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Phonemes, Features, and Syllables: Converting Onset and Rime Inventories to Consonants and Vowels*

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Phonemic analysis has been thought to be the 'greatest achievement' in phonology; in contrast, progress at other levels, such as the feature level below and the syllable level above, has been limited. We argue that not only are features and syllables important, but phonemic analysis is inadequate without reference to them. In other words, features and syllables are not separate areas of inquiry, but solve fundamental problems in phonemic analysis. We demonstrate the point with an in-depth analysis of Lanzhou Chinese. We show that, without reference to features and syllables, phonemic analysis is ambiguous in that it is open to alternative solutions, a problem noted by Yuen Ren Chao. In addition, there is no explanation for the patterns of occurring and non-occurring syllables. In contrast, if we take features and syllables into consideration, not only can we account for occurring and non-occurring syllables, but the phonemic analysis itself becomes simpler and less ambiguous.

Key words: features, Lanzhou Chinese, onset, phoneme, rime, syllable

1. Introduction

The problem we address here arose during our attempt to compile a phoneme inventory database of China, similar to that of the University of California at Los Angeles (UCLA) Phonology Segment Inventory Database (Maddieson & Precoda 1990, 2011). We found that most descriptions of a Chinese language or dialect start with an onset inventory and a rime inventory, rather than an inventory of phonemes (consonants and vowels), the latter being the standard practice in the Western tradition.

The difference between the two traditions may have resulted from their respective writing systems. Western languages are written alphabetically, where consonants and vowels seem to be the building blocks of words and a natural point to start the phonological analysis. In contrast, Chinese orthography is based on syllables, and the pronunciation of a syllable is traditionally indicated by two other syllables, one representing the onset of the target syllable and one representing its rime; this is known as the *Fǎnqiè* annotation system, which became widely used after 200 AD. Given its convenience and success, decomposing syllables into onsets and rimes, rather than consonants and vowels, has continued in China right up to the present day.

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A number of theoretical questions arise. Are phonemes real? Are syllables real? Can basic phonological units differ between languages? Linguistic opinion is divided. For example, Chomsky & Halle (1968) assume that consonants and vowels are real but syllables are not. In contrast, Ladefoged (2001:170–173) suggests that syllables are real but phonemes are not. It is also possible that phonemes are real in some languages and syllables are real in others. Yet another view is that both phonemes and syllables are real in all languages. It is not our intention to evaluate the various views here. Instead, we agree with Goldsmith (2011) and assume that both phonemes and syllables are real.

If both phonemes and syllables are real, there ought to be a way to convert onset and rime inventories to a phoneme inventory, but this problem is notoriously difficult. In particular, as noted by Chao (1934), multiple solutions are often possible and there seems to be no reasonable way to choose among them. For example, should the onset [kw] be treated as a single phoneme or two? Should the rime [ai] be treated as one or two phonemes? Should the answer depend on what language we are looking at?

In this study, we offer an in-depth analysis of Lanzhou Chinese, in order to highlight the problems in phonemic analysis and suggest a method to solve them. We propose that, if features and syllables are taken into consideration, most problems can be resolved and ambiguities often disappear. We also show that features and syllables point to new problems and call for new solutions, such as the distribution patterns of missing syllables.

We begin in §2 with inventories of onsets and rimes in Lanzhou Chinese, followed by analyses of onsets in §3 and rimes in §4. Subsequently, we consider occurring and non-occurring syllables in §5. Concluding remarks are given in §6.

2. Onsets and rimes in Lanzhou Chinese

Lanzhou Chinese is a variety of Lanyin Mandarin (Zhou 2005). There have been a number of studies of its phonology (Gao 1980, 1985; Hou et al. 1997; Karlgren 2003[1915–1926]; Lanzhou University 1963; Zhang et al. 2009). Let us begin with the inventory of onsets and rimes, shown in (1). As is often the case, it is not always obvious whether a given transcription is phonetic or phonemic. Therefore, we use square brackets for all International Phonetic Alphabet (IPA) transcriptions.

(1) Inventory of onsets (25 in all) and rimes (32 in all) in Lanzhou Chinese
[p pʰ m pf pfʰ f v t tʰ n ts tsʰ s z tʂ tʂʰ ʂ ʐ tɕ tɕʰ ɕ ȵ k kʰ x]
[ɪ ɭ ɯ i u y a ia ua ə iə uə yə ɛ uɛ ɔ iɔ ei uei ou iou ɛ̃ iɛ̃ uɛ̃ yɛ̃ ɔ̃ iɔ̃ uɔ̃ ə̃n ĩn ũn ỹn]

Alternative transcriptions of some items have been used in previous studies, which can be seen in Table 1. A cell with '+' means the transcription is the same as that on the left. A cell with '–' means the given onset is not included. If a listed transcription differs from that in the first column, it is given in the table cell.

Table 1: Comparison of five transcriptions of onsets and rimes in Lanzhou Chinese (Author abbreviations are: L = Lanzhou University (1963), G = Gao (1980), Z = Zhang & Mo (2009), H = Hou et al. (1997), and K = Karlgren (2003[1915–1926]). All authors list the rimes [ɿ ʅ ɯ], which we have omitted.)

Onset	L	G	Z	H	K
p	+	+	+	+	+
pʰ	+	+	+	+	+
m	+	+	+	+	+
pf	+	+	+	+	+
pfʰ	+	+	+	+	+
f	+	+	+	+	+
v	+	+	+	+	+
t	+	+	+	+	+
tʰ	+	+	+	+	+
l	+	–	+	+	+
n	–	+	–	+	+
ts	+	+	+	+	+
tsʰ	+	+	+	+	+
s	+	+	+	+	+
z	–	+	+	+	–
tʂ	+	+	+	+	+
tʂʰ	+	+	+	+	+
ʂ	+	+	+	+	+
ʐ	+	+	+	+	+/ʏ
tɕ	+	+	+	+	+
tɕʰ	+	+	+	+	+
ɕ	+	+	+	+	+
ȵ	–	+	–	+	+
k	+	+	+	+	+
kʰ	+	+	+	+	+
x	+	+	+	+	+
ø	+	+	+	+	+

Rime	L	G	Z	H	K
i	+	+	+	+	+
u	+	+	+	+	+
y	+	+	+	+	y/ʯ
a	+	+	+	+	+
ia	+	+	+	+	+
ua	+	+	+	+	+
ə	+	ɤ	ɤ	+	o/ɛi
iə	+	iɤ	ie	+	ie
uə	+	uɤ	uɤ	+	o/uo
yə	+	yɤ	ye	+	yo
ɛ	+	+	+	+	ɛ/ɛi
uɛ	+	+	+	+	+
ɔ	+	+	+	+	ɔ/o
iɔ	+	+	+	+	iɔ/io
ei	+	+	+	+	+
uei	+	+	+	+	+
ou	+	əu	əu	+	əɯ
iou	+	iəu	iəu	+	iɯ
ɐ̃	+	ɛ̃	an	ɛ̃n	æ
iɐ̃	+	iɛ̃	ian	iɛ̃n	iæ̃
uɐ̃	+	uɛ̃	uan	uɛ̃n	uæ
yɐ̃	+	yɛ̃	yan	yɛ̃n	yæ
ɔ̃	+	ɑ̃	ɔŋ	ɑ̃	+
iɔ̃	+	iɑ̃	iɔŋ	iɑ̃	+
uɔ̃	+	uɑ̃	uɔŋ	uɑ̃	+
ə̃n	+	ə̃	ən	+	ə̃
ĩn	+	iə̃	in	+	iə̃
ũn	+	uə̃	uən	+	uə̃
ỹn	+	yə̃	yn	+	yə̃

We shall discuss alternative transcriptions later. In general, if we exclude marginal syllables, the number of onsets and rimes of a Chinese language is usually quite clear. In what follows, we discuss the phonemic analysis of onsets first, followed by the phonemic analysis of rimes.

3. Phonemic analyses of onsets

The features of the onsets of Lanzhou Chinese are shown in Table 2. Besides traditional place and manner features, we have added articulator features, where Coronal (tongue tip) is used in dental, retroflex, and palatal articulations, and Dorsal (tongue body) is used in palatal and velar articulations (Halle 2003).

Table 2: Features of Lanzhou Chinese onsets

Articulators	Labial	Coronal	Coronal	Cor + Dor	Dorsal
Places	Labial	Dental	Retroflex	Palatal	Velar
(oral) Stop	p p^h	t t^h			k k^h
Fricative	f v	s z	ʂ ʐ	ɕ	x
Affricate	pf pf^h	ts ts^h	tʂ $tʂ^h$	tɕ $tɕ^h$	
Nasal	m	n		ɲ	

It may seem that all the onsets in Lanzhou Chinese are single consonants. In particular, the most complicated transcriptions are affricates, such as [pf pf^h ts ts^h], for which there is no need for decomposition. However, it has been proposed that even consonant phonemes can be decomposed in order to minimize them (Jones & Camilli 1933). Consider the analysis in (2).

(2) Decomposing onsets in Lanzhou Chinese
Original simple: [p m f v t n s z ʂ ʐ ɕ ɲ x k] (14 in all)
Original composite: [p^h pf pf^h t^h ts ts^h tʂ $tʂ^h$ tɕ $tɕ^h$ k^h] (11 in all)
Decomposed composites: [p+h p+f p+f+h t+h t+s t+s+h t+ʂ t+ʂ+h t+ɕ t+ɕ+h k+h]
Consonants after decomposition: [p m f v t n s z ʂ ʐ ɕ ɲ x k (h)] (14 in all)

If we decompose affricates and aspiration, and treat [h] as a variant of [x], we can reduce the number of consonants by 11, from 25 to 14, where the 11 'composite' onsets can be represented as combinations of simple consonants. However, this approach would complicate syllable structure. In particular, if the original onsets are all single sounds, the onset is a single consonant C. With the decomposition, the onset can be C, CC (e.g. [ts] and [t^h]), and CCC (e.g. [ts^h]). Therefore, few linguists have adopted such decomposition.

Nevertheless, the onset list can be further reduced according to their distribution and feature structure. We assume that, as in other Chinese dialects, the maximal syllable in Lanzhou is CGVX, where C is the onset, V the main vowel, G a glide (or high vowel) between C and V, and X a final consonant or the second part of a diphthong. Now, let us consider the pattern of CG combination in Lanzhou Chinese, as shown in Table 3. We represent G as [j], [w], or [ɥ], although it can be represented as [i], [u], or [y] instead. The consonant [z] has limited distributions and will be discussed shortly.

Table 3: CG combination in Lanzhou Chinese ([z] is discussed later)

C	C^{j}	C^{w}	$C^{ɥ}$
p	+	–	–
p^{h}	+	–	–
m	+	–	–
pf	–	–	–
pf^{h}	–	–	–
f	–	–	–
v	–	–	–
t	+	+	–
t^{h}	+	+	–
ts	–	+	–
ts^{h}	–	+	–
s	–	+	–
n	–	+	–
tɕ	+	–	+
$tɕ^{h}$	+	–	+
ɕ	+	–	+
ȵ	+	–	+
tʂ	–	–	–
$tʂ^{h}$	–	–	–
ʂ	–	–	–
ʐ	–	–	–
k	–	+	–
k^{h}	–	+	–
x	–	+	–

The distribution pattern is similar to that in Standard Chinese (Putonghua), where each set of onsets has fairly different CG combinations. If we represent C and G with their features, a more precise generalization emerges. Following Halle (2003) and Duanmu (2007), we divide C into three classes according to their articulators (Table 2): Labial (Lab), Coronal (Cor), and Dorsal (Dor). In addition, we divide G into three classes: [w] = Labial, [j] = Dorsal, and [ɥ] = Labial + Dorsal. The resulting generalization is shown in Table 4, where a CG combination is unavailable if C and G have the same articulator. In particular, *Labial – Labial rules out Labial + [w] and Labial + [ɥ]: *[p p^{h} m pf pf^{h} f v] + [w] and *[p p^{h} m pf pf^{h} f v] + [ɥ]; and *Dorsal – Dorsal rules out Dorsal + [j] and Dorsal + [ɥ]: *[k k^{h} x] + [j] and *[k k^{h} x] + [ɥ]. A separate constraints against retroflex and palatal (as proposed in Duanmu 2007) will rule out *[tʂ $tʂ^{h}$ ʂ ʐ] + [j] and *[tʂ $tʂ^{h}$ ʂ ʐ] + [ɥ].

Table 4: Feature analysis of CG combinations (Duanmu 2007)

	[j] = Dor	[w] = Lab	[ɥ] = Lab + Dor
Labial	+	–	–
Coronal	+	+	+
Dorsal	–	+	–

Let us take a close look at four sets of sounds: the labial set [pf pfʰ f v], the dental set [ts tsʰ s n], the palatal set [tɕ tɕʰ ɕ ȵ], and the retroflex set [tʂ tʂʰ ʂ ʐ]. The dental and palatal sets are in complementary distribution, similar to the case in Putonghua (Duanmu 2007). The labial and retroflex sets are also in complementary distribution, even though they have fairly different features and articulators.

For the dental and palatal sets, we propose the same analysis as that in Putonghua, shown in (3), where [ts tsʰ s n] are palatalized before [i y] (or [j ɥ]). The analysis is phonetically natural and allows us to exclude the onsets [tɕ tɕʰ ɕ ȵ] from the consonant inventory.

(3) Palatalization of Coronals in Lanzhou
[ts] → [tɕ] / __ [i] or [y]
[tsʰ] → [tɕʰ] / __ [i] or [y]
[s] → [ɕ] / __ [i] or [y]
[n] → [ȵ] / __ [i] or [y]

Next we consider the labial set [pf pfʰ f v] and the retroflex set [tʂ tʂʰ ʂ ʐ]. First, we expect labials to be able to combine with [j] (see Table 4), which [p pʰ m] do, but [pf pfʰ f v] do not. Second, the retroflex set [tʂ tʂʰ ʂ ʐ] ought to be able to combine with [w], which they do in Putonghua, but fail to do in Lanzhou. We propose an analysis that solves both puzzles: in Lanzhou, [tʂw tʂʰw ʂw ʐw] (or [tʂu tʂʰu ʂu ʐu]) have become [pf pfʰ f v], respectively. Evidence for the proposal can be seen in the corresponding words between Lanzhou and Putonghua, shown in (4).

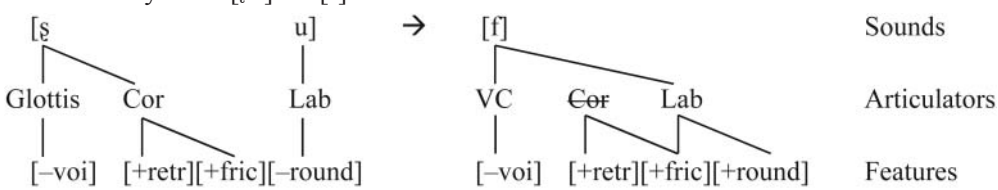
(4) Retroflex + [w] and labials in Putonghua and Lanzhou, where '#' indicates no corresponding writing symbol. There is no contrast between [u] and [w]; we use [w] when it occurs before the nuclear vowel and [u] otherwise.

Word	Putonghua	Lanzhou
珠 'pearl'	[tʂu]	[pfu]
爪 'paw'	[tʂwa]	[pfa]
桌 'desk'	[tʂwo]	[pfə]
追 'chase'	[tʂwei]	[pfei]
拽 'pull'	[tʂwai]	[pfɛ]
專 'focus'	[tʂwan]	[pfɐ̃]
装 'load'	[tʂwaŋ]	[pfɔ̃]

Word	Putonghua	Lanzhou
準 ‘prepare’	[ʈʂwən]	[pfə̃]
初 ‘beginning’	[ʈʂʰu]	[pfʰu]
欻 ‘onomatopoeic word’	[ʈʂʰwa]	[pfʰa]
戳 ‘stab’	[ʈʂʰwo]	[pfʰə]
吹 ‘blow’	[ʈʂʰwei]	[pfʰei]
揣 ‘carry’	[ʈʂʰwai]	[pfʰɛ]
川 ‘small river’	[ʈʂʰwan]	[pfʰɛ̃]
床 ‘bed’	[ʈʂʰwaŋ]	[pfʰõ]
春 ‘spring’	[ʈʂʰwən]	[pfʰə̃]
書 ‘book’	[ʂu]	[fu]
刷 ‘brush’	[ʂwa]	[fa]
說 ‘speak’	[ʂwo]	[fə]
睡 ‘sleep’	[ʂwei]	[fei]
帥 ‘cute’	[ʂwai]	[fɛ]
拴 ‘tie up’	[ʂwan]	[fɛ̃]
霜 ‘frost’	[ʂwaŋ]	[fõ]
順 ‘along’	[ʂwən]	[fə̃]
入 ‘enter’	[ʐu]	[vu]
# ‘fiddle with’	[ʐwa]	[va]
弱 ‘weak’	[ʐwo]	[və]
銳 ‘sharp’	[ʐwei]	[vei]
軟 ‘soft’	[ʐwan]	[vɛ̃]
潤 ‘moist’	[ʐwən]	[və̃]

The change from a retroflex-[w] combination to a labial consonant is not often reported in other languages or dialects or languages. Nevertheless, we can analyze the process according to its feature structure. Consider the change from [ʂu] to [f], shown in (5). Following Halle (2003), we assume that a sound is made of one or more articulators, which in turn dominate features.

(5) Feature analysis of [ʂu] → [f] of Lanzhou



We assume that [u] is [–round] in Lanzhou, because it is often realized as [v], as noted by Lanzhou University (1963) and Zhang (1981). In addition, [ʂ] has two articulators: Coronal, which performs the features [retroflex] and [fricative], and Glottis, which performs the feature [–voice]. The change involves deleting the Coronal articulator (indicated by strikeover), upon which the feature [+fricative] is shifted to the Labial articulator. The feature [+retroflex] cannot be shifted to Labial, because [+retroflex] is a gesture specific to Coronal, or is 'articulator-bound' to Coronal (Halle 2003). The two resulting articulators (Labial and Glottis, and their features) form the content of [f]. The analyses of other retroflex-[u] pairs are similar. In particular, [ʐu] differs from [ʂu] in that the [ʐu] has the feature [+voice] (rather than [–voice]), yielding [v] instead of [f]. In addition, [tʂu] differs from [ʂu] in that the [tʂu] is an affricate (rather than a fricative), yielding [pf] instead of [f]. Finally, [tʂʰu] differs from [tʂu] in that [tʂʰu] is aspirated (rather than unaspirated), yielding [pfʰ] instead of [pf].

The labials [pf pfʰ] only occur when [tʂu tʂʰu] are expected; therefore, they need not be treated as independent phonemes. On the other hand, [f] comes from two sources: one being [ʂu] and one being [f]. The realizations of the two sources have merged in Lanzhou but remain distinct in Putonghua. This can be seen in (6).

(6) Realizations of [ʂu] and [f] in Putonghua and Lanzhou Chinese

Source	Word	Putonghua	Lanzhou
ʂu f	霜 'frost' 方 'square'	[ʂuaŋ] [faŋ]	[fɔ̃] [fɔ̃]
ʂu f	刷 'brush' 發 'distribute'	[ʂua] [fa]	[fa] [fa]
ʂu f	說 'say' 佛 'Buddha'	[ʂuo] [fuo]	[fə] [fə]
ʂu f	書 'book' 夫 'husband'	[ʂu] [fu]	[fu] [fu]
ʂu f	睡 'sleep' 費 'fee'	[ʂuei] [fei]	[fei] [fei]
ʂu f	栓 'tie up' 翻 'tip over'	[ʂuan] [fan]	[fɐ̃] [fɐ̃]
ʂu f	順 'along' 份 'portion'	[ʂuən] [fən]	[fə̃] [fə̃]

Similarly, [v] comes from two sources, one being [ʐu] and the other being syllable-initial [u] (or [w]). The realizations of the two sources have again merged in Lanzhou but remain distinct in Putonghua. This can be seen in (7).

(7) Realizations of [ʐu] and [u] in Putonghua and Lanzhou Chinese ('#' indicates no corresponding writing symbol.)

Source	Word	Putonghua	Lanzhou
[ʐu] [u]	入 'enter' 霧 'fog'	[ʐu] [u]/[vu]	[vu] [vu]
[ʐu] [u]	# 'fiddle with' 娃 'kid'	[ʐua] [ua]/[va]	[va] [va]
[ʐu] [u]	弱 'weak' 我 'I, me'	[ʐuo] [uo]/[vo]	[və] [və]
[ʐu] [u]	鋭 'sharp' 危 'danger'	[ʐuei] [uei]/[vei]	[vei] [vei]
[ʐu] [u]	軟 'soft' 晚 'late'	[ʐuan] [uan]/[van]	[vɛ̃] [vɛ̃]
[ʐu] [u]	潤 'moist' 問 'ask'	[ʐuən] [uən]/[vən]	[və̃] [və̃]

Such data show that [pf pfʰ v] are not independent phonemes, whereas [f] is. In addition, [tʂ tʂʰ ʂ ʐ] do not always become labials. When there is no following [u], [tʂ tʂʰ ʂ ʐ] remain unchanged, as shown in (8).

(8) Independent occurrence of [tʂ tʂʰ ʂ ʐ] in Lanzhou Chinese and Putonghua

Word	Putonghua	Lanzhou
周 'week'	[tʂou]	[tʂou]
抽 'draw'	[tʂʰou]	[tʂʰou]
收 'collect'	[ʂou]	[ʂou]
肉 'meat'	[ʐou]	[ʐou]
閘 'floodgate'	[tʂa]	[tʂa]
茶 'tea'	[tʂʰa]	[tʂʰa]
沙 'sand'	[ʂa]	[ʂa]

Finally, let us consider two marginal onsets, [l] and [z]. Karlgren (2003[1915–1926]) lists [l n] as two separate phonemes, but most others treat them as allophones of the same phoneme, such as [lɛ̃]/[nɛ̃] 蘭 'orchid'. There is evidence that the two sounds have merged since Karlgren's work. For example, [lan] 蘭 'orchid' and [nan] 南 'south' are distinct in Putonghua, but they have merged in Lanzhou, and both can be pronounced as [nɛ̃] or [lɛ̃].

The onset [z] only occurs with the rimes [ei ɔ ɿ], and there are no writing symbols for any of them. [zei] is used only in drinking games and is thus seldom used nowadays. [zɔ] and [ʐɔ] are free variants, and [zɿ] has the same meaning as 肆 [sɿ] 'unbridled' in Putonghua. It has been proposed that [ɿ] is not a vowel (often called an 'apical vowel'), but a syllabic [z] (Chao 1968; Duanmu 2007), so that 'unbridled' is [zz] in Lanzhou and [sz] in Putonghua. Nothing much else can be said about this issue and we shall elaborate no further.

In summary, our analysis of 25 onsets in Lanzhou yields 18 consonants. They are shown in (9) and (10).

(9) Consonants in Lanzhou Chinese (18 in all)
[p pʰ m f t tʰ n ts tsʰ s z tʂ tʂʰ ʂ ʐ k kʰ x]

(10) Non-phonemic onsets in Lanzhou Chinese (seven in all)

[pf pfʰ]	realization of [tʂu tʂʰu]
[v]	realization of [ʐu] or syllable-initial [u] (or [w])
[tɕ tɕʰ ɕ ȵ]	palatalized versions of [ts tsʰ s n] respectively

The proposed consonant inventory is substantially smaller than the onset inventory. We are not aware of any previous study that has proposed a similar or simpler analysis. Our result is achieved by taking both features and syllables into consideration, rather than performing phonemics in isolation.

4. Phonemic analyses of rimes

We discuss the phonemic analysis of rimes in three steps: (1) the decomposition of rimes into smaller units; (2) phonemic analysis based on phonemic economy alone; and (3) phonemic analysis based on a consistent syllable structure.

4.1 Decomposition of rimes

There are different views on whether the rime inventory should be decomposed. Four approaches are outlined in (11) and illustrated in (12).

(11) Four views on the analysis of Chinese rimes
a. You et al. (1980): no further decomposition
b. Lee & Zee (2003): decomposing VC; keeping diphthongs and triphthongs
c. Hu (2013): decomposing VC, triphthongs, and rising diphthongs; keeping falling diphthongs
d. Duanmu (2007): decomposing VC, triphthongs, and diphthongs

(12) Sample analysis of some rimes in Putonghua

Rime	[iau]	[ian]	[ia]	[an]
You et al. (1980)	[iau]	[ian]	[ia]	[an]
Lee & Zee (2003)	[iau]	[ia], [n]	[ia]	[a], [n]
Hu (2013)	[i], [au]	[i], [a], [n]	[i], [a]	[a], [n]
Duanmu (2007)	[i], [a], [u]	[i], [a], [n]	[i], [a]	[a], [n]

According to You et al. (1980), Chinese rimes should not be further decomposed. The main reason for this is that agreement is easy to obtain on the number of onsets and rimes, but it is hard to obtain on how to decompose rimes into smaller units.

Lee & Zee (2003) decompose VC (vowel + consonant) rimes, but not diphthongs or triphthongs. No explanation is offered for their decision, but it seems to be a common practice in the IPA tradition, probably because there is no clear boundary within a diphthong or triphthong, whereas there often is one between a consonant and a vowel.

Hu (2013) decomposes VC rimes and triphthongs. In addition, he decomposes rising diphthongs, such as [ia], but not falling diphthongs, such as [au]. The proposal is based on the stability of articulatory targets, rather than phonetic duration or phonology.

Duanmu (2007) offers a number of arguments for decomposing VC rimes, triphthongs, and diphthongs. The arguments mainly come from syllable structure. First, we consider VN (vowel + nasal coda) rimes. In Putonghua, there are rimes like [in] and [yn]. Since [i] and [y] are independent vowels, and [n] is an independent onset, there is no reason to consider [in] and [yn] to be new phonemes; rather, they are combinations of known phonemes. Similarly, since [a] and [n] are independent phonemes already, it is reasonable to split [an] into [a] and [n] instead of treating [an] as a new phoneme.

Next, in Chinese (and English), [iau] rimes with [mau], which means that the basis for riming is [au]. Therefore, [iau] is not a basic phonological unit, but is made of [i] and [au]. Likewise, the first high vowel in all triphthongs should be decomposed from the rest of it. In addition, since [ian] rimes with [man] and [ia] rimes with [ma], [ian] should be decomposed into [i] and [an] and [ia] should be decomposed into [i] and [a].

Finally, we consider diphthongs. It is well known that a diphthong cannot be followed by a nasal in Chinese, such as *[ain], although both [ai] and [an] are found. This means that [ai] and [an] are of the same size, but [ain] exceeds this size. If [an] is made of two sounds, as discussed previously, [ai] ought to be as well. In addition, the rime of unstressed Chinese syllables (those that do not have an underlying tone or those that cannot maintain it) is only half as long as regular rimes (Lin & Yan 1988); this is further evidence that regular rimes, such as [ai] and [an], comprise two units each.

Before we consider the decomposition of rimes in Lanzhou Chinese, let us take a closer look at the transcription in (1). It can be seen that a nasal vowel does not contrast with an oral vowel. In particular, we can omit the diacritic for nasalization. The alternative is shown in (13), which is similar to that given by Zhang & Mo (2009).

(13) Alternative transcription of nasal rimes in Lanzhou Chinese

As given in (1)	ɛ̃	iɛ̃	uɛ̃	yɛ̃	ɔ̃	iɔ̃	uɔ̃	ə̃n	ĩn	ũn	ỹn
Alternative	ɐn	iɐn	uɐn	yɐn	ɔn	iɔn	uɔn	ən	in	un	yn

Nasalization of a vowel before a nasal coda is also found in English (Ladefoged & Johnson 2011), but since it is not contrastive, it need not be represented as different phonemes. For the time being, we focus on keeping different rimes distinct, rather than considering their exact transcription or their decomposed units. For example, [ɛ̃] has been transcribed as [ɛ̃] (Gao 1980, 1985), [ɛ̃n] (Hou et al. 1997), and [an] (Zhang & Mo 2009); we shall discuss these shortly.

Let us now consider the decomposition of triphthongs, diphthongs, and VC rimes in Lanzhou Chinese. Assuming the alternative transcription in (13), the resulting list of distinct transcriptions, which we shall call phones, is shown in (14). For comparison, the list of original composite rimes is also given.

(14) Distinct transcriptions (phones) in Lanzhou Chinese, obtained by decomposing composite rimes (i.e. triphthongs, diphthongs, and VC rimes)
Original phones: [ɿ ʅ ɯ i u y a ə ɛ ɔ]
New phones: [e o ɐ (n)]
Composite rimes: [ia ua iə uə yə uɛ iɔ ei uei ou iou ɛ̃ iɛ̃ uɛ̃ yɛ̃ ɔ̃ iɔ̃ uɔ̃ ə̃n ĩn ũn ỹn]

The decomposition yields 13 vowel phones, including three new phones [e o ɐ]. The nasal [n] is not counted, as it is already found in the onset inventory. Lanzhou University (1963:83) considers the 13 phones to be independent vowels, without offering a phonemic analysis—a practice not uncommon in the Chinese tradition.

4.2 Analysis based on phonemic economy

Having decomposed rimes into vowel phones, let us consider how to group them into phonemes. We note that the decomposition created new environments, which can be used to examine complementary distribution. For example, in the original rime list, the only environment to the right of an item is a syllable boundary. With the decomposition, some vowels have a new environment, such as [_i] for [e] (i.e. [e] occurs before [i]) and [_u] for [o] (i.e. [o] occurs before [u]).

[ɿ ʅ] have been called 'apical vowels'. The use of the term is based on the assumption that every syllable must have a vowel. However, this assumption is controversial. If some syllables can be made of consonants only, such as [n] 'fish' in Shanghai Chinese, there is no need to assume apical vowels. Instead, we can treat [ɿ ʅ] as syllabic versions of [z ʐ] (Chao 1968; Duanmu 2007). The syllabic-consonant analysis also explains why [ɿ ʅ] do not occur with a medial glide, a vowel, or a nasal coda.

The vowel [ɯ] is marginal in Lanzhou and is found in two syllables only: [kɯ] 給 'give' and [ɯ] 耳 'ear'. The remaining vowels can be grouped into five phonemes, shown in (15).

(15) Analysis of vowel phones in Lanzhou Chinese (excluding [ɿ ʅ ɯ])
[ɛ] = [ai]
[ɔ] = [au]
[ɐ] = [a]/_[n]
[o] = [ə]/_[u]
[e] = [ə/_[i]
Vowel phonemes: [i u y a ə]

The vowel [a] does not occur before [i] or [u]. Instead, we find [ɛ] and [ɔ]. Therefore, we can treat [ɛ] as the realization of [ai] and [ɔ] as the realization of [au]. There is some evidence for this analysis, based on a comparison between Putonghua and Lanzhou Chinese, which is shown in (16).

(16) Correspondence between [ai au] in Putonghua and [ɛ ɔ] in Lanzhou Chinese

Word	Putonghua	Lanzhou	Word	Putonghua	Lanzhou
擺 'put'	[pai]	[pɛ]	包 'purse'	[pau]	[pɔ]
牌 'brand'	[p^{h}ai]	[p^{h}ɛ]	泡 'soak'	[p^{h}au]	[p^{h}ɔ]
埋 'bury'	[mai]	[mɛ]	毛 'hair'	[mau]	[mɔ]
來 'come'	[lai]	[nɛ]	腦 'brain'	[nau]	[nɔ]

Similarly, there is a correspondence between [an] in Putonghua and [ɐn] or [ɐ̃] in Lanzhou, which supports the analysis of [ɐ] as the realization of [a] in the environment [_n]. An example is shown in (17).

(17) Correspondence between [an] in Putonghua and [ɐ̃] in Lanzhou Chinese

Word	Putonghua	Lanzhou
完 'finish'	[wan]	[wɐ̃]

Finally, we note that the vowel [ə] does not occur before [i] or [u]. Instead, we find [e] and [o] in these environments. Therefore, we can propose that [ei] is the realization of [əi] and [ou] is the realization of [əu]. In other words, [e o] are allophones of [ə]. A similar analysis is proposed for Putonghua (Duanmu 2007; Lin 1989; Wang 1993).

This discussion yields five vowels in Lanzhou Chinese, repeated in (18). The inventory is similar to that in Putonghua.

(18) Vowel phonemes in Lanzhou Chinese, based on phonemic economy
[i u y a ə]

The five-vowel analysis is a considerable reduction from the 13 phones we started out with. This analysis will be confirmed via a consideration of syllable patterns next.

4.3 Analysis based on syllable patterns

We now consider whether the five-vowel analysis can account for syllable patterns. First, let us consider the rime inventory again, repeated in (19).

(19) Rime inventory in Lanzhou Chinese
[ɿ ɭ ɯ i u y a ə ɛ ɔ ia ua iə uə yə uɛ iɔ ei uei ou iou ɐ̃ iɐ̃ uɐ̃ yɐ̃ ɔ̃ iɔ̃ uɔ̃ ə̃n ĩn ũn ỹn]

Let us focus on the vowel [ɔ]. In the five-vowel analysis, [ɔ] is derived from [au]. There are altogether five rimes that contain [ɔ]. Their analysis is shown in (20).

(20) Five-vowel analysis of rimes that contain [ɔ]

Rime	Underlying	Putonghua
[ɔ]	[au]	[au] 襖 'jacket'
[iɔ]	[iau]	[iau] 咬 'bite'
[ɔ̃]	[aun]	[aŋ] 骯 'dirty'
[iɔ̃]	[iaun]	[iaŋ] 癢 'nurture'
[uɔ̃]	[uaun]	[uaŋ] 網 'net'

The analysis of [ɔ] and [iɔ] is unproblematic; their underlying forms are the same as those in Putonghua. However, the five-vowel analysis of [ɔ̃], [iɔ̃] and [uɔ̃] is problematic. First, their underlying forms exceed the standard size. In particular, their riming parts are all [aun] (i.e. the part without G, which determines riming in poetry), which exceeds the maximal size of VX (Duanmu 2007). Second, their underlying forms differ from the corresponding ones in Putonghua.

The data show that [ɔ] in Lanzhou Chinese comes from two separate sources, one from [au] and one from [aŋ]. If we assume that the maximal size of a Chinese syllable is CGVX (Duanmu 2007), where the riming part is VX, then there are two possible analyses of [ɔ], shown in (21).

(21) Two analyses of [ɔ] in Lanzhou Chinese

Analysis	Vowels	[ɔ]	[ɔ̃]	[ɐ̃]	Nasal codas
Five-vowel	[i u y a ə]	[au]	[aŋ]	[an]	[n ŋ]
Six-vowel	[i u y a ɔ ə]	[ɔ]	[ɔn]	[an]	[n]

In the five-vowel analysis, [ɔ] is derived from [au], whereas [ɔ̃] is derived from [aŋ], rather than from [aun]. In the six-vowel analysis, [ɔ] is an independent vowel, regardless of its historical origins.

As far as maximal syllable size and phonemic economy are concerned, it is unclear which analysis is better. In particular, the five-vowel analysis proposes one fewer vowel but one more nasal. Therefore, the two analyses propose the same number of phonemes and neither exceeds the maximal syllable size of CGVX.

The discussion shows that when a language loses a substantial number of syllable contrasts, a restructuring of its phonemic system will take place sooner or later. At some point during the process, there might be competing phonemic analyses available, which may be settled when the syllable inventory is further simplified.

5. Accounting for missing syllables

In the phonological description of a Chinese language, a syllable inventory is often included. The inventory is created in the form of a table, where every onset is combined with every rime. Such a table for Lanzhou is given in the Appendix, where the onset list has been shortened, based on our analysis in §3.

As can be seen in the Appendix, missing syllables constitute nearly 50% of all cells. While some missing syllables could be accidental gaps, we must ask whether others, or most of the missing forms, are the result of systematic constraints. Traditional analyses rarely raise this question or consider the answer. However, if we take features into consideration, considerable insight can be gained. Specifically, it can be shown that nearly half of the missing syllables come from missing CG combinations, which we discussed in §3. For example, labial onsets do not combine with a medial [u] or [y] (the *Labial – Labial constraint), and velar onsets do not combine with rimes that start with [i] or [y] (the *Dorsal – Dorsal constraint). The feature analysis is quite simple, yet it offers real insight into why so many syllables are missing in a language whose syllable inventory is already small.

Next we consider rimes. Traditional analyses offer little discussion of missing rimes, because rimes are treated as single units and only the occurring rimes are listed. However, if we decompose rimes into smaller units then a large number of missing forms appear again, which calls for an explanation. Let us consider this in detail.

As in other Chinese languages, the maximal syllable in Lanzhou is CGVX, where C is a consonant, G a glide (or a high vowel), V a regular vowel, and X an off-glide or a nasal. Some sample syllables are shown in (22).

(22) Sample syllables in Lanzhou Chinese

Structure	Example
CGVG	[twei] 對 ‘correct’
CGVN	[kwan] 關 ‘shut’
CVN	[mən] 門 ‘door’

We have already discussed restrictions on CG combinations (see §3). Let us now consider restrictions on GVX combinations. In the preceding section, we discussed two competing analyses of phonemes in Lanzhou Chinese: a five-vowel analysis and a six-vowel analysis. Let us consider the five-vowel analysis first and then the six-vowel analysis.

In the five-vowel analysis, there are three glides, five vowels (excluding the marginal [ɿ ɻ ɯ]), and two nasal codas, giving 100 possible combinations, which are calculated in (23).

(23) Possible GVX combinations in Lanzhou Chinese

G = 4 choices	three high vowels [i u y], or no G
V = 5 choices	[i u y a ə], excluding marginal [ɿ ɻ ɯ]
X = 5 choices	[i u n ŋ] or no X

Total = 4 × 5 × 5 = 100

Of the 100 possible rimes, just 29 are found to occur—not even one third. The 29 rimes are repeated in (24).

(24) Actual GVX combinations in Lanzhou Chinese (29 in all, excluding marginal [ɿ ɻ ɯ])
[i u y a ia ua ə iə uə yə ɔ iɔ ɛ uɛ ei uei ou iou ɐ̃ iɐ̃ uɐ̃ yɐ̃ ɔ̃ iɔ̃ uɔ̃ ə̃n ĩn ũn ỹn]

Before we examine the complete table of GVX combinations, let us introduce some notations. First, consider Table 5.

Table 5: Illustrations of GVX combinations

	G = 0	G = j	G = w	G = ɥ	
i	[i]	[ji]	[wi]	[ɥi]	X = 0
u	[u]	[ju]	[wu]	[ɥu]	
y	[y]	[jy]	[wy]	[ɥy]	
…	…	…	…	…	

The first column indicates the nuclear vowels. The top row indicates options for G, which can be null (G = 0), [j], [w], or [ɥ]. The last column shows the coda, which is null here (X = 0). Each cell in the middle area indicates a combination of GVX. For example, the cell on row 3, column 4, is [wu], whose G is [w], V is [u], and X is null.

Not every possible GVX combination occurs. To account for the non-occurring combinations, we propose three constraints, shown in (25). It can be seen that all the constraints are variations of the Obligatory Contour Principle, which has been proposed for Chinese previously (Yip 1988).

(25) Constraints on GVX forms

Label	Name	Definition
HH	No [+high] – [+high]	No adjacent [+high] sounds are allowed
II	No [i]_[i]	[i] cannot occur in both medial and coda
UU	No [u]_[u]	[u] cannot occur in both medial and coda

If a GVX combination is found to occur, its IPA transcription is shown. If a GVX combination is ruled out by a constraint, the constraint label is shown instead. The remaining cells are indicated with a minus sign, which means that it ought to occur but does not. This is shown in Table 6.

Table 6: Illustration of constraints on GVX combinations

	G = 0	G = j	G = w	G = ɥ	
i	[i]	HH	HH	HH	X = 0
u	[u]	HH	HH	HH	
y	[y]	HH	HH	HH	
a	[a]	[ia]	[ua]	–	
ə	[ə]	[iə]	[uə]	[yə]	

In Table 6, there are 20 GVX combinations. Nine of them are ruled out by HH, such as [ji], [ju], [jy], and [wi]. Ten of them occur; the transcriptions of these are given. The remaining one ought to occur but does not, and is indicated by a minus sign.

The full set of GVX combinations is shown in Table 7, where most missing forms are ruled out by the constraints HH, II, and UU. For example, II rules out forms like [iai] and [iei], and UU rules out forms like [uau] and [uou]. The vowel [y] can be seen as a combination of [i] and [u]; therefore, it is subject to both II and UU and cannot occur with either [u] or [i]. For example, [you] is ruled out by UU and [yei] is ruled out by II. There are only nine other missing forms, indicated with a minus sign.

Table 7: GVX combinations in a five-vowel analysis of Lanzhou Chinese. IPA transcriptions indicate occurring forms. Most non-occurring forms are ruled out by the constraints HH, II, and UU, defined above. The remaining non-occurring forms are indicated with a minus sign. For ease of comparison, we follow previous analyses and use [i u y] for G in the transcription.

	G = 0	G = j	G = w	G = ɥ	
i	[i]	HH	HH	HH	X = 0
u	[u]	HH	HH	HH	
y	[y]	HH	HH	HH	
a	[a]	[ia]	[ua]	–	
ə	[ə]	[iə]	[uə]	[yə]	
i	HH	HH	HH	HH	X = i
u	HH	HH	HH	HH	
y	HH	HH	HH	HH	
a	[ɛ]	II	[uɛ]	II	
ə	[ei]	II	[uei]	II	
i	HH	HH	HH	HH	X = u
u	HH	HH	HH	HH	
y	HH	HH	HH	HH	
a	[ɔ]	[iɔ]	UU	UU	
ə	[ou]	[iou]	UU	UU	
i	HH	HH	HH	HH	X = n
u	HH	HH	HH	HH	
y	HH	HH	HH	HH	
a	[ɐ̃]	[iɐ̃]	[uɐ̃]	[yɐ̃]	
ə	[ən]	[iə̃]	[uə̃]	[yə̃]	
i	–	HH	HH	HH	X = ŋ
u	–	HH	HH	HH	
y	–	HH	HH	HH	
a	[ə̃]	[iə̃]	[uə̃]	–	
ə	–	–	–	–	

Let us take a close look at rimes that end in [n] (the set X = n). If we assume that [n] is [+high], then HH can rule out [in un yn]. For the occurring rimes [ĩn ũn ỹn], we can interpret them as [iən uən yən] (or [iə̃ uə̃ yə̃]) respectively. This reinterpretation has two merits. First, it is consistent with the transcriptions of several authors, where the main vowel is [ə] (see Table 1). Second, the reinterpretation allows us to rule out the non-occurring [in un yn] by HH.

It can be seen that HH rules out both [ji] and [wu]. This does not mean that [ji] and [wu] cannot occur phonetically, or that [i] and [u] cannot influence the onset. Instead, [ji] and [wu] can be achieved by a rule called G-spreading (Duanmu 2007), where the nuclear vowels [i u y] obligatorily spread to the onset. In any case, there is no contrast between the underlying [ji wu ɥu] and [i u y].

In (26) we summarize the five-vowel analysis. It can be seen that the constraints HH, II, and UU account for 62% of the data and 87% of the missing forms.

(26) Summary of the five-vowel analysis of GVX forms in Lanzhou

HH	54	54%
II	4	4%
UU	4	4%
–	9	9%
[ ]	29	29%
All	100	100%

Let us take a close look at the nine GVX forms that ought to occur but do not. They are shown in (27).

(27) Nine GVX forms in the five-vowel analysis that ought to occur but do not
[ya iŋ uŋ yŋ yaŋ əŋ iəŋ uəŋ yəŋ]

It can be seen that except for [ya], all of the GVX forms end in [ŋ], clearly because [ŋ] is no longer a productive phoneme in Lanzhou. In addition, we observe that [ən iən uən yən] do occur. There is, therefore, a possible explanation for the lack of [əŋ iəŋ uəŋ yəŋ]. Based on the transcriptions in Table 1, it is likely that all VN rimes in Lanzhou are realized as a nasalized vowel, with no nasal closure. Therefore, we do not expect [əŋ iəŋ wəŋ yəŋ] to contrast with [ən iən uən yən]. Instead, we would expect there to be just one series, [ə̃ iə̃ uə̃ yə̃], which occurs in its entirety.

Next, we consider the six-vowel analysis of occurring and non-occurring syllables. For the sake of space, we omit the full GVX table and offer a summary of the analysis in (28).

(28) Summary of the six-vowel analysis of GVX forms in Lanzhou

HH	45	47%
II	6	6.25%
UU	6	6.25%
–	10	10.5%
[ ]	29	30%
All	96	100%

The six-vowel analysis shows a slightly higher percentage of unexplained GVX forms, which we list in (29).

(29) 10 missing GVX forms in the six-vowel analysis that ought to occur but do not
[ya wɔ yɔ ɔi wɔi au iau ɔu iɔu yɔn]

This time, seven of the 10 missing forms contain [ɔ], clearly because [ɔ] is not yet a productive phoneme in Lanzhou. It is unclear why [ya] is missing, since [yan] (or [yɛ̃]) is an occurring rime. Nevertheless, for most of the missing forms, a historical explanation is available. In particular, we note that [ɔ] in Lanzhou comes from the historical form [au], which is still used in Putonghua; for example, 貓 'cat' is [mau] in Putonghua and [mɔ] in Lanzhou. Given this, we offer the analysis in (30), according to which all missing GVX forms besides [ya] and [yð] are accounted for.

(30) A historical explanation for the absence of [wɔ yɔ ɔi wɔi au iau ɔu iɔu] in Lanzhou
[wɔ] Historically [wau], violating UU
[yɔ] Historically [yau], violating UU
[ɔi] No historical [aui], which exceeds VX
[wɔi] No historical [uaui], which exceeds GVX
[au] Has changed to [ɔ]
[iau] Has changed to [iɔ]
[ɔu] No historical [auu], which exceeds VX
[iɔu] No historical [iauu], which exceeds GVX

To end this section, we offer a comparison between the five-vowel analysis and the six-vowel analysis, shown in (31).

(31) Comparison of two phonemic analyses of Lanzhou Chinese

	Five-vowel analysis	Six-vowel analysis
Vowels	[i u y a ə]	[i u y a ə ɔ]
Consonants	19 (nasals: [m n ŋ])	18 (nasals: [m n])
Basic phonemes	24	24
Marginal phonemes	[z ɯ]	[z ɯ]
Constraints on GVX	HH, II, UU	HH, II, UU
Missing GVX	[ya iŋ uŋ yŋ yaŋ əŋ iəŋ uəŋ yəŋ]	[ya wɔ yɔ ɔi wɔi au iau ɔu iɔu yɔn]

The two analyses are comparable in most respects, and both can account for occurring and non-occurring GVX forms in a fairly simple way, which is much simpler and more general than the analysis of GVX forms in Putonghua (Duanmu 2007), where more constraints are used and quite a few missing forms remain unaccounted for. It can be seen that in the five-vowel analysis, most of the missing GVX forms (i.e. non-occurring forms not ruled out by the constraints HH, II, and UU) contain [ŋ], clearly because [ŋ] is an extra phoneme in this analysis. In contrast, in the six-vowel

analysis, most of the missing GVX forms contain [ɔ], again because [ɔ] is an extra phoneme in this analysis.

6. Conclusion

We have shown that a conversion from onset and rime inventories to an inventory of phonemes (consonants and vowels) is possible, thus establishing a link between phonological descriptions from two separate traditions: the Chinese tradition of onsets and rimes and the Western tradition of phonemes.

The conversion requires a phonemic analysis that makes reference to both features and syllables. The CGVX structure of Chinese syllables, along with patterns of riming, allows us to view rimes as GVX, which can be decomposed into smaller units. The feature structures of sounds can help us understand restrictions on CG combinations and help us minimize the inventory of consonants. Syllable structure can also help us interpret the underlying forms of some rimes, such as the choice between [iə̃ uə̃ yə̃] and [ĩn ũn ỹn] in Lanzhou.

The decomposition of rimes into GVX also offers a full picture of occurring and non-occurring syllables, a picture not observed in traditional analyses. In such a picture, the majority of GVX forms are missing, which seems unexpected for a language whose syllable inventory is already small (compared with that of English). This puzzle requires an explanation. We have shown that, with a few general constraints on feature structure, the majority of missing syllable forms can be accounted for.

We have illustrated our approach with a phonological analysis of Lanzhou Chinese. We have shown that phonemic analysis is sometimes open to alternative solutions, which is a well-known fact (Chao 1934). For example, we have shown that, by most criteria, a five-vowel analysis and a six-vowel analysis are comparable in Lanzhou Chinese. This may remind us of a proposal by You et al. (1980), who argue that it is sufficient to stop at an onset inventory and a rime inventory, without phonemic analysis, because the latter cannot yield a unique solution. However, we have shown that our approach can substantially reduce alternative solutions in phonemic analysis. In particular, we have shown that there is no advantage to treating diphthongs or triphthongs as single phonemes (Lee & Zee 2003), nor is there any advantage to treating VN rimes as single phonemes (You et al. 1980). In addition, there is a clear advantage to excluding [tɕ tɕʰ ɕ] and [pf pfʰ v] from the phoneme inventory of Lanzhou Chinese. This means that alternative solutions in phonemic analysis are highly restricted, and may well be a property of a language in the process of simplification, rather than a shortcoming of phonemic theory itself.

In summary, the success of our analysis, in terms of its simplicity (e.g. the small size of the proposed phoneme inventory compared with its onset and rime inventories) and the explanatory insight it yields (e.g. the amount of missing syllables accounted for), is evidence for the viability of the proposed approach. Our approach offers a better understanding of the relation among phonemes, features, and syllables, a better way to describe the phonologies of languages in China, and a new way to search for general phonological patterns in the languages of the world.

Appendix: A complete list of onset-rime combinations in Lanzhou Chinese

A table of full combinations between 19 onsets (first row) and 32 rimes (first column). In the first row, 0 indicates the lack of a consonant onset (also called the 'zero onset'). The onset list has been shortened, based on our analysis in §3. For example, [tɕ tɕʰ ɕ ȵ] have been excluded, because they are treated as palatalized versions of [ts tsʰ s n], respectively. Similarly, [pf pfʰ] are treated as realizations of [tʂu tʂʰu], and [v] as a realization of either [ʐu] or syllable-initial [u].

A plus sign indicates an occurring syllable (327 in all). A plus sign in parentheses indicates a syllable rarely or no longer in use (five in all), but reported in earlier literature. A plus sign in brackets indicates a syllable that is realized in the same way as another one already in the table (seven in all); for example [ʂua] is realized as [fa], the latter being an independent syllable. All in all, Lanzhou has about 320 distinct syllables, similar to the number identified by Lanzhou University (1963:84–85), give or take a few marginal syllables.

It can be seen that most of the missing syllables come from missing distributions in CG combinations, which we discussed in §3. For example, labial onsets do not combine with a medial [u] or [y] (the *Labial – Labial constraint), and velar onsets do not combine with rimes that start with [i] or [y] (the *Dorsal – Dorsal constraint).

	0	p	pʰ	m	f	t	tʰ	n	ts	tsʰ	s	z	tʂ	tʂʰ	ʂ	ʐ	k	kʰ	x
ɿ									+	+	+	(+)							
ʅ													+	+	+	+			
ɯ	+																+		
i	+	+	+	+		+	+	+	+	+	+								
u	+	+	+	+	+	+	+	+	+	+	+		+	+	[+]	+	+	+	+
y	+							+	+	+	+								
a	+	+	+	+	+	+	+	+	+	+	+		+	+	+		+	+	+
ia	+	+	(+)					+	+	+	+								
ua	+												+	+	[+]	+	+	+	+
ə	+	+	+	+	+	+	+	+	+	+	+		+	+	+	+	+	+	+
iə	+	+	+	+		+	+	+	+	+	+								
uə	+					+	+	+	+	+	+		+	+	[+]	+	+	+	+
yə	+							+	+	+	+								
ɛ	+	+	+	+		+	+	+	+	+	+		+	+	+		+	+	+
uɛ	+												+	+	+		+	+	+
ɔ	+	+	+	+		+	+	+	+	+	+	(+)	+	+	+	+	+	+	+
iɔ	+	+	+	+		+	+	+	+	+	+								
ei	+	+	+	+	+	(+)			+			(+)							
uei	+					+	+	+	+	+	+		+	+	[+]	+	+	+	+

(*continued*)

(*continued*)

	0	p	pʰ	m	f	t	tʰ	n	ts	tsʰ	s	z	tʂ	tʂʰ	ʂ	ʐ	k	kʰ	x
ou	+					+	+	+	+	+	+		+	+	+	+	+	+	+
iou	+					+		+	+	+	+								
ɛ̃	+	+	+	+	+	+	+	+	+	+	+		+	+	+	+	+	+	+
iɛ̃	+	+	+	+		+	+	+	+	+	+								
uɛ̃	+					+	+	+	+	+	+		+	+	[+]	+	+	+	+
yɛ̃	+							+	+	+	+								
ɔ̃	+	+	+	+	+	+	+	+	+	+	+		+	+	+	+	+	+	+
iɔ̃	+							+	+	+	+								
uɔ̃	+												+	+	[+]		+	+	+
ɔ̃n	+	+	+	+	+	+	+	+	+	+	+		+	+	+	+	+	+	+
ĩn	+	+	+	+		+	+	+	+	+	+								
ũn	+					+	+	+	+	+	+		+	+	[+]	+	+	+	+
ỹn	+							+	+	+	+								

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音位、特徵和音節：如何將聲韻母轉爲元輔音

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John A. Goldsmith 認爲，到目前爲止，音系學的最大成就仍然是音位分析，但是下一步我們應該將注意力轉向小於音位的「特徵」和大於音位的「音節」。我們認爲特徵和音節的研究不但重要，而且也是音位分析的基礎。音位分析中的很多疑難問題，如果沒有特徵理論和音節理論，就很難解決。我們以蘭州話的分析爲例，指出沒有音節和特徵的概念，音位分析往往有多種答案，而且很難對其進行選擇，正如趙元任所說。如果將音節和特徵帶入音位分析，不僅能夠大大減少可行的答案數量，而且可以探討一系列新的問題，特別是解釋音節的空檔問題（即哪些音節會出現，哪些音節不會出現）。

關鍵詞：音位，特徵，音節，聲母，韻母，蘭州話