was the first category for classifying syllables, and rhymes were listed in corresponding order within each tonal category. In the ninth century, under the influence of the Sanskrit alphabet (which unlike western alphabets recognizes the syllable as an essential constituent), Buddhist monks developed a more elaborate classification of onsets and rhymes in the so-called rhyme tables.

It is not surprising, therefore, that the syllable continued to be treated as a basic unit in Western-inspired linguistic studies of Chinese in the twentieth century. This was especially important in order to take account of lexical tone, a subject that was not provided for in *SPE*. For example, in *A Synchronic Phonology of Mandarin Chinese* (Cheng 1973), using *SPE* features C.C. Cheng set up the following formula for the

Chinese syllable, assumed to be applicable not only to Mandarin, but to other contemporary forms of the language:

<table>
<tr><td colspan="5">tone</td></tr>
<tr><td rowspan="4">initial</td><td colspan="4">final</td></tr>
<tr><td rowspan="3">medial</td><td colspan="3">rime</td></tr>
<tr><td rowspan="2">nucleus</td><td colspan="2">ending</td></tr>
<tr><td>vocalic ending</td><td>consonantal ending</td></tr>
</table>

Medial refers to post-initial vocalic segments as in *guān* ‘official’ or *biān* ‘border’. The possibility of a pre-final vocalic segment, not exemplified in Mandarin, was recognized in order to accommodate endings such as -eing in Fuzhou dialect. A similar structure, changing ‘ending’ to ‘coda’ and omitting the possibility of combined vocalic and consonantal ending, was proposed by Matthew Chen in his attempt to reconstruct the diachronic development of Middle Chinese to modern Peking (1976). Chen also expressed this in the formula: $(C_1)(G_1)V(C_2,G_2)$, where G stands for glide and the comma between C_2 and G_2 means ‘or’. It should be noted, however, that he always writes these ‘glides’ with the symbols for high vowels and claims: “There is no reason to introduce a contrast between vowels and glides in Chinese. … [H]igh vowels are automatically realized as glides when adjacent to other vocalic elements.” He admits that ambiguity can exist in the case of a sequence /iu/ or /ui/, but appeals vaguely to what he calls “pattern congruity” to regard them as GV sequences. Unfortunately, this does not work in Cantonese which has [wu:j] for Mandarin *huí* ‘return’ and [ki:w] for Mandarin *jiāo* ‘proud’.

The practice of ignoring the difference between high glides and vowels in Chinese dialect description seems to go back to Y.R. Chao’s analysis of Mandarin in his famous article, ‘The non-uniqueness of phonemic solutions of phonemic systems’ (1934), and to his critique of Bernhard Karlgren’s Middle Chinese reconstruction (Chao 1941), in which he argued that Karlgren’s distinction between vocalic -i- and -u- and consonantal -i̯- [= IPA -j-] and -w- before a following low or mid vowel as medials was redundant, since in every case Karlgren also posited a contrast in the following mid or low vowel. Unfortunately, in extending this as a general principle applicable to other forms of Chinese, he did not take into account a feature of Min dialects that had already been pointed out by another great pioneer of modern linguistics in China, Luo Changpei. In his study of the Xiamen (Amoy) dialect (1931:16), Luo stated very clearly that as the first element in diphthongs palatal -i- and rounded -u- were “long, not short as in Beiping, without any tendency to become consonantal [j] and [w]. Therefore, the sounds [ɪa], [ɪo], [ɪu], [ʊa], [ʊe], [ʊɪ], are neither short-long combinations of sound nor long-short like the two diphthongs [aɪ], [aʊ]. Their first and second vowels are of equal length." The late Søren Egerod also systematically distinguished between glides and syllabic vowel clusters, not only in his phonemic analysis of Longdu, an isolated Min dialect near Macao (Egerod 1956), but also in the brief descriptions of other Min dialects that he included at the beginning of his book.

That this is a general characteristic of Min dialects is confirmed by the second edition of the *Hanyu fangyin zihui* (Glossary of Chinese Dialect Readings), 2nd edition, 1985. Although in the body of the text the traditional practice of not distinguishing high glides and vowels is followed, in the introductory descriptions of all the Min dialects it is stated very clearly that, as Luo and Egerod maintained, sequences like -ia-, -ua-, -ya- are to be interpreted as VV, not as GV. As argued elsewhere, this Min evidence supports the possibility of reconstructing VV diphthongs as syllabic nuclei in Middle Chinese, which is suggested also by Sino-Vietnamese, which continues to have such structures at the present time. In the northern dialects that evolved into what is now called the Mandarin family, there was a systematic elimination of VV nuclei (see below). This did not, however, extend to Min and Yue.

The pharyngealization of final [ŋ] in Mandarin is a vestige of another characteristic of Middle Chinese, in which all final velars, including the stop [k] in the so-called Entering Tone, were either palatalized, or labialized, or pharyngealized in contrast to final labials and dentals. In this respect Northern Min exemplified by the Fuzhou dialect is even more archaic than Middle Chinese in that it retains palato-labialized finals in [ɥ͜ŋ] as well as palatalized [j͜ŋ] and labialized [w͜ŋ] which can be shown to be a feature of Old Chinese.

15. Pharyngeal glide as a coda for mid and low vowels in Mandarin

This is not the place for a full-scale discussion of Mandarin phonology for which many phonemic analyses have been offered, from Chao (1934) onward, including Hartman (1944), Hockett (1947, 1950), Cheng (1973), Pulleyblank (1984), and Duanmu (2000). Something more needs to be said, however, about the assumption, for which *prima facie* evidence has been offered on the basis of *r*-suffixation in Changli, that the pharyngeal glide -ɑ̯ is present as the coda for the mid and low vowel finals transcribed in *pinyin* orthography as *-e*, *-ie*, *-ue*, *-uo*, *-a*, *-ia*, *-ua*, for which Y. R. Chao (1968:23-24) offers the phonetic readings: [ɤ] *or* [ɤ^], [iɛ] *or* [iɛ<], [yɛ] *or* [yɛ<], [uɤ] *or* [uo^], [A], [iA], [uA], the alternative readings being described as "very narrow". The tradition has been to treat the mid vowel finals as having the same nuclear vowel /ə/ as in *-ei* [ej], *-ou* [ou], *-en* [ən], *-eng* [ʌŋ], and the low vowel finals as having the same nuclear vowel /a/ in *-a* [A] (including *-ia* and *-ua*) as [a] in *-ai* [ai], -au [ɑu], *-an* [an], and [ɑ] in *-ang* [ɑŋ], the phonetic variants being treated as conditioned allophones. In the light of the role of the tongue-root features [±RTR] as an enhancement for other vowel distinctions in various languages and the clear evidence of *r*-suffixation in Changli, one must assume that this is a too drastic application of the rule of minimal pairs, which is no doubt a useful rule of thumb, but must not be applied too rigidly.

This analysis of Mandarin also supports the assumption that, as argued above, the vowel *schwa* /ə/ needs to be treated as unspecified and epenthetic, filling an empty V slot and assimilating to its surroundings. This is different from Duanmu's definition of *schwa* as underlyingly [-high, -low] without specification for [back] and [round] (2000:40). It is not clear how he can account for the [+back, -round] phonetic value [ɤ] that it acquires when (according to him) it lengthens in order to occupy two moras in an open syllable, as in *gē* [kɤ] 'song'.

16. Shortening of CV(V)C to CVC in Early Mandarin

The common assumption that the formula CVX for syllable structure is applicable to all modern forms of Chinese is contradicted by the existence of -VV- diphthongs as nuclei in present-day Min dialects. The present situation in northern dialects in which the bimoraic requirement for fully stressed syllables must be satisfied by nasal consonant or a glide or a coronal continuant in the nucleus only came about in the transition from Late Middle Chinese (LMC) of the 9th century and Early Mandarin (EM) of the 13th and 14th. This involved a systematic simplification of -VV- nuclei to -V-. Yue dialects as well as Min were exempted from this change so that vowel length is still phonemic in Cantonese.

Between Late Middle Chinese and Early Mandarin there was a systematic change in syllable structure eliminating the possibility of a second -V- in the nucleus. The way in which this occurred provides insight both into the role of syllable weight and to that of secondary articulation of final velars. This was discussed in detail in Pulleyblank 1986 but it will be useful to summarize some of the main points here.

First consider the finals in -an. In LMC the nine finals -an, -aːn, -jaːn, -waːn, -ian, -jian, -uan, -yan, and -jyan were grouped together in the *shān* rhyme group and could all rhyme together in vernacular verse, in spite of the fact that, judging by Sino-Japanese loanwords which have *-en* for words in -ian, the low central vowel in /ia/ must have been allophonically raised and fronted by the proceeding /i/. In other words, neither the contrast in length between short /a/ and long /aː/ nor the allophonic effects on /a/ of a preceding high vowel counted from the point of view of rhyming. Earlier, when the Early Middle Chinese (EMC) /ɛn/ rhyme had not yet broken to /(j)ian/, it had been included with EMC /(j)ian/ rhyme in a *tóngyòng* ‘use together’ rhyme category, recognizing the allophonic fronting and raising of /a/ by the preceding high front vowel. At that stage the EMC /ɨan/ rhyme *yuán*, in which the head vowel would have been allophonically raised without fronting by the preceding high central vowel, was still distinct from /ian/, did not rhyme with /an/ or /aːn/, but with EMC /ən/. In the shift to LMC, /ɨ/ was fronted to /i/ so that /ɨan/ merged with /ian/ and became part of the *shān* rhyme group.

In the global change of syllable structure from LMC to EM, long -aː- shortened to -a- so that -aːn merged with -an, which continued to rhyme with -jan < -jaːn and -wan < -waːn. The two vowels in the VV diphthong -ian-, however, coalesced giving -ɛn-, combining the features [Coronal +front, Radical -RTR] which now ceased to rhyme with [an]. Final [-jɛn] < LMC [-jian] rhymed with [ɛn] but was still treated as distinct from [-ɛn] in the *ḥP‘ags-pa* alphabetic orthography for Chinese based on Tibetan created in the second half of the 13th century as found in the rhyme dictionary *Menggu ziyun*. In the early 14th century rhyme dictionary, *Zhongyuan yinyun*, however, they had merged, presumably as [-jɛn]. Both dictionaries set up an [-ɛn] rhyme separate from [-an]. The LMC front-rounded finals [-yan] and [-jyan] became [-ɥɛn] ([-wɛn] after retroflex) and were also placed in the [-ɛn] rhyme. The two vowels in the LMC final [-uan] similarly fused to [-ɔn]. This was still put in the [-an] rhyme in the *Menggu ziyun* but was separated from it in the *Zhongyuan yinyun*. The three rhymes [-an, -ɛn, -ɔn] were kept separate in vernacular poetry of the Mongol period.

Since that time, [-jan] has merged with [-jɛn] and [-ɔn] has merged with [-wan], while [-ɥɛn] has been retained by some speakers, with the same main vowel as [jɛn], but for other speakers it has become [ɥan]. The low front vowel in [jɛn], which might be better characterized as [æ], combining Coronal [+front] and Radical [-RTR], according to the scheme of Table 2, is treated as allophonic both in the current *pinyin* romanization (which spells it as *-ian*) and in popular rhyming. The preference for a fronted vowel (allophonic in Mandarin, but generally recognized in phonetic descriptions) before the coronal nasal has a universal basis (Pulleyblank 1989). All four surviving finals from the *shan* rhyme group can now rhyme freely together as they could in LMC, although there has been a drastic reduction in the number of distinct syllables.

The history of the *dàng* rhyme group, LMC -a͡ɑ̯ŋ, was quite different. Medial -i- in a word like *jiāng* LMC kia͡ɑ̯ŋ ‘border’ did not fuse with the following nuclear -a- which was linked to the pharyngealized coda. Instead the -VV- sequence was reduced to -V- by changing -i- to nonsyllabic -j-, giving EM kjaɑ̯ŋ, which continued to rhyme with -aɑ̯ŋ. This is clearly shown in the contemporary alphabetic orthography invented for Chinese by the Tibetan monk *ḥP‘ags-pa* (Pulleyblank 1970). It can be accounted for on the assumption that the phoneme /a/ in the melody was linked both to the second X-slot of the nucleus and to the X-slot of the coda /ŋ/ as a secondary articulation, which prevented fusion with the preceding /i/ into a single V, as shown in Fig. 3.

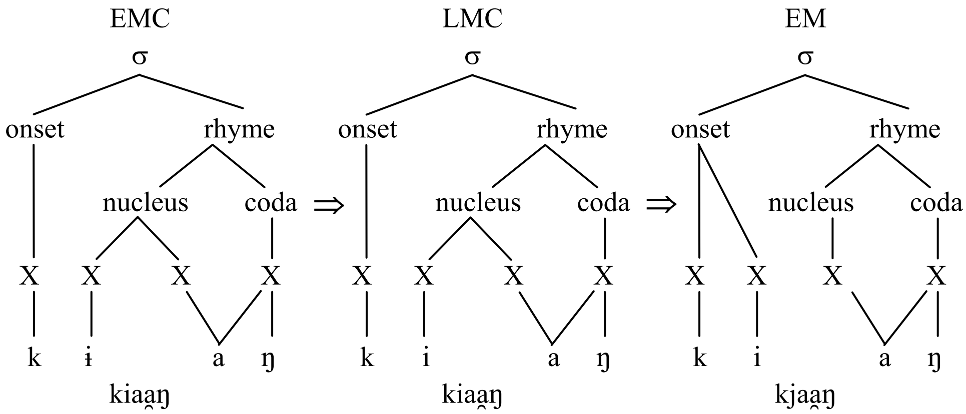


Fig. 3: *jiāng* EMC, LMC kiaɑ̯ŋ EM kjaɑ̯ŋ ‘border’

The story becomes more complicated in the case of the EMC palatal and retroflex sibilants which had formed two distinct series of initials in EMC but merged as retroflex in LMC as a result of (1) a general rule fronting the high central vowel /ɨ/ to /i/, and (2) a general rule eliminating /i/ after retroflex sibilants, which brought the two types of initial into complementary distribution, merging as retroflex. Figures 4 and 5 illustrate this along with the subsequent development for the words *shāng* (EMC ɕɨaɑ̯ŋ, LMC ʂiaɑ̯ŋ ‘discuss’) and *shuāng* (EMC ʂɨaɑ̯ŋ, LMC ʂaːɑ̯ŋ ‘frost’).

In both words the first step was the fronting of -ɨ- to -i-. In the case of ‘discuss’, the sequence ɕiaɑ̯ŋ- would have at first been quite acceptable. In the case of ‘frost’, however, the resulting sequence ʂiaɑ̯ŋ was unacceptable according to the current rule that disallowed a palatal vowel after retroflex. Medial -i- was dropped, but syllable weight was preserved by compensatory lengthening, giving ʂaːɑ̯ŋ. At this stage, palatal sibilants only occurred before -i- or -y- while retroflex sibilants never occurred in such a context. The two types of consonant were phonemically identified and their subsequent history makes it clear that they were treated as retroflex. There was no loss of distinction among lexical items. In the LMC rhyme table, *Yunjing*, words with former palatals were placed in Grade III, while the words that already had retroflex initials in the EMC rhyme dictionary, *Qieyun*, were placed in Grade II.

Diachronically, the long-term trend to eliminate front vowels after retroflex continued to operate. In the shift from LMC to EM, the post-initial vowel -i- in LMC ʂiaɑ̯͡ŋ ‘discuss’ must have first become a semivowel -j- and then been deleted, giving EM ʂaɑ̯͡ŋ, as attested in the *ḥP‘ags-pa* spelling. In a word like *shuāng* ‘frost’ (LMC ʂaːɑ̯ŋ), one might suppose that the reduction in syllable weight from -VVC to -VC could have been achieved simply by shortening the vowel. This would have brought about merger with *shāng* 'discuss', which did not occur. My assumption is that what must have happened instead is that the first -a- in the nucleus became nonsyllabic -ɑ̯-, as in the case of -ia- becoming -ja-. As in Axininca Campa cited above, the very sonorous pharyngeal semivowel was replaced by the corresponding velar semivowel [ɰ], which had the same tonality. This will account for the *ḥP'ags-pa* spelling *šhaŋ*. In that alphabet the letter *h*, which transcribes Chinese /x/ as an initial, is also used as a diacritic on a following vowel, implying centralization. Thus *-hi-* is used for the vowel [ə] in *dēng* (LMC təɑ̯ŋ, EM təɑ̯ŋ 'climb'), spelt *dhiŋ* ,and in *gēn* (LMC and EM kən), spelt *ghin*. We also find *-hi-* used to spell so-called apical vowels as in *šhi* for *shī* 'teacher' and *shi* for *sī* 'think' which were already pronounced [ʂɹ̩] and [sz̩] respectively as in Modern Mandarin.

By the time of the *Zhongyuan yinyun* in the 14th century, the velar semivowel [ɰ] had been replaced by labiovelar [w], giving the current Mandarin value. We can tell this by the fact that in the later dictionary it was treated as a homophone of *shuāng* 'pair' (EMC ʂaɨwŋ, LMC ʂwaːwŋ, EM ʂwaŋ), spelled as *šwaŋ* in *ḥP'ags-pa*, in which the medial -w- had a quite different source. The change of -ɰ- to -w- in words like 'frost' is easily explained by the fact that the semivowel -ɰ- was a unique phoneme found in no other context in the language and carried a very small functional load. Medial -w- in 'pair', which is attested by the *ḥP'ags-pa* spelling, had a quite different origin (Pulleyblank 1984:121-122). It is an example of a word with a retroflex sibilant initial from the *jiāng* rhyme group containing only the Grade II rhyme *jiāng* (along with its counterparts in other tones), which combined the Type A words with *Cr- clusters that came from three Old Chinese rhyme groups ending in rounded or front-rounded velars. My hypothesis (1991:15) is that before the shift from EMC to LMC it ended in -œːwŋ/k. In the same way that unrounded Grade II finals in EMC -ɛː- shifted to -jaː- in the transition to LMC, front-rounded -œːwŋ/k- shifted to -ɥaːwŋ/k-, which then simplified to -aːwŋ/k after labials, -jaːwŋ/k after velars, and -waːwŋ/k after retroflex, subsequently becoming -waːɑ̯ŋ/k in the merger of the *jiāng* group with the *dàng* group that was already underway within the Tang period and was complete by early Song times.

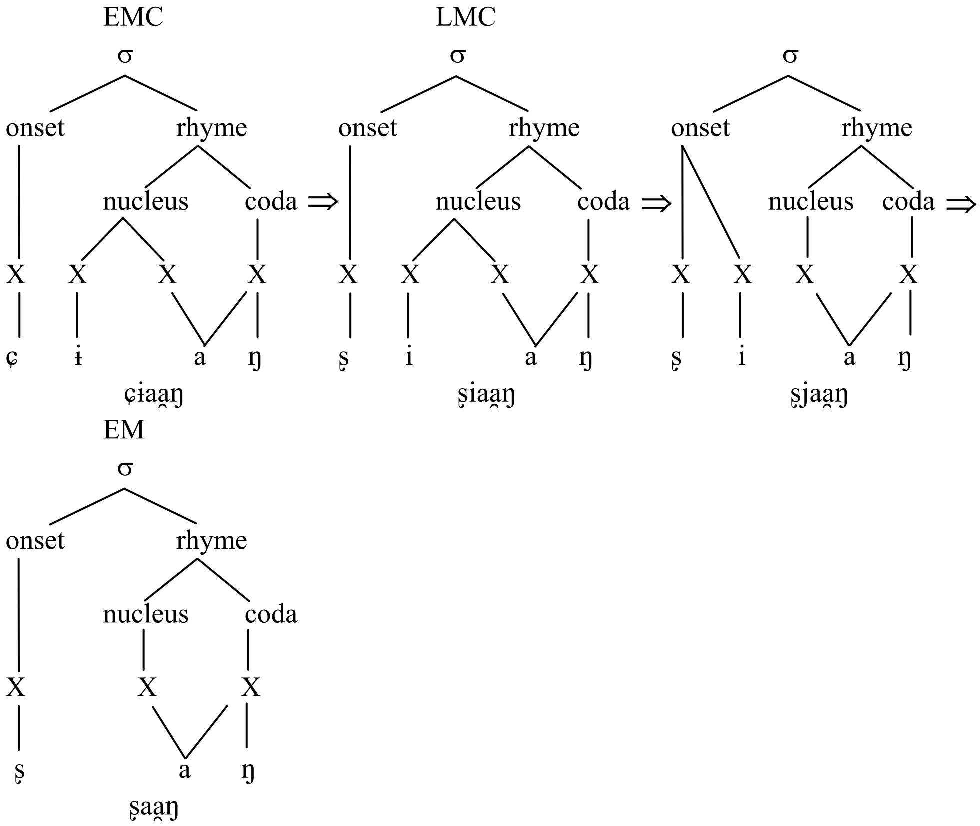
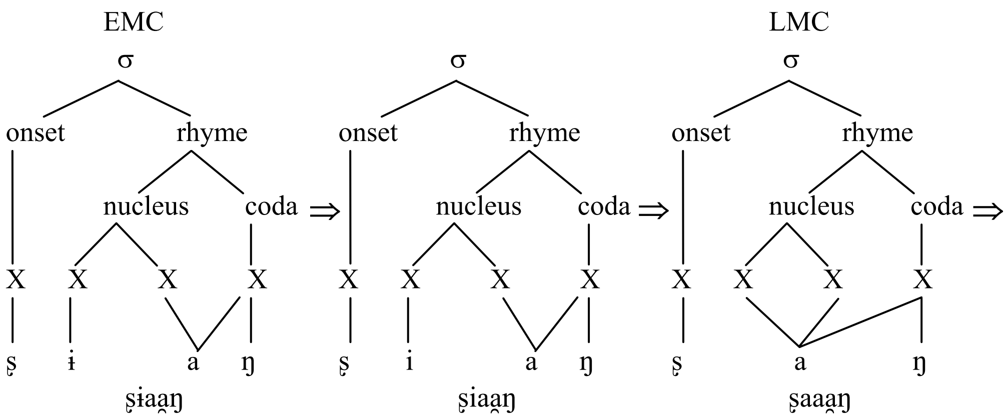


Fig. 4: *shāng* EMC çɨaa̯ŋ LMC ʂiaa̯ŋ EM ʂaa̯ŋ ‘discuss’



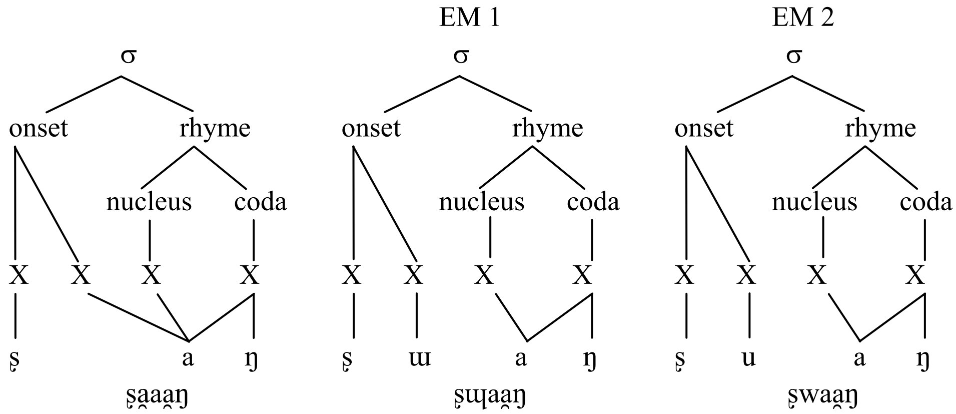


Fig. 5: *shuāng* EMC ʂ̣ɨaɑ̯ŋ LMC ʂ̣aːɑ̯ŋ EM ʂ̣ɰaɑ̯ŋ > ʂ̣waɑ̯ŋ ‘frost’

17. Loss of final oral stops with retention of glides from secondary articulation of velars in Mandarin

Another major simplification in the phonology of northern Chinese dialects between the ninth and thirteenth centuries was the reduction of the so-called Entering Tone, that is, syllables ending in an oral stop. A first step was debuccalization of oral stop to glottal stop, which still remains in some dialects. In Early Mandarin, as represented by rhyme dictionaries of the thirteenth and fourteenth centuries, however, words in this tone category were redistributed over the other three earlier categories, Level, Rising, and Departing (Pulleyblank 1978, 1984). From the point of view of the present discussion, the important thing to note is that there was a significant contrast in the treatment of words in final *-p or *-t and words in *-k. In the case of *-p and *-t the consonant was simply dropped, while in the case of *-k, which always had one of the three secondary articulations, -j, -w, or -a̯, the glide remained as the coda; e.g., *gu* ‘bone’(LMC kut, EM ku), but *guo* ‘country’ (LMC kuɑ̯k > kujk EM kuj). For the EM form of the latter compare Xi’an *kui*. The present-day standard Mandarin reading originated as a literary pronunciation [kwəa̯], imported into Beijing from the south in early Ming times, when the capital was moved from Nanjing to Beijing. In the more northerly dialect that became the standard in the Mongol period, LMC -ajŋ/k and -əɑ̯ŋ/k merged as -əjŋ/k. This illustrates the way in which pharyngealization in Chinese must be treated as a secondary articulation on the same level as palatalization and labialization.

18. [RTR] as enhancement for vowel length distinctions in Cantonese

Cantonese has essentially the same contrast as western European languages (like English or German) between long vowels that can occur either in open syllables or before a coda consonant and short vowels that require a consonantal closure. The correct pairing of corresponding short and long vowels in Cantonese is, however, complicated by many historically determined gaps in distribution that make it difficult to apply the standard method of minimal pairs. The one clear case is that of the long vowel transcribed as low central [Aː] in Anne Hashimoto (1972), which is found either in open syllables or before a consonant, and the somewhat raised short low vowel transcribed as [ɐ], which can only occur in the latter environment. This is comparable to the contrast in tense and lax low vowels in German or the contrast between the vowels in *father* and *but* in English. In the case of the high vowels [iː] and [uː], which (like tense high vowels in western European languages) can occur either in open syllables or before the dental and labial consonants [n, t, m, p], there is, however, complementary distribution with short [ɪ] and [ʊ], which only occur before the velars [ŋ, k]. There is a good historical explanation for this. The finals [-iːm/p, -iːn/t] derive from LMC bimoraic -iam/p, -ian/t respectively; while [-ɪŋ/k] and [-ʊŋ/k] have a quite different origin involving the simplification of complex codas in -əjŋ/k and -əwŋ/k by the spread of the secondary articulations into the nucleus (Pulleyblank 1997).

Superficially there appears to be complementary distribution in Cantonese between the vowels transcribed as long [ɛː, ɔː, œː], which can occur either in open syllables or before consonants, and short [e, o, ø], which require a following consonant or semivowel, and they have sometimes been regarded as tense and lax variants of the same vowels. Historically, however, these long and short vowels have nothing to do with one another. In Cantonese the short vowels are higher than the corresponding long vowels, which is the opposite of the relationship between tense and lax mid vowels in Western European languages. Cantonese long [ɛː], [ɔː], and [œː] are best regarded as having the Coronal and Labial features [+front], [+round], and [+front, +round] respectively added to the purely Radical vowel [ɑː], with no contribution at all from Dorsal. In terms of feature composition Cantonese [ɛː] and [ɔː] correspond to English [æ] and [ɒ], rather than to the English lax mid vowels [ɛ] and [ɔ]. On the other hand, the short high-mid front vowel [e] of Cantonese, found only in the final [ej], is historically derived from the diphthongization of long -iː and can be interpreted, like final -ej in Mandarin, as phonemically /əj/ with surface assimilation of the schwa vowel to the following semivowel. Long -uː and -yː have similarly diphthongized to -ow and -øɥ and can similarly be analyzed as /əw/ and /əɥ/ (Pulleyblank 1997).

19. Additional problems in Mandarin *r*-suffixation

The hypothesis that the apparently open mid and low vowels of Mandarin end in a pharyngeal glide offers a ready explanation for a puzzle about *r*-suffixation that has troubled investigators from the time of Hartmann (1944) and Hockett (1947, 1950) onward: why *gē* 'song' + *-r* ≠ *gēn* 'root' + *r*. This can be explained on the assumption that *gē* 'song' is phonemically /kəɑ̯/ and that when -r is added /kəɑ̯r/ from *gē* remains distinct from /kər/ from *gēn*.

Nevertheless, a problem remains. The distinction in question is only found in Tones 1 and 2. In Tones 3 and 4 it is neutralized so that, for example, while in Tone 1 the word *jiē* 'street' + *r* gives /tɕjəɑ̯r/, remaining distinct from *jī* 'chicken' + *r* which gives /tɕjər/, in Tone 3 *jiě* /tɕjəɑ̯/ 'sister' + r is not distinct from *jǐ* /tɕij/ 'how many' + *r*. In both cases the insertion of [ə] to separate the high front glide in the onset from the retroflex coda is easily explained by the assumption that retroflex has the coronal feature [-front] and is therefore in contradiction with the preceding [+front] feature of [i, j].

Historically, Tones 1 and 2 in Mandarin are descended from the Middle Chinese Level Tone, which split into Upper (*yin*) and Lower (*yang*) registers during the Tang period (7th to 9th centuries) conditioned by the loss of voicing in obstruent initials. Tone 3 is primarily the descendant of the Middle Chinese Rising Tone, which is now widely accepted to have originated in a final glottal stop /ʔ/. My assumption is that Departing Tone also had a glottal feature in Middle Chinese, in this case final aspiration symbolized as raised -^{h}, derived at least partly from a formative suffix *-s but possibly also from a final velar fricative *x (Pulleyblank 1984).

More directly relevant to the present discussion is phonetic evidence suggesting that there are still glottal features associated with these tones in present-day Beijing pronunciation. In Tone 3 there is often an audible glottal catch in the vowel at the lowest point of the tone.[13] Also, according to Y. R. Chao, after Tone 4, which he describes as ending in a *perdendosi* pitch (an Italian musical term meaning 'losing itself, dying away in volume of tone and in speed'), a high vowel in a neutral-tone syllable with a fricative or affricate initial tends to be voiceless, as in *zhàngfu* [-fu̥] 'husband' (1968: 37, 141). It is tempting to suppose that these characteristics of present-day

[13] Duanmu refers to what he calls "murmur" or "breathiness" as a feature of Tone 3 (2000:213). This is surely a misunderstanding. Murmur, symbolized by [ɦ] as a feature attached to a consonant or subscript [a̤] under a vowel in IPA, is indeed a feature of lower register tones in modern Wu dialects. It goes with the way in which the velar fricatives, x- and ɣ- of northern Middle Chinese debuccalized to h- and ɦ- in Wu. The glottal catch of Tone 3 in Beijing is quite different. It is like the creaky tone in Burmese, which, like the Rising Tone in Chinese, corresponds historically to final glottal stop.

Mandarin tones, now regarded as mere surface phenomena, could be a survival in the underlying articulatory targets of the tones in question of the glottal features that were originally responsible for the development of the tonal system in the first place.

Just how these glottal features would interfere with the preservation of the -ɑ̯ glide in -r suffixation in Tones 3 and 4 is not clear and must await further investigation.

20. Semitic gutturals

The tongue-root articulations that have been discussed so far are vocalic, including both the generally recognized features ATR and RTR found in vowel harmony systems and [±RTR] as a proposed replacement for the *SPE* feature [±low], used in various ways as an enhancement of other phonemic contrasts. This is also true of the not-generally- recognized pharyngeal glide [ɑ̯] that is proposed as the secondary articulation responsible for pharyngealization of consonants wherever it occurs and as a coda in Mandarin, on a par with [j] and [w] as nonsyllabic forms of [i] and [u]. The voiceless and voiced pharyngeal fricatives ħ and ʕ of Semitic and other related languages, on the other hand, function as consonants. They are on a par with other oral consonants as components of the triliteral roots that are characteristic of such languages. In this respect it has been argued that they belong, along with the uvulars χ and ʁ and the laryngeals ʔ and h, to a 'natural class' of gutturals, requiring us to abandon the hypothesis of Radical as an oral articulator on the same level as Labial, Coronal, and Dorsal, and instead to recognize Pharyngeal or Guttural as an orosensory region (McCarthy 1991, 1994).

I am not in a position to discuss the phonology of Semitic languages in any detail, but I offer the following observations. (1) As far as the vowel /a/ is concerned, it seems clear that the Radical feature [±RTR] operates in essentially the same way in Semitic as in other languages that have been discussed above. (2) The special characteristics of guttural consonants in these languages can be explained by the physical difficulty of making a real consonantal occlusion by retraction of the tongue root towards the wall of the pharynx. A number of studies have shown that the pharyngeal consonants [ʕ] and [ħ] typically involve concomitant action lower down by the epiglottis and also by raising of the larynx (Ladefoged and Maddieson 1996:37). On the other hand, it seems to me that there is good reason to argue that, in Arabic, Tongue Root is the articulator for so-called low vowels and for pharyngealization as a secondary articulation in exactly the same way that we have illustrated for other languages.

Classical Arabic is commonly said to have only three vowel phonemes /i, a, u/. These do, however, have contrastive allophones. According to Mitchell (1993:67-89), in Reading Style the low vowel /a/ has two allophones, front [a] and back [ɑ]. As one might expect, the latter is found after pharyngealized consonants traditionally called ‘emphatic’, as in [tˤɑːʔ], name of ‘emphatic’ *T*, in contrast to [taːʔ], name of plain *t*. What is surprising at first sight is that the names of the pharyngeal consonants themselves, [ħaː] and [ʕajn], have the front allophones; that is, they are not pharyngealized! On reflection, however, this ceases to seem strange. Labial consonants can be labialized in some languages, but more commonly (as in Chinese or in native words in English) they are excluded by the Obligatory Contour Principle (OCP). Palatalized palatals seem to be unattested. Plain coronals can be palatalized, but in English, for example, there is a strong dissimilatory tendency to eliminate /j/ after alveolars: *tune* [tjuːn] > [tuːn], etc. In Arabic the contrast between the RTR ‘low vowel’ [ɑ] and the ATR ‘low’ vowel [a], which is used in German to enhance the contrast between VV and V, is used to enhance the contrast between ‘emphatic’ (pharyngealized) and ‘non-emphatic’ (non-pharyngealized) consonants. Pharyngeal consonants themselves, however, are not pharyngealized. This contrast occurs for both short and long vowels. According to other sources in modern dialects, the ATR “allophone” of /a/ is fronted still further to [æ]. This may be compared to what has happened historically in the case of earlier “lax” short [a] in English.

McCarthy, who has little to say about the vowels in his discussion of Arabic gutturals, does cite pharyngeal [ħæːl] ‘condition’ in contrast to uvular [χaːl] (better [χɑːl]?) ‘maternal uncle’ as evidence that “the tongue body is front with the Arabic pharyngeals”, but does not discuss or try to explain the contrast with pharyngealized consonants (1991:9, 1994:197).

21. Conclusion

Two issues of major importance for distinctive feature theory have been discussed. The first is the replacement of the feature [±low] under the Dorsal articulator by [±RTR] under Radical. This has the advantage of obviating the need for treating vowel height as a multivalent feature and making it possible to treat all distinctive features as at most binary, consistent with the concept of language as having a digital structure.

Secondly, it has been shown that the assumption that phonemic contrasts must be established by rigorously eliminating redundancies through the method of minimal pairs is overly strict. Redundant features are often employed to reïnforce distinctions that might be confused in rapid speech. Specifically, it has been argued that in Western European languages like English and German the so-called tense/lax contrast that enhances the contrast between long and short vowels in stressed syllables is achieved by adding the feature [+RTR] to [+high] or [-high] in the case of short high and mid vowels and changing [+RTR] to [-RTR] in the case of short low vowels. On the other hand, in languages that use tongue-root vowel harmony to link together two or more syllables—a root and its affixes—that form a word, [+RTR] and [-RTR] will contrast systematically at all traditional levels of vowel height, though the contrast may be neutralized for low vowels and sometimes also for high vowels. Tongue-root harmony may also be used to enhance front-back harmony in languages like Turkish and Mongolian and may even replace it diachronically.

In the case of Mandarin Chinese, the use of the pharyngeal glide -ɑ̯ as a coda is related to the monosyllabicity which has characterized Chinese from the earliest recorded times. The pharyngealization of -ŋ is also a survival from a much earlier pattern in which final velars, in contrast to labials and coronals, all had a secondary vocalic articulation, a pattern that still survives in present-day Fuzhou.

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非對比特徵還是冗餘特徵的增強？

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在漢語中，當詞綴 -r 附加於以 -n 或 -ŋ 結尾的音節時，-n 和 -ŋ 都會失落，但只有 -ŋ 之前的元音會發生鼻化。近來有人提出 (Zhang 2000) 這是由於 -r 尚未附加時，-ŋ 的元音就比 -n 的元音鼻化程度大，並且這種原本非音位的差異在附加了詞綴以後變得有區別力。本文則主張，-r 尾尚未附加時，帶 -ŋ 的形式和帶 -n 的形式便已經具有音位上的區別，即軟顎鼻音的喉音化；此外，在以中、低元音收尾的所謂「開」音節中，其結尾處也有一個喉腔流音 /ɑ̯/。這項主張可以經由與昌黎方言的比較而得到支持。在昌黎方言中，-n 與 -ŋ 兩個鼻音尾在附加 -r 之後都消失了，但二者的分別仍一致地保留下來。對於確認喉腔流音 /ɑ̯/ 爲一可能音位，以及在區別性特徵理論中，用舌根徵性 [±RTR] 取代舌體徵性 [±low] 的更進一步的證據來自漢語的歷史以及其他語言（包括英語）。在英語中，[±RTR] 取代了傳統鬆／緊徵性的對立來描述長短元音的差異。這證實了根據標準的最小對比測試，特徵的對立嚴格說起來應爲冗餘特徵的概念，而冗餘特徵在容易造成混淆的環境中，具有增強區別力的作用。

關鍵詞：非對比特徵，冗餘特徵，喉腔流音，r 詞尾附加