Phonological Contrast in Bai

by

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DEDICATION

This dissertation is dedicated in memory of my Aunt Nina and Uncle John

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ABSTRACT

This dissertation presents an account of synchronic phonological contrast for the Bai language. Bai is a Sino-Tibetan language primarily spoken in Yunnan Province in Southwest China. There is a sizable amount of published research on this language due to the large amount of Chinese-related basic vocabulary in Bai, which is of considerable interest in the field of Sino-Tibetan historical linguistics. However, most of the available references prioritize the ability to transcribe the observed contrastive syllables as distinct from one another instead of offering synchronic phonological analysis of this language. The proposal I present in this dissertation intends to fill this gap in the literature with phonological analysis of the consonant, vowel, and tone systems of the Erhai (Dali), Jianchuan, and Heqing varieties of Bai.

My phonological analysis assumes articulator-based distinctive features, syllable structure, time slots, and other commonly assumed phonological architecture to generate all well-formed phonological representations in this language. The proposal fundamentally differs from prior descriptions in that pre-nuclear glides are consistently treated as constituents of the onset and not as constituents of the rime of the Bai syllable. Along with this fixed syllable structure, underspecification and economy in underlying representations are argued to optimize the ratio of attested-to-possible syllables within the space of predicted syllable types. Furthermore, these principles are suggested to limit the range of surface phonological variation attested across speakers. Specific phonemena addressed in detail include spreading processes (such as palatalization), identification of

merged tone categories, representation of the rhotic vowel, and epenthetic segments. The generalizations I identify are supported by descriptions of word-based evidence and phonetic data – both from the literature and collected through lexical elicitation in the field. The Zhaozhuang variety is explored in thorough detail and a syllable inventory of this variety with lexical examples for each syllable type glossed in English and Chinese is included in the appendicies of this dissertation.

Chapter 1. Introduction

Language data is presented in a variety of ways. Some language data, perhaps most data, is presented in textual representation. In a sense any excerpt of text for a natural language can be considered language data and can be analyzed not only for its content, but also as a corpus for analysis of the linguistic structure of that language (such as ordering of words in sentences or the attested sequences of sounds in syllables). For languages which lack strong written traditions, however, the nature of language data takes the shape of phonetic transcriptions. In this dissertation I explore the nature of phonological contrast (the patterning of sounds used in distinguishing meaning) in such a language – the Bái language, a Sino-Tibetan language spoken in Southwest China. My analysis is primarily derived from text-based references and is enhanced with generalizations from primary phonetic data.

Although Bái lacks a strong written tradition and is not a widely familiar language outside of circles of Sino-Tibetan linguistics, there is a large amount of descriptive data presented in phonetic transcription available for this language. This data, by and large, is prepared in a manner such that any contrast between two given morphemes can be reflected with different transcriptions. However, I argue that the commonly assumed norms for the representation of phonological contrast in references for this language lack the ability to make distinctive predictions differenciating potential well-formed syllables (accidental gaps) from impossible syllables (systematic gaps) in this language.

In brief, if the discrete phonological units specified in a given reference are treated as contrastive it is not always possible to determine which units can combine with one another and which units cannot combine with one another. While most combinations of consonants and monophthongs are attested in Bái, it is not obvious why certain combinations of particular classes of consonant onsets and units transcribed as diphthongs or syllabic consonants are attested while other combinations are not attested. For instance, based on these descriptions alone it is not clear why syllables such as [pia] and [kua] are attested while syllables such as *[pua] and *[kia] are not attested. Additionally, it is unclear why the segment transcribed as a syllabic [ɣ] can occur with a somewhat wide-range of consonants (ex. [fɣ], [tɣ], [kɣ], etc.) and not with others (ex. *[pɣ], *[tɕɣ], *[xɣ]).

In this dissertation I follow a common assumption that the phonological analysis of a language should account for both attested and unattested patterns in that language (Gibbon & Langer 1992). I present evidence that simple and well-defined syllable structure offers an effective evaluation process for dictating the relevant phonological environments necessary for the analysis of phonemic contrast in Bái. Although some descriptive works on Bái allude to or imply syllable structure, the generalizations offered in most of these works are subject to a host of problems including inconsistent treatment of phonological units of interest, following biased conventions of transcription to appear similar (or dissimilar) to Chinese languages, or cannot account for massive amounts of gaps in the available space of possible syllables.

Although my analysis of phonological contrast in this language uses commonly assumed architecture in phonological theory such as time-slots, distinctive features,

syllable structure, and mappings between underlying and surface representations, I combine these theoretical constructs in a somewhat unorthodox presentational framework I refer to as "Articulator Instruction Phonemics" (henceforth AIP). This framework is not a new or original model of phonemic analysis but offers an easy-to-read format for expression of the following assumptions in phonological representation. First, the finite set of available distinctive features are expressed as gestures made by the articulators. Second, the linearization of bundles of features is dictated by a minimally underspecified order in underlying representation. Third, these bundles of features map to pre-defined slots in syllable structure at surface representation. Through this approach, I show that a minimal amount of phonological material needs to be specified in underlying representation to generate all well-formed phonological forms (corresponding to syllables in Bái) while simultaneously avoiding overgeneration of phonotactically illicit forms. Furthermore, while the majority of my analysis and understanding of phonological contrast across varieties of Bái is derived from textual data, my analysis of the vowel and tone systems is enhanced by acoustic measurements and the results of a tone identification task.

This dissertation addresses the parameterization of phonological contrast in Bái as follows. Chapter 2 introduces and reviews a substantial amount of the literature on the Bái language. Chapter 3 explores the nature of the phonological and lexical data from the major descriptive Bái references. Chapter 4 proposes that Bái requires a fixed syllable structure affiliating the features for pre-nuclear glides to the onset. Chapter 5 presents an "Articulator Instruction Phonemics" account of phonological contrast in Bái defined by articulator-based features within syllable structure. The focus in this chapter is on the

linearization of bundles of features for Consonant-Vowel and Consonant-Glide-Vowel syllable types in underlying representation. Chapter 6 presents describes the attested variation in the rime systems (vowels and tones) across Bái varieties in AIP format, enhanced by acoustic measurements and impressionistic transcriptions based on original elicitation with native speakers in the field. Chapter 7 presents an AIP account of processes which spread phonological material from onset-to-rime and rime-to-onset. Discussion concludes in chapter 8 by summarizing the major findings of the the investigative survey of Bái language descriptions and the implications the data have for phonological inquiry more broadly.

Background and reference information is unpacked in the appendicies. The language conventions used throughout this dissertation are summarized in Appendix A. Appendix B includes maps of the Bái-speaking area as discussed throughout this dissertation. The syllable inventory of the Zhàozhuāng dialect is presented in Appendix C. The responses to the tone identification task discussed in 6.4.3 are tabulated in Appendix D.

Chapter 2. Previous Research on Bái

This chapter introduces the broad context of prior research on Bái linguistic varieties. Although the focus throughout this dissertation is on the representation of synchronic phonological contrast in Bái, this chapter provides the background necessary to follow the place names of the Bái-speaking area and the nature of most of the work available on Bái. Furthermore through this review I intend to emphasize that prior research on Bái, although extensive, has yet to present a rigorous account of synchronic phonological contrast for these linguistic varieties. Section 2.1 provides background information about the Bái people and the languages they speak. Section 2.2 places Bái varieties in the context of the Sino-Tibetan language family and discusses some of the major works on Bái oriented toward historical linguistics. Section 2.3 surveys major lexical and descriptive grammatical work on Bái. Section 2.4 surveys major experimental and phonetic work on Bái. Section 2.5 surveys major sociolinguistic work on Bái. Detail on the phonological descriptions from these works is presented in chapter 3. This chapter concludes in section 2.6 with a summary on the state of prior phonological research on Bái and introduces the context of investigation for phonological contrast in Bái presented in this dissertation.

2.1 Bái People and their Languages

The People's Republic of China is home to fifty-six government-designated ethnic groups, one of which is the Bái nationality.[1] There are roughly two million ethnic Bái across Yúnnán 云南, Guìzhōu 贵州, Sìchuān 四川, and Húnán 湖南 provinces (XĪ Shòudǐng 溪寿鼎 2014). Bái people primarily live in Yúnnán province with strongest concentrations in Dàlǐ Báizú Zìzhìzhōu 大理白族自治州 [Dàlǐ Bái Autonomous Prefecture] (Wiersma 2003, XĪ Shòudǐng 2014). Maps of the geographic areas discussed in this dissertation are provided in Appendix B.

The Bái people speak various languages depending on geographic location and socio-economic background, but the speech varieties original to this group are referred to as *Bái* or *Báic* in English (typically without the Pīnyīn tone-2 diacritic). Other ethnic groups who live in contact with the Bái are the Huí 回, Yí 彝, Nàxī 纳西, Lìsù 傈僳 and, of course, the national majority – Hàn 汉. Each government designated ethnic group has their own designated standard language and in some cases, such as the Hàn and Yí, many mutually unintelligible linguistic variants in addition to this designated standard (Mullaney 2004, Pelkey 2008, LaPolla m.s.). An exception to this generalization is the Huí. The Huí are generally defined by their Muslim faith and typically speak the languages of the Hàn in their geographic proximity (Gladney 1996:20). In addition to varieties of Chinese and their own native ethnic languages, some members of these other groups have proficiency in Bái (Fēng WĀNG 2015a). One of the primary references introduced in 2.3.8, LǏ Zhèngqīng 李正清 (2014), for instance, is authored by an ethnic

[1] Some literature refers to the ethnic minorities in China as 'nationalities'. This terminology is a remnant of the policy borrowed from the Stalinist classification in the former USSR (Hefright 2011:52).

Huí who is a native speaker of the variety of Bái spoken in Kēlǐzhuāng 珂里庄 in Xǐzhōu 喜洲 prefecture.

In English language sources, the term *Bái* refers to both the ethnic group and the language; however, these terms are not interchangeable in Chinese. The Bái people are referred to as *Báizú* 白族 and the Bái language is referred to as *Báiyǔ* 白语 in Chinese. Both of these words share the first syllable and Chinese character, *Bái* 白 which means 'white'. This nomenclature has been assumed since 22 November 1956, when the First People's Congress of Dàlǐ Bái Autonomous Prefecture convened and confirmed the Bái ethnonym (XǏ Shòudǐng 2014:171), but the term 'Bái' can be perhaps first attributed to the *Mán Shū* 蛮书 by Fán Chuò 樊绰 authored in 863 CE. This text refers to one group as the Báimán 白蛮 'white barbarians' who, along with the Wūmán 乌蛮 'black barbarians', established the Nánzhào 南诏 Kingdom (738-937). The Nánzhào Kingdom was centered on the area which is currently Dàlǐ Bái Autonomous Prefecture in Yúnnán Province (SHǏ Wéidá 施惟达 & DUÀN Bǐngchāng 段柄昌 2004:45) and was later replaced by the State of Dàlǐ 大理国 (937-1095, 1096-1253). In 1253, the Mongolian Empire conquered this region and incorporated the area into Yúnnán province of the Yuán 元 Dynasty. This area has remained subject to the successor dynasties, Míng 明 (1368-1644) and Qīng 清 (1644-1912), the Republic of China (1912-1949) and presently, the People's Republic of China (1949 onwards). In between the period when the Bái people were referred to as Báimán and Báizú, this group was commonly referred to as the Mínjiā 民家. Sources about the language written before 1956 (Luó Chángpéi 罗常培 (1943[2004])) refer to the language as Mínjiāyǔ 民家语.

It is clear that Bái varieties belong to the Sino-Tibetan language family; however, for reasons discussed in the next section, the classification of Bái varieties within this family and the classification of the varieties themselves within the Bái group are controversial. Ethnologue (Lewis et al. 2015) lists four Bái languages: Central Bái (800,000 speakers), Southern Bái (400,000 speakers), Lāmǎ 拉马 Bái (60,000 speakers)[2], and Panyi Bái (12,000 speakers).[3] These figures are probably fair estimates given the number of ethnic Bái registered in this region, but are not without conflict as it is hard to estimate the proportion of Bái people in a given community who have shifted to Chinese.

The fieldwork projects conducted on Bái in the 1960s organized by the central government onwards designate three distinct Bái languages – Northern Bái, Central Bái, and Southern Bái. The majority of Chinese language references assume these designations (consider popular references XÚ Lín 徐林 & ZHÀO Yǎnsūn 赵衍荪 (1984) and YÁNG Lìquán 杨立权 (2007) for instance). The results of a Recorded Text Tests dialect survey conducted by Bryan Allen and his research team (introduced in detail in 2.5.1) suggest that Central Bái and Southern Bái are mutually intelligible to some degree and that those dialects are not mutually intelligible with Northern Bái (the varieties specified as Panyi and Lāmǎ in Ethnologue). Consequently, Bradley (2012) lists the Bái language group as having two distinct branches – Bái and Lèmò 勒墨/Lāmǎ. Fēng WĀNG (2006) explores the classification of Bái in thorough detail based on innovations and makes a similar distinction between these two branches except that he refers to these branches as 'Eastern Bái' and 'Western Bái'. The 'Eastern Bái' of Fēng WĀNG (2006)

[2] The ethnolinguistic designation 'Lāmǎ' is also rendered as 'Nāmǎ 那马' in some sources.
[3] It is not entirely clear what 'Panyi' refers to in this source. I use this reference to estimate numbers of Bái speakers because it is the most recently published survey.

corresponds to varieties of ‘Central Bái’ and ‘Southern Bái’ in prior classifications whereas ‘Western Bái’ in that work corresponds to ‘Northern Bái’ in prior classifications. The scope of phonological contrast introduced in this dissertation is limited to “Mainstream Bái” which includes ‘Western Bái’ and excludes ‘Eastern Bái’. The next section continues discussion on the Bái languages in the broader context of the Sino-Tibetan language family.

2.2 Bái as a Sino-Tibetan language

Sino-Tibetan is one of the world’s major language families comparable in terms of geographic spread and number of native speakers to Indo-European (Matisoff 2003, Handel 2008, Comrie 2009). Languages in this family are indigenously spoken throughout East and Southeast Asia. Matisoff (2003:1-3) estimates that there are somewhere between 200 and 300 distinct Sino-Tibetan languages. There are many theories of subgrouping within this family; however, discussion in this section focuses exclusively on the possible genetic affiliations for Bái instead of thorough review of each of these theories. Although most theories of Sino-Tibetan starting with Benedict (1972) distinguish two major branches – the Sinitic (Chinese) languages and the Tibeto-Burman languages – the affiliation of Bái within Sino-Tibetan is an issue that remains unresolved. Hefright (2011:54-79) provides a more rigorous review of these some of the proposals introduced in this chapter than I can offer; however, since my dissertation deals with phonological contrast I focus discussion of genetic affiliation as expressed by regular phonological correspondences in basic vocabulary with lexical examples either taken from these works or from other sources.

The three most common viewpoints can be summarized as follows. The most popular view in China is that Bái varieties belong to the Ngwi subgroup of the Burmic branch (also known as Lolo-Burmese or Ngwi-Burmese) of Tibeto-Burman. This view is perhaps based on geography as the majority of indigenous languages surrounding the Bái-speaking area belong to the Burmic branch of Tibeto-Burman. However, affiliation to Burmic is poorly supported as none of the innovative features of the Burmic languages are attested in Bái varieties (Bradley 2013). Given the lack of Burmic innovations in Bái, another popular view is that Bái is Tibeto-Burman but with unclear affiliation or separate branch status in the family. A less popular, but noteworthy, view is the grouping of Bái and Sinitic together as Sino-Bái.

Sub-section 2.2.1 introduces some selected features common to the languages of the Sino-Tibetan family. Sub-section 2.2.2 discusses classification proposals suggesting Tibeto-Burman affiliation for Bái. Sub-section 2.2.3 discusses classification proposals suggesting Sinitic affiliation for Bái. Sub-section 2.2.4 concludes this section by exploring some of the other affiliation possibilities in the literature.

2.2.1 Features of Sino-Tibetan Languages

Although Sino-Tibetan languages are spoken over a vast stretch of land and any degree of mutual intelligibility between two randomly selected variants cannot be assumed, it is fairly straightforward to compile lists of cognate words across Sino-Tibetan languages. However, for certain reasons noted at the end of this sub-section, I only consider one diagnostic – the 'ng-set' – to be absolutely indicative of Sino-Tibetan affiliation.

Handel (2008:425) states that, in nearly all Sino-Tibetan languages, the three words 'five', 'fish', and 'I' generally have onset [ŋ-] or regular correspondences derived from earlier forms with an onset [ŋ-].[4] The cognate set provided in (1) includes glosses from four Sino-Tibetan languages – Jiànchuān Bái, Hakka Chinese, Burmese and Lhasa Tibetan – which each exhibit these correspondences. I also include the glosses for these words in two non Sino-Tibetan languages spoken in Yúnnán province – the Kra-Dai language Dǎi 傣 (as spoken in 景洪 Jǐnghóng) and the Austroasiatic language Wǎ 佤 – as counterexamples to this criterion. Contrastive tone categories are irrelevant to discussion and are omitted from the phonetic transcription of lexical items in (1).[5]

Fig. (1) The 'ng-set' as a Sino-Tibetan Diagnostic

	Jiànchuān Bái	*Hakka*	*Burmese*	*Lhasa Tibetan*	*Jǐnghóng Dǎi*	*Wǎ*
'five'	ŋɣ	ŋ̍	ŋa:	ŋa	ha	p^huan
'fish'	ŋɣ	ŋ̍	ŋa:	ŋa̰	pa	kaʔ
'I'	ŋo	ŋai	ŋa:	ŋa	to xa	ʔɤʔ

Other works, such as Benedict (1972:174), Norman (1988:13), and Baxter (1995:6-7), provide numerous regular correspondences from cognate words in the basic lexicon of several Sino-Tibetan languages. Some of the numerous examples that are consistently mentioned in later sources include a second-person pronoun beginning with onset [n-], negative function morphemes with onset [m-], onset [s-] in the number 'three',

[4] Some Sino-Tibetan languages only have one or two of these items. Consider Nuòsū 诺苏 for instance; the Nuòsū word 'fish' is [xi^{33}] whereas the other two items both have [ŋ-] onsets. On the other hand, some languages, such as Standard Mandarin Chinese lack, the [ŋ-] onset. This diagnostic can only be applicable if regular correspondences to the items in (1) can be demonstrated to have [ŋ-] onsets in the direct ancestor of a given language; evidence from Middle Chinese and other dialects of Mandarin suggest this to be the case for Standard Mandarin Chinese.

[5] The sources providing the data in this cognate set are as follows: Central Bái – XÚ & ZHÀO (1984), Hakka – GǓ Guóshùn 古國順 (2004), Burmese and Lhasa Tibetan – HUÁNG Bùfán 黃布凡 et al. (1992), Jǐnghóng Dǎi – YÙ Cuìróng 喻翠容 & LUÒ Měizhēn 落美珍 (1980), Wǎ (Va) – ZHŌU Zhízhì 周植志& YÀN Qíxiāng 谚其香 (1984).

the nominal root ‘wood/tree’, and the verbal root ‘to die’, and nuclear vowel [i~e] in the words ‘day/sun’ and ‘dog’.

While regular phonological correspondences in the basic lexicon such as those in (1) and listed in the previous paragraph provide strong evidence that the Sinitic and Tibeto-Burman languages descend from a common ancestor language, correspondence sets between these languages have not been worked out thoroughly. As Handel (2008:425) mentions, there are repeated irregular alternations with regard to voicing, aspiration, and morphological function of affixed units across proposed sets. These irregularities and inconsistencies lead to the proposal of inaccurate or misleading correspondences. For instance, although the Middle Chinese *khwenX* and Proto Tibeto-Burman *k^{w}əy are typically believed to be cognate forms of the nominal root ‘dog’, it is more likely that the Middle Chinese root is cognate with Proto Tibeto-Burman form *kywal ‘jackal’ for at least two reasons.[6] First, there are many regular correspondences between Middle Chinese coda *[-n] and Proto Tibeto-Burman coda *[-l]. Second, it is otherwise hard to explain the absence of such a coda segment in the reconstructed Proto Tibeto-Burman *k^{w}əy ‘dog’.

In addition to regular correspondences in basic vocabulary, previous work has noted some other generalizations regarding word order in language subgroups of the Sino-Tibetan language family. I only mention basic word order as Dryer (2003:54) notes that most constructions in any given Sino-Tibetan language resemble the patterns observed in its contact languages. Tibeto-Burman languages each have Subject-Object-Verb basic word order with the exception of languages in the Bái and Karen (pronounced

[6] William Baxter introduced me to this example which was first pointed out to him by Laurent Sagart. The Middle Chinese glosses in this dissertation are extracted from Baxter & Sagart (2014). Middle Chinese is not a reconstruction, but rather a transcription based on the categories of *Qièyùn*-*Guǎngyùn* rimebooks.

[kə.ˈrɛn] in English) subgroups. These subgroups along with the Sinitic languages each have Subject-Verb-Object basic word order. These differences in basic word ordering are commonly mentioned in discussions of the affiliation of Bái (LaPolla 2003:31), but are not convincing regarding genetic affiliation due to the limited possible variation in canonical word ordering across languages of the world. Despite this crucial difference observed in the modern languages, LaPolla (2015:53) suggests that the verb-medial ordering is a later innovation and that the ancestor language to both Sinitic and Tibeto-Burman was verb-final. Discussion in the next sub-sections explores proposed affiliations of Bái within Sino-Tibetan.

2.2.2 Bái as a Tibeto-Burman Language

Most researchers and published works affiliate Bái with Tibeto-Burman. There are two commonly proposed sub-affiliations for Bái within this family. Earlier works group Bái into the Ngwi branch of Burmic (also referred to as Ngwi-Burmese, Lolo-Burmese or Yí-Miǎn 彝缅). On the other hand, the more recent proposal is that Bái is an independent branch of Tibeto-Burman. If we believe that innovations determine genetic affiliation, then Bái cannot be part of Burmic or either of its subgroups – Ngwi or Burmish – as the innovative features of this family are not attested in varieties of Bái.

Burling (1967), Bradley (1979) and Bradley (2013) compare several Tibeto-Burman languages and list several innovative features for Burmic languages. Bradley (2013:172) states that "the clearest and most consistently attested innovations include the development of a third reconstructed tone category in non-stop final rhymes and presence of prenasalized stop and affricate initials *mb *nd *nts *ɲc *ŋg in numerous etmya". With regard to the latter innovation, the words with these items are generally not cognate

in Bái and furthermore Bái (and proposed reconstructions of earlier forms of Bái such as Fēng WĀNG 2006) lacks a contrast between prenasalized and voiced onsets. These prenasalized onsets, additionally, have merged with their voiced counterparts in the Burmish branch and several of the modern Ngwi languages.

Ngwi is distinct from Burmish through a further innovation in tonal contrasts which was conditioned by onset voicing in syllables with stop-final rhymes (Matisoff 1972). Matisoff (2001) specifies some tonal correspondences between Burmic (both Ngwi and Burmic as a whole) and Bái but many of the words which are listed are either Chinese loans or not in the most basic level of vocabulary (Swadesh 100-list); he concludes on page 39 that "it is best to regard [Báic] as a separate subgroup of Tibeto-Burman, though perhaps fairly close to [Ngwi]". Lee & Sagart (2007) also group Bái into Tibeto-Burman, but instead of focusing on innovations they stratify the lexicon of the Jiànchuān dialect of Bái into three layers determined by phonological correspondences in Tibeto-Burman languages, reconstructed Old Chinese, Middle Chinese, Southwest Mandarin, and Jiànchuān Mandarin. I summarize the nature of the layers of the Bái lexicon from Lee & Sagart (2008) in (2).

Fig. (2) Layers of the Bái Lexicon (Lee & Sagart 2008)

Name	**Source**	**Approximate Dating**	**Nature of Lexical Items**
Non-Chinese	Genetic	N/A	12% of Swadesh
A	Chinese (Old, Middle)	From Hàn 汉 (206 BCE-220 AD) to Táng 唐 (618-907 AD)	47% of Swadesh, enormous amounts of cultural vocabulary
B	Varieties of Mandarin (Southwest Mandarin, Jiànchuān Mandarin)	From Míng 明 (1368-1644 AD) to Qīng 清 (1644-1911 AD)	Almost no basic vocabulary, about half as numerous as layer A

Lee & Sagart (2008) stratify the lexicon of Bái according to a principle they refer to as the *coherence principle* which states that all correspondences come from a single layer or stratum in borrowed syllabic morphemes; these layers are specified in the first column of (2). This work finds correspondences in the initials, finals, and tones between the lexical items in Jiànchuān Bái from HUÁNG Bùfán et al. (1992) and the phonological systems of the source languages listed in the second column of (2). The third column of (2) indicates the approximate dates of the borrowed lexical items. The fourth column of (2) summarizes information about the nature of each proposed layer of the Bái lexicon. Note that while Lee & Sagart (2008) provide estimates regarding the percentages of lexical items in the basic vocabulary from the Swadesh 100-list, these percentages do not add up to 100%. Laurent Sagart explained to me in personal communication that some possible reasons for this gap are as follows. First, there are some items which cannot be confirmed to exclusively belong to one layer or the other because the correspondences for these items fit multiple layers; for instance, the paper cites 'claw' <tsua21 tsɨ33> as an example of a Chinese loanword that corresponds to layers A and B. Second, it likely is possible to find more correspondences with layer A but loans were not detected due to unrecognized sound changes in Bái. Third, and most importantly, there are probably more items in the genetic layer but it is unclear which words can be considered innovative of Báic or some other branch of Tibeto-Burman due to lack of modern languages for comparison which can help us determine sound correspondences.

Although much of the lexicon has regular correspondences with different synchronic layers of Sinitic varieties, Lee & Sagart (2008) argue that Bái is not Sinitic because the 12% lexical items in the Swadesh 100-list in the earliest layer are more basic

in nature (pronouns, lower numerals “one” and “two”, other basic items) and have regular correspondences with other Tibeto-Burman languages (spanning branches outside of Burmic including Qiangic, Kachinic, and Central Tibeto-Burman), but lack such correspondences with any of the Sinitic varieties considered. Perhaps the biggest contribution to historical linguistics this research demonstrates is that it is possible for a language to borrow very large amounts of items into its basic vocabulary instead of shifting to the primary donor language.

Despite the absence of sufficient cognates to recognize regular phonological correspondences with the innovative lexicon indicative of the Ngwi subgroup of Burmic, many researchers insist on classifying Bái varieties as Ngwi. These arguments often assume that Bái was more similar to Ngwi in the distant past before prolonged extensive contact with Sinitic. Hefright (2011:57-62) notes that some sources advocating this affiliation such as ZHÀO Yǎnsūn (1982) focus on constituent ordering in specific constructions (i.e Bái should be grouped with Ngwi because it uses the [Head Noun]+[Number]+[Classifier] ordering in noun phrases instead of the typical Sinitic noun phrase ordering [Number]+[Classifier]+[Head Noun]) while other sources such as XÚ & ZHÀO (1984) and Hongkai SŪN (1988) assume a typological approach based on synchronic similarities (i.e. Bái should be grouped with Ngwi because both have tense-lax productions of vocalic contrasts and absence of nasal codas whereas Sinitic languages lack such phenomena).

These aforementioned arguments for affiliation with Ngwi are weak for several reasons. First, although most of the specified characteristics are not typical of Sinitic languages, they are attested in the family. Hefright (2011:59) points out that the

constituent ordering in Bái noun phrases ([Head Noun]+[Classifier]+[Number]) is typical of certain written registers of Chinese including the norms of Classical Chinese (the written standards for Chinese prior to the popularization of the modern written language in the early 20th century). Furthermore, the contrast between nasal codas and nasalized vowels has been lost in Shanghai Chinese (Sān DUĀNMÙ 2008:115). Second, the phonological characteristics (i.e. vowel phonation contrasts and absence of closed syllables) which group Bái with Ngwi are not attested in every variety of Bái. As we will see in chapters 3 and 4, many varieties traditionally classified as Southern Bái lack such phonation contrasts and on the other hand some varieties traditionally classified as Central Bái list nasal vowels and nasal codas in their inventory of vocalic contrasts (such as Fēng WĀNG 2006). Third, and most importantly, these arguments assume that these features could not have been borrowed from contact with Ngwi languages. Areas in which Bái is spoken are all multilingual; Bái speakers are in intense contact with varieties of Chinese in addition to speakers of various Ngwi languages such as Lìsù and the numerous mutually unintelligible languages spoken by the ethnic Yí living in and surrounding their communities. Although varieties of Chinese are the prestige languages in most of these areas currently, it is unclear if this was always the case. It is very well possible that Bái speakers had linguistic proficiency in these surrounding Ngwi languages throughout different periods of history.

In brief, despite geographic proximity and shallow typological similarities with Ngwi languages, there is little support attested in modern languages that Bái has any genetic affiliation with this subgroup. At present, any proposal of independent subgrouping within Tibeto-Burman is more convincing than affiliation to Ngwi.

2.2.3 Bái as a Sinitic Language

Since it is unquestionable that large portions of the Bái lexicon have more in common with Sinitic than Tibeto-Burman, a substantial body of literature argues for genetic inheritance from Sinitic in contrast to the results of the search for correspondences presented in Lee & Sagart (2008). These proposals all acknowledge that Bái is divergent from most of the major developments in attested other branches of Sinitic, each suggesting fairly early dates of separation. I summarize some of the major detailed works taking the stance of Sinitic affiliation in loose chronological order for the remainder of this sub-section.

Starostin (1995) is the earliest work I can find that provides explicit support for affiliation of Bái to Sinitic. His approach combines regular phonological correspondences with lexicostatistics. Starostin (1995) presents correspondences in the tonal, initial consonants, and final systems between Jiànchuān Bái and Chinese (primarily Middle Chinese, but also examples from reconstructed Old Chinese) and presents the results of lexicostatistical calculations between Standard Chinese, Bái, Fúzhōu Chinese, and Hakka Chinese from the Swadesh 100-list and ten additional items from the Yakhontov-35 list. I summarize the regular tone system correspondences between Bái and Middle Chinese in (3) as these correspondences are not immediately accessible without background knowledge of historical Chinese phonology and are relevant to the other proposals introduced in this chapter. The lexicostatistical calculations suggest 68-70% of the basic vocabulary in Bái is cognate with the three aforementioned Sinitic varieties and that Bái split from “mainstream” Chinese around 200 BCE.

Fig. (3) Tone Correspondences Between Jiànchuān Bái and Middle Chinese

(a)
Jiànchuān Bái

1	33 – Lax	Modal Low Level
2	42 – Tense	Tense Fall
3	31 – Lax	Modal Fall
4	55 – Lax	Modal High Level
5	35 – Lax	Modal Rise
6	44 – Tense	Tense Low Level
7	21 – Tense	Harsh Low
8	55 – Tense	Tense High Level

(b)
Middle Chinese

	Píng	*Shǎng*	*Qù*	*Rù*
Yīn	4	1	2	6
Yáng-1	4/7	1	2/3	6
Yáng-2	7	1	3	2

Starostin (1995) states that he references Jiànchuān Bái data from XÚ & LÍN (1984) in comparison with Sinitic data. The table in (3a) lists the eight contrastive tones in Jiànchuān Bái from XÚ & LÍN (1984). Since this source is in Chinese I reproduce this information in English as follows. The leftmost column in (3a) provides category numbers for the eight tones. The center column in (3a) presents the characterization of each category on the numerical scale indicating pitch (as introduced in 3.1.2:60) and in terms of lax (松 *sōng*) or tense (紧 *jǐn*) phonation as introduced in XÚ & LÍN (1984:12). These characterizations of the tone categories are revised throughout this dissertation. The rightmost column presents a simplified characterization of these tones from Edmondson et al. (2001), which is discussed in detail in 2.4.1.

The reflexes of the Middle Chinese tone system attested in Jiànchuān Bái are summarized in (3b) and can be understood as follows. Middle Chinese had four tones – *Píng* 平, *Shǎng* 上, *Qù* 去, and *Rù* 入 – which correspond to the columns.[7] These tone categories further split in half based on the voicing register of the onset – syllables with

[7] 'Middle Chinese' here refers to the Sinitic phonological system from the *Qièyùn* 切韵 rimebook of 601 AD attributed to Lù Fǎyán 鲁法言.

voiceless onsets went to the *Yīn* 阴 register and syllables with voiced onsets went to the *Yáng* 阳 register. This register split yields a system with eight tone categories, and every modern Sinitic language has regular correspondences between their tone categories and this system. The tonal reflexes of these eight categories in modern Sinitic languages show that the sonority of Middle Chinese onsets correlates with innovative re-categorization of these eight categories throughout the historical changes between Middle Chinese and these modern languages. For instance, the reflexes of these Middle Chinese categories in Jiànchuān Bái show that syllables with nasal and liquid onsets from the *Yáng* register affiliated with a register I refer to as *Yáng-1* and that syllables from the *Yáng* register with obstruent onsets affiliated with a register I refer to as *Yáng-2*. The correspondences between Middle Chinese tones from the *Yīn* and *Yáng-2* registers and Jiànchuān Bái are fully regular and predictable; for instance, the Middle Chinese *Píng* tone in the *Yīn* register corresponds with Jiànchuān tone 4, the Middle Chinese *Qù* tone in the *Yáng-2* register corresponds with Jiànchuān tone 3, etc. On the other hand, Starostin (1995) does not directly address whether or not the multiple correspondences in Jiànchuān for single tone categories in the *Yáng-1* register were the result of conditioned and regular sound change. The stratified correspondences reflected in varieties of Mandarin spoken in Jiànchuān discussed in Lee & Sagart (1998), Matisoff (2001), and Lee & Sagart (2008) supersede the relevance of the correspondences in (3); however, the philological approaches taken in ZHÈNGZHĀNG Shàngfāng 郑张尚芳 (1999) and LǏ Zhèngqīng (2014) as well as the classificatory approach presented in Norman (2003) provide potential support that Bái should be a sister branch of Sinitic. It is important to note that

these proposals assume that Sinitic and Bái share a common ancestor language and that the Sino-Tibetan language family has two major branches – Sino-Bái and Tibeto-Burman.

ZHÈNGZHĀNG Shàngfāng (1999) presents a comprehensive account of correspondences in the initials, finals, and tones of Bái found in Middle and Old Chinese with numerous exemplars for each category. Furthermore, this work presents Chinese character etymologies for every item on the Swadesh-100 list of basic vocabulary from numerous well-known references including the *Shuōwén Jiězì* 说文解字 (c. 121 AD) and the *Guǎngyùn* 广韵 (1008 AD). Many of these characters are not the typical items found in mainstream Chinese or are infrequently used in the modern languages, however. The thesis in ZHÈNGZHĀNG (1999) concludes with rhetoric appealing to the applicability of Chinese characters to write Bái. In brief this portion of the argument demonstrates that nearly anything in Bái can be represented in Chinese characters, with some examples thereby suggesting strong cultural and linguistic affinity with Sinitic. LǏ Zhèngqīng (2014) takes this line of reasoning much further. This work (introduced in detail in 2.3.8) is essentially a comprehensive description of Bái including a phonological sketch, dictionary including Bái glosses of Chinese characters from major literary works, grammar, and correspondences between Old Chinese and Middle Chinese.

Norman (2003) establishes criteria for classifying languages as Sinitic and further into dialect sub-groups. This work provides a diagnostic list of 40 lexical items determining Sinitic affiliation; some of these words are found in the Swadesh 100 (13/40) while others are vocabulary items not found in the list (27/40; examples of basic vocabulary include *sam^{1} ‘three’, *biaŋ^{6} ‘sick’, *thian^{1} ‘sky’, etc. whereas examples of non-basic vocabulary include *kiai^{1} ‘chicken’, *ciuk^{7} ‘bamboo’, *ziak^{8} ‘mat’, etc.).

These items consist of eight groups of five items; each group corresponds to one of the eight tones of Common Chinese.[8] Absence of lexical items corresponding to the reconstructed Common Chinese forms for some of these items does not disqualify Sinitic affiliation, as the goal behind this list is to provide numerous potential correspondences between commonly-used lexical items and the Common Chinese tone system. Like the other sources, Norman (2003) also uses data from the Jiànchuān dialect of Bái in his discussion. His views on the relationship between Bái and Sinitic are as follows. He acknowledges that Jiànchuān is the least Sinitic of the modern languages he compares – roughly 70% of the lexical items from this subset of Bái data exhibit regular phonological correspondences with reconstructed Common Chinese. On the other hand, he states that "cursory inspection" of the *Tibeto-Burman Lexicon* [HUÁNG Bùfán et al. (1992)] suggests a small number of clear links to Tibeto-Burman and that close links with Sinitic "cannot be easily dismissed". Norman (2003) concludes that Bái and Sinitic form a major sub-group of the Sino-Tibetan family.

All reviewed theories affiliating Bái to Sinitic suggest that although there are clear correspondences between different synchronic stages of Chinese languages and modern Bái, Bái diverged from "mainstream" Sinitic at a relatively early time and must be branched separately as a result. The philological approaches are interesting because these obscure and uncommon Sinitic morphemes may have regular correspondences to items in the layer referred to as "Genetic" of the Bái lexicon in Lee & Sagart (2008); however, it remains to be seen whether these correspondences reliably map to recent reconstructions of Old Chinese such as Baxter & Sagart (2014). On the other hand, the fact that nearly

[8] Common Chinese consists of reconstructed forms derived from applying the comparative method to Chinese dialects. The reconstructed eight tone categories in Common Chinese generally correspond to the eight tone categories of Middle Chinese.

any morpheme in Bái can be transcribed with a Chinese character, generally with reliable correspondences, shows that there is something intimate in the relationship between Bái and Sinitic either taking the form of intense contact or genetic inheritance.[9] In my view, Sinitic affiliation remains inconclusive at best until the obscure Sinitic forms from works such as ZHÈNGZHĀNG Shàngfāng (1999) and LǏ Zhèngqīng (2014) can be proven to have accurate and regular correspondences with Bái data.

2.2.4 Other Possibilities

There are several other theories regarding the genetic affiliation of Bái in addition to the possibilities introduced in 2.2.2 and 2.2.3. Outdated or tangential work advocates for affiliation to Mon-Khmer (Terrien de Lacouperie 1887, Davies 1909). Additionally, there are many detailed comparative-oriented studies which opt not to take a strong stance on genetic affiliation. Other noteworthy positions suggest that Bái is a mixed language. I summarize the latter two possibilities, as discussed in the literature, for the remainder of this section.

The non-committed comparative studies are summarized chronologically as follows. Dell (1981) compares roughly 1000 Bái lexical items with Middle Chinese and finds many correspondences, but also finds several items that lack such regular correspondences; there is no conclusive statement for affiliation in this work. Wiersma (1990) is also uncommitted with regard to classification despite rigorous comparison between Jiànchuān Bái and Middle Chinese etyma; however, this work does seriously entertain hypothetical situations of language contact between Chinese and Bái with the final assessment that the absence of a well-defined historical speech community of Bái language users makes conclusive statements of genetic affiliation problematic. In recent

[9] Although very few people are actually familiar with this tradition or practice.

years Fēng WĀNG of Peking University is perhaps the most productive researcher on the history of Bái. His 2006 book, introduced in 2.3.5, provides a reconstruction for Proto-Bái based on original fieldwork from nine Bái dialects and an original framework for genetic affiliation for languages in contact called the "Distillation Method". This work compares this original Bái data to the Middle Chinese forms from Baxter (1992) and the Old Chinese reconstructions from LǏ Fang-Kuei (1971[1980]) and suggests that the oldest layer of lexical items in Bái are cognate with Sinitic; however, WĀNG does not overtly confirm Sinitic affiliation for Bái due to the fact that internal categorization of Tibeto-Burman languages has not been established based on shared innovations. In further effort to distinguish Bái from Ngwi, WĀNG Fēng 汪锋 (2013) compares Bái data with Sinitic and Ngwi data and finds that that Bái is closer to Old Chinese than to Proto-Yí (reconstructed Proto-Ngwi) but expresses that the exact position cannot be confirmed until the complete tree of all Sino-Tibetan languages is mapped out.

LǏ Shàoní 李邵尼 (1992) and CHÉN Kāng 陈康 (1992) advocate mixed language status for Bái. The scope of LǏ Shàoní (1992) is rather limited; this work claims mixed language status based on the etymologies of the Bái numbers. On the other hand, CHÉN Kāng (1992) proposes that Bái is a modern hybrid of Sinitic and Ngwi due to correspondences between tense tone categories in Jiànchuān Bái and both Middle Chinese and Ngwi languages. Again, these arguments are superseded by the evidence introduced in Lee & Sagart (2008).

Hefright (2011) reviews and criticizes the mixed language proposals based on procedures laid out in Thomason & Kaufman (1988). His evaluation of these proposals and supporting data suggests that the aforementioned correspondences attested in Bái are

the result of genetic relationship and not due to contact; however, he states that the identification of non-Sinitic features of Bái as Tibeto-Burman is not particularly convincing because the reconstructed Proto-Tibeto-Burman has not been established based on shared innovations. Conversely, Hefright (2011:79) speculates that the nature of Bái resembles a situation "in which borrowing and interference through shift/imperfect learning occurred simultaneously" between groups of Sinitic and non-Sinitic speakers as introduced in Thomason & Kaufman (1988:45,115).

2.2.5 Summary

This section presents a brief overview of major works on the genetic affiliation of Bái within Sino-Tibetan. As the focus of this dissertation is on the expression of synchronic phonological contrast in modern varieties of Bái, I choose not to address each and every available published reference on the history of this language.[10] This is not only because many sources are redundant, but also because the genetic affiliation of Bái is clearly such a complex and controversial topic that the scope of this dissertation is not able to thoroughly argue for one position over another.

At present I am most convinced by the arguments and evidence presented in Lee & Sagart (2008). On the other hand, their procedure may not yield the same results if lexical data from different varieties of Bái or reconstructed Proto-Bái are compared with recent reconstructions of Old Chinese such as Baxter & Sagart (2014). Furthermore, it is clear from the work of Fēng WĀNG and Lee & Sagart (2008) as well as notes in Hefright (2011) that the current state of Tibeto-Burman phylogeny and insufficient documentation of relevant languages are major obstacles to resolving the issue of the genetic affiliation

[10] See YÁNG Lìquán 杨立权 (2004) for a more exhaustive review of the literature in Chinese.

of Bái. Finally, any future discovery of historical documentation of Bái-speaking communities and the nature of their contact with Sinitic speakers may provide support for a mixed language hypothesis. I remain open to persuasion as work in this field continues to come to fruition.

2.3 Lexical and Descriptive Work on Bái

This section reviews most of the major lexical and descriptive work on Bái. Although the previous section has already mentioned many of these works with regard to the classification of Bái within the Sino-Tibetan language family, this section presents a detailed introduction to each of these references since this dissertation is dependent on the large amounts of data from these sources. Each of these sources provides at least two of the following four kinds of Bái data – glossaries of lexical data (at least 1000 items), descriptions of the major sentence structures and word-formation processes (often with numerous examples), annotated texts, and phonological inventories. The phonological inventories, particularly the nature of their organization and specification of representative dialects, are the data that are most valuable to this dissertation. I review most of the phonological inventories from these sources in thorough detail in the next chapter. The remainder of this section briefly introduces each of these references in loose chronological order by providing the following information: full name in original language (and English translation if applicable), intended primary function, specified affiliation within Sino-Tibetan (if directly stated), and dialect(s) surveyed. It is noteworthy that the sources that either suggest affiliation with Sinitic or compare the phonological system to Standard Chinese either include pre-nuclear glides after palatal consonants (LǏ Zhèngqīng 2014) or make note of the existence of pre-nuclear glides in

underlying forms (Dell 1981, Fēng WĀNG 2006) as this is the standard practice in descriptions of Chinese dialects (consider the 1964 *Hànyǔ Fāngyán Cíhuì* 汉语方言词汇 'Chinese Dialect Dictionary' published by the Chinese Department of Peking University for instance); this convention is not followed for the sources that either do not describe Bái in comparison to Sinitic or that assume a Tibeto-Burman affiliation for Bái.

2.3.1 XÚ & ZHÀO (1984)

Although this reference was published in 1984 after the Cultural Revolution (1966-1976), the data collection and majority of the write up was first prepared in the 1960s. This source is titled *Báiyǔ Jiǎnzhì* 白语简志 which loosely means 'Bái Simple Reference' and is perhaps the most commonly cited reference on the Bái language. This work is part of a series called *Zhōngguó Shǎoshù Mínzú Yǔyán Jiǎnzhì Cóngshū* [Collection of Descriptions of Chinese Minority Languages]. The *Báiyǔ Jiǎnzhì* provides an outline of the phonology, grammar, glossary of three major varieties of Bái – Jiànchuān 剑川 (Jīnhuá 金华 village), Dàlǐ 大理 (Xǐzhōu 喜洲), and Bìjiāng 碧江. These varieties are further classified as Central, Southern, and Northern, respectively. Since the majority of nationalities are assigned a standard spoken variety and Jiànchuān dialect was selected to be the standard,[11] all examples of grammatical usage are provided in Jiànchuān dialect with examples from the other varieties only provided when there is a substantial difference. This reference states affiliation to the Ngwi sub-group of Tibeto-Burman and, being the most consulted source for information on Bái, may explain why Bái is often thought to belong to this sub-group despite lacking the citation innovations.

[11] The Jiànchuān variety was selected to be the standard Bái because Jiànchuān county has the largest percentage of ethnic Bái of any county in China (some counts at 92%). Interestingly, this county is commonly cited as having the largest percentage of minority nationalities in all of China.

2.3.2 Dell (1981)

Like the *Báiyǔ Jiǎnzhì*, the original research for this published work was conducted during the 1960s and published later in the 1980s. The full title for this reference is *La langue bai: phonolgie et lexique* or 'The Bái language: Phonology and Lexicon'. As the title specifies, this work is primarily a description of the phonological system and lexicon of Bái. Dell also includes limited information on the morpho-syntax of Bái through some annotated text samples in this work. The original data presented throughout this work is a variety of Southern Bái. According to the text the data were collected in 1966 from an informant referred to by the initials G.K.C who is stated to have grown up around Dàlǐ Prefecture. However, through personal communication with the author, François Dell, I have learned that this informant is more specifically from Xǐzhōu. I mention this because there is a particular aspect of the vowel system described for this variety divergent from most other varieties of Bái that I discuss in 3.5.2 and 6.2.

2.3.3 DUÀN (2008a)

This reference is a reprint of the *fāngyán zhì* 'dialect almanac' section of the *Dàlǐ Báizú Zìzhìzhōu zhì* [Dàlǐ Bái Autonomous Prefecture Almanac] originally printed in 2000, in the *Dàlǐ Cóngshū – Báiyǔ Piān* 大理丛书：白语篇 [Dali Series – Bai Language Selections]. The author, DUÀN Líng 段伶 is a native speaker of Jiànchuān Bái and has published widely on various aspects of Bái language and culture; some of these works are discussed as supporting evidence for my analysis of phonological contrast and syllable structure in Bái. DUÀN (2008a) introduces ten dialects of Bái, providing phonological inventories for these dialects, brief description of the basic grammar of Bái, and a glossary of 3,000 items for four of these dialects.

2.3.4 Wiersma (1990), (2003)

Grace Wiersma wrote her Ph.D. thesis *A study of the Bai (Minjia) language along historical lines* at Berkeley in 1990 under the primary supervision of James Matisoff. As mentioned in 2.2.4, this work is a comparative and descriptive work focusing on the Jiànchuān dialect of Bái with an uncommitted stance of affiliation. This work is comprehensive including numerous correspondences between Bái data with other languages, an analysis of spoken texts, rhyming glossary with English translations, and a syllable inventory listing attested syllables distributed by initials, finals, and tones. A simpler syllable inventory table including attested syllables in Dàlǐ Bái is provided in Wiersma (2003). Wiersma (2003) is a chapter-long revised, brief summary of the major points from Wiersma (1990) for *The Sino-Tibetan languages*, a major reference work for many of the major languages of the Sino-Tibetan family, edited by Graham Thurgood and Randy LaPolla.

2.3.5 Fēng WĀNG (2006)

Fēng WĀNG (2006) is a monograph revision of his 2004 City Univerity of Hong Kong Ph.D. thesis. The work is titled *Comparision of languages in contact: The distillation method and the case of Bai*. As mentioned in 2.2.3 and Chirkova (2007) (a review of this monograph), the primary contribution this work intends to offer is an original framework for determining genetic affiliation of languages in contact called the "distillation method". In addition to this methodological contribution, this work provides phonological inventories and a glossary of 2,124 lexical items for nine dialects of Bái based on original fieldwork. This work divides Bái into two large groups – Eastern Bái and Western Bái. The Eastern Bái varieties surveyed include Tuǒluò 妥洛, Gòngxīng 共

兴, Ēnqí 恩棋, Égā 俄嘎, and Jīnmǎn 金满; the former three varieties are spoken by the ethnolinguistic Lāmǎ subgroup of the Bái nationality, and the latter two varieties are spoken by the ethnolinguistic Lèmò subgroup of the Bái nationality. Western Bái varieties surveyed include 金星 Jīnxīng, 周城 Zhōuchéng, 大石 Dàshí, and 马者龙 Mǎzhělóng; each of these varieties are spoken by "mainstream" Bái people. I introduce and discuss the phonological and lexical data from the former three varieties of Western Bái in 3.1.6. Each of the other varieties is divergent from the "mainstream" Bái dialect continuum and accordingly my analysis of phonological contrast in Bái does not necessarily apply to these varieties.

2.3.6 ZHÀO Jīncān (2011)

ZHÀO Jīncān 赵金灿 (2011) is a monograph titled *Hèqìng Báiyǔ Yánjiū* 鹤庆白语研究 [Hèqìng Bái language research]. This work is primarily a reference grammar of the Hèqìng dialect of Bái spoken in Kāngfú 康福 village as spoken by the native speaker author. This dialect is a considered a variety of Central Bái in most of the relevant literature. Furthermore, varieties of Bái spoken in Hèqìng are distinguished from other varieties of Central Bái in that they contrast aspiration in fricatives (ex. minimal pairs <sua^{44}> 'to yell' and <s^{h}ua^{44}> 'blood' are contrasted exclusively by aspiration). This work includes a phonological inventory, a syllable inventory, a description of word-formation processes, a description of grammatical structures, annotated texts of speech passages, and a glossary of roughly 3,000 lexical items with Chinese translations.

2.3.7 ZHÀO Yànzhēn (2012)

ZHÀO Yànzhēn 赵燕珍 (2012) is a monograph titled *Zhàozhuāng Báiyǔ Cānkǎo Yǔfǎ* 赵庄白语参考语法 [Reference Grammar of Zhàozhuāng Bái]. This work is a revised version of her 2009 PhD thesis. Zhàozhuāng Bái is spoken in Xīyáo village in Xiàguān city and would be considered a variety of Southern Bái in the most popular framework of Bái dialect classification. The phonological and lexical data in this work is deviant from most other descriptions of Southern Bái in two noteworthy respects. First, the tone inventory has six categories instead of the traditional eight. Second, velar consonants can co-occur with high front vowels. This work includes a phonological inventory, descriptions of word-formation processes and word categories, analyses of phrase and sentence structures, annotated texts of speech passages, and a glossary of 2,914 items.

2.3.8 LǏ Zhèngqīng (2014)

This work is titled *Dàlǐ Báiyǔ Shūzhèng* 大理白语疏证 [Commentary and Explanation of Dàlǐ Bái]. As mentioned in 2.2.3, this work assumes that Sinitic and Bái share a common ancestor language, and Sinitic etymologies for Bái morphemes are provided in nearly every section. This work has four chapters. The first chapter is a phonological sketch of the variety of Dàlǐ Bái spoken in Kēlǐzhuāng, Xǐzhōu prefecture. The description of the phonological system is organized like typical descriptions of Sinitic varieties. The syllable inventory lists Chinese character exemplars of attested syllables as vector combinations of initials, finals, and tones. The second chapter is an extensive glossary of Dàlǐ Bái. The majority of this chapter provides Chinese translations of Bái lexical items organized by initial with glosses from Middle Chinese based on the

Guǎngyùn 广韵 rimebook (1008 AD). There are also portions providing Bái glosses of Chinese characters from numerous canonical texts such as the *Shījīng* 诗经 (c. 600 BCE, collection of ancient Chinese poetry) and annotations of tablets in Bái represented in Chinese characters such as the *Shānhuā Bēi* 山花碑, a tablet of a Bái poem from 1460 AD found in Xǐzhōu. The third chapter offers a brief description of different word categories and an even briefer description of sentence structures. The fourth chapter lists Old Chinese and Middle Chinese correspondences in Dàlǐ Bái.

2.3.9 Other Relevant Works

This section introduces the sources of the phonological inventory data considered in my comprehensive analysis of phonological contrast; with the exception of Allen (2004), which I summarize in 2.5.1. There are two other types of descriptive data I introduce here. The first type of descriptive data is supporting works. The second type of represents varieties outside of "mainstream Bái" and are not applicable to my proposal.

My discussion of reduplication in Bái uses items from DUÀN Líng (2008b) – an extensive collection of reduplication, word-formation processes, and poetic rhyming patterns. DUÀN Líng also authored a monograph in 1997 titled *Báizú Qǔcí Gélǜ̈ Tōnglùn* 白族曲词格律通论 'Folk song and form of the Bái nationality' which provides similar information with numerous poetic excerpts from the Dàlǐ and Jiànchuān varieties of Bái. These data are particularly useful for supporting my arguments about sub-syllabic constituency and are discussed in 4.4.

In addition to the descriptive and lexical works introduced throughout this section, there are also numerous sources which I do not consider in my analysis. The first of these is WÁNG Fēng 王锋 (2008). This source is an extensive glossary of dozens of Bái

varieties which also includes phonological inventories for each considered variety. I do not include this reference in my analysis for several reasons. First, most of the sources are redundant with those introduced throughout this section. Second, there are several dialect pronunciations missing for particular glosses. Third, this work is organized by Chinese gloss and not by Bái pronunciation. Another reference, also by WÁNG Fēng, is his 2012 monograph titled *Kūnmíng Xīshān Shālǎng Báiyǔ Yánjiū* 昆明西山沙朗白语研究 'Research on the Bái language spoken in Shālǎng (Xīshān district of Kūnmíng)'. This is an excellent reference grammar similar in format to those introduced in 2.3.6 and 2.3.7 but representative of a non-mainstream variety of Bái spoken in Kūnmíng, over 300 kilometers away from the core Bái-speaking area of Dàlǐ Bái Autonomous Prefecture.

2.4 Experimental and Phonetic Work on Bái

Although the body of experimental and phonetic work on Bái is neither as extensive nor as developed as the available body of impressionistic and lexical work, there are several works which are particularly relevant to the nature of phonological contrast. Sub-section 2.4.1 introduces the implications from phonetic work on voice quality in Jiànchuān Bái. Dissemination of relevant work on these phenomena led by Jerold Edmonson and colleagues spanned nearly two decades and includes both spectrograph analysis and laryngoscopic imaging of Jiànchuān Bái and the Nuòsū variety of Yí. Fēng WĀNG (2015b) presents a recent study on the variation in phonation attested in the Jiànchuān Bái community. Sub-section 2.4.2 summarizes the results of Allen & Allen (2003), an acoustic description of the tone system of Xǐzhōu Bái. Sub-section 2.4.3 introduces the phonetic analysis of the fricative aspiration contrast in certain varieties of

Bái from YÁNG Xiǎoxiá 杨晓霞 (2007_. The relevance of these studies with regard to my analysis of phonological contrast in Bái is summarized in sub-section 2.4.4.

2.4.1 Phonation in Jiànchuān Bái

Edmondson, Ziwo, Esling, Harris & LǏ (2001) begins with an introduction stating that descriptions of voice quality in Bái are dependent on impressionistic statements, the reliability of which are hard to verify due to the facts that the location of the larynx makes observation of phonation difficult and that laryngoscopes cannot easily be transported to locations where native speakers of Bái (and other languages of the area) live. In this study, the fourth author, LǏ Shàoní, a male native speaker of Jiànchuān Bái, produced several iterations of the 15 items in (4) exhibiting the complete set of attested pitch and voice quality contrasts for the segmental configuration [tɕi]. The numbers following the transcribed syllable reflect change in pitch over time (as explained in 3.6) and the subscripts reflect breathiness [̤], whisper [̥], and tenseness [̲]; like change in pitch, change in subscripts indicates change in voice quality over time. These iterations were recorded on S-VHS video while the fiber optic bundle of the laryngoscope was lowered into the nasal-pharyngeal cavity just over the glottis through a nostril.

Fig. (4) Bái Test Syllables from Edmonson et al. (2001)

Lax, Oral	*Tense, Oral*	*Lax, Nasal*	*Tense, Nasal*
(a) [tɕi55] ‘much’	(d) [tɕi66] ‘to mail’	(i) [tɕĩ55] ‘gold’	(k) [tɕĩ66] ‘sword’
(b) [tɕi33] ‘to pull’	(e) [tɕi44] ‘leech’	(j) [tɕĩ33] ‘near’	(l) [tɕĩ44] ‘naughty’
(c) [tɕi31̤̥] ‘earth’	(f) [tɕi42̲] ‘to chase’	(k) [tɕĩ31̤̥] ‘decrease’	(m) [tɕĩ42̲] ‘arrow’
	(g) [tɕi21̤̲] ‘flag’		(n) [tɕĩ21] ‘bracelet’
	(h) [tɕi35] ‘nervous’		

Jiànchuān Bái contrasts oral and nasal vowels. The vowels in the items in the first two columns from the left are oral, and the vowels in the items in the second two columns on the right are nasal. Through the observations made in video analysis, the lax and tense

phonation as transcribed in the example syllables from (4) can be understood as follows. Lax voice, as they explain, is nearly the same as modal voicing as defined in Laver (1980). Tense voice involves both sphinctering (sometimes to the extent of trilling) of the aryepiglotic folds and raising of the larynx. These phonation qualities have been demonstrated to not affect vowel formants in prior spectral analysis (Edmonson & LǏ 1994). Since "Tense-Lax" is typically used to refer to differences in vowel height (among other properties) and there is no obvious interaction observed in this regard, the terms 'lax' and 'tense' are replaced by 'modal' and 'harsh' respectively in Edmonson & Esling (2006) throughout discussion of these contrasts observed in Jiànchuān Bái. Furthermore, breathy voice in Jiànchuān Bái is expressed by a persistent slight opening "in the posteriormost portion of the glottis". Breathy voice ends on a whisper for tone [31] as expressed in (4c) and (4k). The revised descriptions of these tone categories in Edmonson & Esling (2006) state that tone [21] (4g) has strong aryepiglottic trilling which is also found in the beginning of the production of tone [35] (4h) and the end of tone [42] (4f) and (4m).

Fēng WĀNG (2015b) presents the results of electroglottographic measurements of the eight contrastive tonal categories from the first two columns on the left in (4) for four speakers (M1:55, M2:37, F1:65, F2:78) of Jiànchuān Bái. This work offers slightly different pitch numbers from (4) as the result of a formula converting F_0 to pitch numbers introduced in Chao (1930). To avoid confusion I do not include these numbers in discussion; however, the results of the F_0 measurements and the extracted Open Quotient and Speed Quotient measurements from electroglottographic signals have noteworthy implications for the phonological analysis of tonal contrasts in Bái. For the non-modal

categories, different speakers either use ‘pressed’ or ‘harsh’ phonation instead of consistently using one or the other in tandem with pitch to yield each of the contrasts. Since different speakers in the community employ different strategies to produce non-modal phonation, perhaps the primary distinction should simply be modal or non-modal in phonological representation instead of a more complex three-way distinction.

The impressionistic descriptions of tone and voice quality in descriptive research prior to the phonetic works mentioned in this sub-section leave a large amount of the nature of tone in Jiànchuān unclear. These works provide empirical evidence that the tense-lax distinction has no effect on vowel position and that non-modal contrasts have variable realizations across the community of Jiànchuān Bái speakers.

2.4.2 Acoustic Description of the Tone System in Xǐzhōu Bái

As can be inferred from the discussion in this chapter thus far, the vast majority of work on Bái focuses on phenomena attested in Jiànchuān Bái. The Bái variety spoken in Xǐzhōu is also fairly well described and has been the representative dialect for Southern Bái in numerous works. Allen & Allen (2003) presents an acoustic description of the tone system for Xǐzhōu Bái. This variety also has eight tone categories, but the pitches of these categories are somewhat different than those of Jiàchuān Bái; the Xǐzhōu categories from Allen & Allen (1997:54) are tabulated in (5).

Fig. (5) Tone Categories of Xǐzhōu Bái from Allen & Allen (2004)

Pitch	*Phonation*	*Syllable*	*Gloss*
33	Lax	[tɕi]	‘to pull’
44	Tense	[tɕi]	‘queen ant’
55	Lax	[tɕi]	‘how many?’
35	Lax	[tɕi]	‘many’
31	Lax	[tɕi]	‘field’
42	Tense	[tɕi]	‘to chase’
21	Tense	[tɕi]	‘loan’
32	Lax	[tɕi]	‘arrow’

Allen & Allen (2003) recorded six speakers of Southern Bái – four from Xǐzhōu, one from Hǎidōng 海东, and another from Wānqiáo 湾桥 – producing several lexical items in isolation. The F_0 measurements for the tokens of the various tone categories in Allen & Allen (2003) suggest that productions of tones [31] and [32] have no observable acoustic differences. However, Allen & Allen (2003) also note that speakers indicate that they can hear and produce a difference between these categories despite this lack of measurable acoustic distinction. Additionally, discussion states that tone [21] is followed by breathiness and that tone [42] is a higher fall than typically indicated in most tone number system transcriptions. This work is discussed in further detail in section 6.4, which describes the production and perception of these eight tone categories by speakers of Southern Bái living in close proximity to the Ěrhǎi Lake.

2.4.3 Aspirated Fricatives in Bái

All varieties of Bái have a two-way contrast between voiced and voiceless fricatives. Some varieties, most notably the varieties spoken in Hèqìng, also contrast aspirated and non-aspirated fricatives. YÁNG Xiǎoxiá (2007) is an MA degree thesis on this contrast as found in Hèqìng, Nánhuá 南华, and Báishí 白石. This thesis serves two functions. The first is to verify the existence of this aspiration contrast through acoustic

measurements and spectrographic illustrations, as this contrast is not common in languages of the world (see Jacques 2011:1518). YÁNG Xiǎoxiá (2007) presents three spectrograms with annotations showing that the aspirated fricatives measured to include the aspirated portion are longer than their non-aspirated counterparts and proposes that the longer duration of the pre-vocalic aspirated fricative is determined by the height of the vowel (i.e. high vowels are predicted to yield shorter fricative durations as opposed to the durations yielded by low vowels). YÁNG Xiǎoxiá (2007) then shows that aspirated fricatives are limited to certain tone categories and lists correspondences for this class of consonants in other Tibeto-Burman languages. YÁNG Xiǎoxiá (2007) uses these correspondences to suggest that Bái was historically in contact with Tibetan and Qiangic but does not expand on this proposal.

2.4.4 Summary

These studies are crucial steps in bridging the gap between implied contrast in print and actual phonological contrast in natural speech. Furthermore, each of these studies examines phenomena that are uncommon cross-linguistically. Since the nature of these contrasts is open to interpretation without phonetic analysis, these works help clarify many important ambiguities. For instance, the typical terminology of 'tense-lax' would seem to have mplications for vowel height; however, in Bái this distinction is almost exclusively determined by the position of the larynx. The results of these studies are incorporated and expanded upon for my analysis of phonological contrast in Bái throughout the remainder of this dissertation.

2.5 Sociolinguistic Work on Bái

This section summarizes the implications of two studies about sociolinguistic variation in Bái. The first work, Allen (2004), is a survey of numerous varieties of Bái with the specific intention to single out the variety of Bái which is the easiest for other Bái communities to understand. The second work, Hefright (2011), is a Ph.D. thesis about language use in Jiànchuān County. Both of these works are the result of prolonged and targeted interactions with Bái communities and offer valuable insight on the changing nature of the Bái language.

2.5.1 Allen (2004)

Allen (2004) is the bilingual (English and Chinese) book-length culmination of a two-year collaborative project from 1999 and 2001 between the Yunnan Minority Language Commission (YMLC) and SIL International, East Asia Group. This collaborative project served many purposes, the primary of which was to inform language policy regarding the promotion of Bái within Yunnan province through conducting mutual intelligibility listening tests and collecting lexical data from several sites. This work surveys nine dialects – Yúnlóng 云龙, Ěryuán 洱源, Hèqìng, Jiànchuān, Lánpíng 兰坪, Zhōuchéng 周城, Qīlǐqiáo 七里桥, Xiángyún 祥云, and Luòběnzhuó 落本卓. The lexical and phonological inventory data from this work are included in my analysis of phonological contrast in Bái and are introduced in further detail in 3.2.

Allen (2004) includes glosses for 500 lexical items from each of these dialects. Lexical similarity percentages between these dialects are measured based on this set of lexical items, and the extent of mutual intelligibility is summarized as results of recorded

text tests. The relevant results of this work can be summarized as follows. The Luòběnzhuó variety is the most divergent from the other surveyed varieties. This result is not surprising as that variety is typically considered to be 'Northern Bái' and is outside of the core concentration of mainstream Bái communities. On the other hand, the results of the lexical similarity and mutual intelligibility tests suggest that the Ěryuán variety is generally the easiest for speakers of other varieties to understand. From the perspective of geography this makes sense, because Ěryuán is near the center of the mainstream Bái area; however, this variety holds no historic prestige.

2.5.2 Hefright (2011)

Hefright (2011) is Brook Hefright's Univerisity of Michigan Ph.D. thesis titled *Language contact as bilingual contrast among Bái language users in Jiànchuān County, China*. This work is the culmination of transcripts of spontaneous conversation, elicited narratives, and Bái texts in both romanization and Chinese characters as well as participant observation. The work primarily focuses on how language ideologies affect speakers' categorization of Bái and Chinese. For instance, although Bái can be written in Chinese characters, Bái language users generally categorize such texts as Chinese and not as Bái. There are many issues explored in this work in extensive detail, but the issue most relevant to this dissertation is the documentation of clear preference for Chinese among the youngest generation. As noted earlier, Jiànchuān has the highest concentration of Bái speakers in the entire area.

2.6 Summary and Context for Dissertation

This chapter presents an overview of the large body of work published on Bái. As I suggest in section 2.2, a large portion of the available work focuses on the historical

relationship between Bái and other Sino-Tibetan languages. Although descriptive works (reviewed in section 2.3) provide a large corpus of available sentence structures, word-formation patterns and lexical examples across several varieties of Bái, and targeted works (reviewed in sections 2.4-2.5) explore specific topics in detail, these works have not offered descriptive adequacy in phonological representation with regard to distinguishing well-formed syllables from systematic gaps. This dissertation intends to fill this substantial gap in the linguistic literature on Bái by comparing the attested phonological structures across varieties within a parameterized framework limiting overgeneration of illict forms. The first step of this process is tackled in the next chapter through comparison of phonological inventories in a unified format.

Chapter 3. Previous Phonological Descriptions of Bái

This chapter reviews the phonological descriptions of Bái varieties from the literature introduced in the previous chapter. As noted in the previous chapter my analysis is exclusively limited to varieties of "Mainstream Bái", that is, the varieties classified as 'Central Bái' and 'Southern Bái' in XÚ & ZHÀO (1984) or more recently as 'Western Bái' in Fēng WĀNG (2006). I have decided to focus on these varieties and exclude others for several reasons. First, the mainstream varieties have been demonstrated to form a coherent dialect continuum; conversely, the varieties outside of this mainstream core have been demonstrated to not belong to this dialect continuum. The results of the lexical similarity measurements and Recorded Text Tests (RTT) as reported in Allen (2004) indicate that the lexical similarity measurements across these varieties range from 74% to 91% and that the mean intelligibility figures across these varieties range from 29% to 99% and are typically above 50%. On the other hand, although lexical similarity between Luòběnzhuó and any of the other surveyed varieties ranges from 54% to 61%, speakers of other varieties could not answer any questions from the Luòběnzhuó RTT and Luòběnzhuó comprehension of RTT representative of other varieties ranged from 0% to 29%. Second, the data available for supporting my phonological arguments are rich and robust for the mainstream varieties. It is unclear if these same generalizations are maintained in other Bái varieties. Third, I maintain regular contact with native speakers of mainstream Bái and can resolve any ambiguities regarding the representation of phonological contrast in printed sources through targeted elicitation and discussion.

In this chapter I compare three formats of Bái phonological inventories from the literature with my own proposal. Each of the four formats makes two important theoretical assumptions. The first, and most important, is that the syllable is an authentic and necessary unit for phonological analysis (YĪ & DUĀNMÙ 2015). The second shared assumption is that the contrastive configurations of all possible syllables in a given language can be generated as vectors of one item from each of the three inventory categories: 'initial', 'final', and 'tone'. While most prior descriptions assume that segmental configurations are divided into sub-syllabic constituents 'initial' and 'final', my proposal embraces 'onset' and 'rime' constituencies. Although some researchers use these terms interchangeably, in 3.1.1 and 3.4 I show that the nature of these units differ considerably. I begin this chapter by characterizing these different formats in (6).

Fig. (6) Formats of Phonological Inventory Arrangement

	Initial/Onset	*Final/Rime*	*Example Syllable*
Format 1 (Typical Initial-Final)	Distinct palatals including [j]. **[Medium inventory]**	Nuclear segments and categories with pre-nuclear [i] and [u]. **[Large inventory]**	[tɕia] – Sino-Bái [tɕa] – Tibeto-Burman
Format 2 (Allen 2004)	Distinct palatals and pre-nuclear glides. **[Medium inventory]**	Nuclear segments and categories with pre-nuclear [i] and [u]. **[Large inventory]**	[tɕa]
Format 3 (Dell 1981)	Derived palatals, no pre-nuclear glides. **[Smallest inventory]**	Nuclear segments and categories with pre-nuclear [i], [u], [y]. **[Large inventory]**	/tsia/ → [tɕia]
Format 4 (Original Proposal)	Pre-nuclear glides and complex segments with pre-nuclear glides. **[Largest inventory]**	Exclusively nuclear segments and diphthongs decreasing in sonority. **[Smallest inventory]**	/ts_1 i_1 a_2/ → [tɕa]

These four formats differ primarily with regard to their treatment of pre-nuclear glides and secondarily with regard to their treatment of the palatal consonants

[tɕ, tɕ^{h}, ɕ, ɕ^{h}, ʑ]. The typical format of phonological inventory organization (format 1) offers inconsistent treatment for these glides. Glide [j] (or its non-contrastive fricativized variant [ʑ]) is redundantly included as an initial and as a final whereas other glides are appear as the leftmost segment in complex final categories (finals with two or more segments). Conversely, Allen (2004) (format 2) is consistent in that it includes pre-nuclear glides in both initial and final positions; however, despite consistency, I suggest that this format is uneconomical and makes inaccurate generalizations regarding the distribution of the palatal consonants. Dell (1981) (format 3), on the other hand, treats pre-nuclear glides exclusively as the leftmost constituents of complex finals. Furthermore, this work further does not distinguish palatals as a distinct class of initials but rather as allophones of the dental sibilants occurring before pre-nuclear [i] or [y]. My own proposal presented in this dissertation (format 4) is in line with Dell (1981) in that the palatals are derived from the dental sibilants, differing in so far that the palatals are treated as complex sounds combining dental sibilant consonants and pre-nuclear glides in the onset. The original format for Bái phonological inventories presented in 3.4 assumes large inventories of onsets and small inventories of rimes. Although the large inventories of onsets may seem excessive at first glace, I suggest in 3.5.4 that they are generated under economical conditions.

Discussion for the remainder of this chapter is presented as follows. Section 3.1 introduces the typical initial-final format of organizing phonological inventories with each of the phonological inventories from the relevant sources introduced in chapter 2. Section 3.2 introduces the phonological inventories from Allen (2004) and compares these inventories to the typical initial-final format. Section 3.3 discusses the nature of the

phonological description of Southern Bái from Dell (1981). Section 3.4 outlines the original proposal for Bái phonological inventory organization. Section 3.5 compares the economy of these four formats by tabulating the attested syllables as vectors of the two segmental inventory constituents. Section 3.6 summarizes this chapter.

3.1 Typical Initial-Final Descriptions

Most previous Bái phonological inventories are prepared in the "Initial-Final" model of syllable description. I place this term in quotation marks because this is my own coining of this framework. This framework is assumed in most Chinese-language descriptions of local languages and has a long history pre-dating, but later influenced by, Western linguistic description.

Discussion begins with a brief overview of this model in 3.1.1. Sub-section 3.1.2 introduces the inventories from XÚ & ZHÀO (1984). Sub-section 3.1.3 introduces the inventories from DUÀN Líng (2008a). Sub-section 3.1.4 introduces the inventories from Wiersma (1990),(2003). Sub-section 3.1.5 introduces the inventories from Fēng WĀNG (2006). Sub-section 3.1.6 introduces the inventory from ZHÀO Jīncān (2011). Sub-section 3.1.7 introduces the inventory from ZHÀO Yànzhēn (2012). Sub-section 3.1.8 introduces the inventory from LǏ Zhèngqīng (2014). Sub-section 3.1.9 tabulates the consistencies and inconsistencies between these inventories. Sub-section 3.1.10 summarizes the advantages and disadvantages of this format of phonological description.

3.1.1 Initial-Final Model of Syllable Description

The Initial-Final model of syllable description provides phonetic glosses for syllables based on two exemplar units – one 'initial' (*shēngmǔ* 声母) and one 'final'(*yùnmǔ* 韵母). Prior to the introduction of alphabetic writing systems (such as the

Latin alphabet), exemplar initials and finals took the form of Chinese characters. Some research suggests that this framework was developed to provide "correct" glosses for Chinese characters around the needs of poets so that they could compose work that employs rhyming, but the original motivation is not explicitly clear (Coblin 1996). The typical procedure of glossing of Chinese characters in this framework is known as *fǎnqiè* 反切. Perhaps the most commonly citied example illustrating how a Chinese character is glossed through this process is the Middle Chinese *tuwng*; a visual representation of this process, adapted from Baxter & Sagart (2014:10) is presented in (7).

Fig. (7) *Fǎnqiè* gloss for the character 東 *tuwng* 'east'

東	德	紅	反
X	**Y**	**Z**	**F**
Character X 東 **tuwng**	Character Y 德 **t**-ok	Character Z 紅 h-**uwng**	Character F 反
Combine initial of Y with final of Z	Gloss initial of X with initial of Y	Gloss final of X with final of Z	Apply *fǎnqiè* process

The character to be glossed corresponds to 'X'. The initial of character 'X' is represented by exemplar character 'Y'. Exemplar character 'Z' represents the final and should have the same tone of character 'X' (if the gloss is completely accurate). The character 'F' is the character 'turn' which tells the reader to apply the *fǎnqiè* process.

Modern linguistic descriptions in this framework both for Sinitic and non-Sinitic languages generally map initial and final categories to representations in segmental phonetic transcription. Furthermore, tone units are categorized separately from finals. However, the assumptions behind these representations differ from typical phonemic transcriptions in several ways. Two relevant differences are summarized here (modified

slightly from Branner (1997:243)). First, these sets need not exclude alternating phonetic forms. It is common for a set of initials or finals to list two or more items that do not yield minimal pairs or sets in contrastive environments. Second, these units are treated as whole categories not necessarily limited to individual segments. This is particularly obvious for sets of finals as these sets generally include members that combine a nuclear vowel with a pre-nuclear glide and/or a post-nuclear consonant. Let us consider the monosyllabic Zhàozhuāng Bái word for 'eight' <pia^{44}> as transcribed in ZHÀO Yànzhēn (2012). This syllable can be decomposed into initial <p>, final <ia>, and tone <^{44}> from the phonological inventory presented in ZHÀO Yànzhēn (2012).

Unlike contemporary Western phonological frameworks which try to provide principled reasons why certain phonological structures exist and other structures cannot be possible in the synchronic state for a given language (Carson-Berndesen 1998, Goldsmith & Laks 2010), phonological inventories presented in the Initial-Final format generally prioritize observational adequacy over descriptive adequacy. In brief, the primary goal is to provide enough information to transcribe for all observed syllables in a given language without accounting for principled gaps (descriptive adequacy). Such practice is perhaps a culmination of the *fǎnqiè* tradition for glossing Chinese characters and the introduction of phonetic transcription from Western missionary-scholars prior to the 20th century. Discussion for the remainder of this section introduces the Initial-Final phonological inventories of Bái from the sources introduced in the previous chapter.

3.1.2 XÚ & ZHÀO (1984)

As mentioned in 2.3.1, most Sino-Tibetanists acknowledge this work as the primary reference for Bái language data. This work focuses description of Bái around the

Jiànchuān dialect. The phonological description of Jiànchuān dialect is reproduced in (8) as a loose translation of the original contents with some reformatting for presentational ease. This description offers more detail than the typical inventory, but does not use rewrite rules to describe conditioned changes observed in initial and final categories. Furthermore, the inventories of Jiànchuān and Dàlǐ dialects as compared in this work (pp. 122-123) are summarized in (9).

Fig. (8) Jiànchuān Bái Phonological Inventory from XÚ & ZHÀO (1984)

(a) Initials: In entirety there are 21 initials; they are each single consonants

Manner / *Place*	*Stop, Affricate*		*Nasal*	*Fricative*		*Lateral*
	Unaspirated	*Aspirated*		*Voiceless*	*Voiced*	
Bilabial	[p]	[ph]	[m]			
Labiodental				[f]	[v]	
Dental	[t]	[th]	[n]			[l]
	[ts]	[tsh]		[s]		
Palatal	[tɕ]	[tɕh]		[ɕ]	[j]	
Velar	[k]	[kh]	[ŋ]	[x]	[ɣ]	

Initial Exemplars

p	paɬ	‘big bowl’, ‘to pour’	ph	phaɬ	‘to pick, to hold up’
m	maɬ	‘rice paddy’	f	fa˥	‘to prosper’
v	vaʌ	‘a pronoun’	t	taɬ	‘to be the same’
th	thaɬ	‘cover’	n	naɬ	‘to sew’
l	laɬ	‘to yell, curse’	ts	tsaɬ	‘plan’
tsh	tshaɬ	‘virtue, rite’	s	saɬ	‘to forget’
tɕ	tɕaɬ	‘to receive’	tɕh	tɕhaɬ	‘to stick’
ɕ	ɕaɬ	‘neck hair of horse’	j	jaɬ	‘to return’
k	kaɬ	‘warehouse’	kh	khaɬ	‘to cover’
ŋ	ŋaɬ	‘to bite’	x	xaɬ	‘stewed’
ɣ	ɣaʌ	‘to gather’			

(b) Finals: There are eight monophthongs – [i], [e], [ɛ], [ɑ], [o], [u], [ɯ], [ɣ]. Furthermore, these monophthongs can be combined to form the diphthongs – [ɑo], [iɛ], [iɑ], [io], [iɯ], [ui], [uɛ], [uɑ]. Also, these monophthongs and diphthongs have a similar set of nasalized counterparts – [ĩ], [ẽ], [ɛ̃], [ɑ̃], [õ], [ũ], [ɣ̃], [iɛ̃], [iɑ̃], [iõ], [iũ], [uĩ], [uɛ̃], [uɑ̃]; altogether, there are 30 finals (of these finals [ɑo] is specially used to transliterate loanwords from Modern Chinese, Bái does not have contrastive nasalization for the finals [u] and [ɑo].

Final Exemplars

i	pi˥	‘left’	ĩ	pĩ˥	‘salt’
e	pe˩	‘to walk’	ẽ	pẽ˧	‘dinner’
ɛ	pɛ˩	‘one hundred’	ɛ̃	pɛ̃˧	‘to support’
ɑ	pɑ˩	‘big bowl’	ɑ̃	pɑ̃˥	‘container for grains’
o	po˩	‘uncle’	õ	põ˧	‘to repay’
u	pu˩	‘apply lacquer’			
ɯ	pɯ˩	‘a set’	ũ	pũ˥	‘instance’
ɣ	tɣ˩	‘crooked’	ɣ̃	tɣ̃˩	‘cave’
ɑo	kɑo˧	‘to write up’			
iɛ	piɛ˩	‘to ask’	iɛ̃	piɛ̃˧	‘to slap a face’
iɑ	piɑ˧	‘to bite’	iɑ̃	piɑ̃˧	‘to nibble’
io	pio˧	‘to not be’	iõ	piõ˥	‘to spill intentionally’
iɯ	phiɯ˥	‘to lose’	iũ	phiũ˥	‘to cover, hide’ (loan)
ui	kui˧	‘to return’	uĩ	kuĩ˧	‘not see’
uɛ	kuɛ˧	‘to be broken’	uɛ̃	kuɛ̃˧	‘horizontal’
uɑ	kuɑ˧	‘stick’	uɑ̃	kuɑ̃˧	‘tube’

- When the vowel /i/ appears after the dentals [ts], [tsh], [s], the pronunciation is that of the apical vowel [ɿ]. For example, [tsi^{33}] ‘street’ is pronounced [tsɿ], [tshi^{33}] ‘stick out (tounge)’ is pronounced [tshɿ], [si^{33}] ‘hemp’ is pronounced [sɿ].
- The vowel [ɛ] is pronounced as [a] with the “tense” tones 44, 42, 21; with the other tones, this vowel is pronounced as [ɛ]. Examples include: [kɛ^{44}] ‘grasp’ pronounced as [ka^{44}], [kɛ^{42}] ‘to pinch’ pronounced as [ka^{42}], [kɛ^{21}] ‘meat’ pronounced as [ka^{21}], [kɛ^{55}] ‘to plant’ pronounced as [kɛ^{55}], [kɛ^{31}] ‘to hinder’ pronounced as [kɛ^{31}].
- When the velar nasal [ŋ] combines with labiodental [ɣ], the actual sound is [ɱ]. For example, [ŋɣ^{55}] ‘fish’ is pronounced [ɱ^{55}], [ŋɣ^{33}] ‘tail’ is pronounced [ɱ̩^{33}].
- The vowels after the consonants [m], [n], [ŋ] are all lightly nasalized.
- The velar fricative [x] is pronounced as the glottal fricative [h] before nasalized vowels. For instance, [xẽ^{55}] ‘sky’ is pronounced [hẽ^{55}], [xẽ^{55}] ‘soup’ is pronounced [hẽ^{55}], [xũ^{33}] ‘completion particle’ is pronounced [hũ^{33}].
- The vowel o is pronounced [ɔ] in syllables with the 21 tone contour; such as [lo^{21}] ‘tiger’ pronounced as [lɔ^{21}], [ko^{21}] ‘lake’ pronounced as [kɔ^{21}]. In syllables with the other tonal categories, the pronunciation is [ou]. For instance, [lo^{31}] ‘retreat’ is

pronounced as [lou^{31}], [lo^{55}] ‘asparagus leaf’ is pronounced as [lou^{55}], [ko^{44}] ‘to plant’ is pronounced as [kou^{44}].

(c) Tones: In entirety there are eight tones, as presented in the table below:

Tone Name	*Contour*	*Chao Letters*	*Tense-Lax*	*Exemplars*	
1	33	˧	Lax	pɑ ˧ ‘lather’	tɕi ˧ ‘to pull’
2	42	˧˥	Tense	pɑ ˧˥ ‘milk’	tɕi ˧˥ ‘to pursue’
3	31	˨˩	Lax	pɑ ˨˩ ‘noisy’	tɕi ˨˩ ‘field’
4	55	˥	Lax	phɑ ˥ ‘to pluck’	tɕi ˥ ‘many’
5	35	˧˩	Lax	pɑ ˧˩ ‘elder bird’	tɕi ˧˩ ‘immediate’
6	44	˦	Tense	pɑ ˦ ‘to pour’	tɕĩ ˦ ‘queen ant’
7	21	˩	Tense	pɑ̃ ˩ ‘hoof’	tɕi ˩ ‘debt’
8	55	˥	Tense	pɑ ˥ ‘embankment’	tɕi ˥ ‘to send’

Although not explicitly stated in XÚ & ZHÀO (1984), it can be assumed that each item in a given category is considered to represent a contrastive unit since the selected exemplars represent sets that are near-minimal contrasts. The primary differences between the transcription of consonants in (8a) and standard IPA transcription are as follows. First, the palatals are transcribed as [tɕ, tɕh, ɕ]. Palatal place is indicated by the “right-to-left curly tail” in the Chinese tradition of phonetic transcription; for instance, nasal palatals are typically transcribed as [ɳ̩] and not [ɲ]. Interestingly, the initials in (8a) list [j] as a voiced fricative, but several other sources transcribe this sound as [ʑ]. Furthermore, aspiration is represented with a lowercase <h> instead of a superscript <^{h}> or an apostrophe <’> as in some later works. I mention two points regarding the inventory of finals in (8b). First, the information after the final exemplars resembles descriptions of allophonic variants. Second, these descriptions state that the apical vowel [ɿ] is non-contrastive with [i] appearing after sibilants; other initial-final descriptions agree with this generalization and either directly state or imply this

distribution. The phonetic symbol [ɻ] is not included in the IPA, but can be understood as a fricative vowel. Accordingly, some phonological descriptions of related languages including various Chinese dialects (Chao 1934), the Sǎní 撒尼 variety of Yí (Ma 1951), and Standard Chinese (Duanmu 2007) treat this sound as a syllabic fricative [ʐ̩]. I assume the syllabic [ʐ̩] view for Bái in 3.5.4, but since the intention of this section is to show the shortcomings of prior work I do not reinterpret apical vowels from these descriptions.

The tone categories (first column on the left in (8c)) are presented with numbers representing contours (second column from the left in (8c)), Chao letters (third column from the left in (8c)), characterization of "tense" or "lax" (fourth column from the left in 3c) as introduced in 2.4.1, and exemplars of near minimal contrasts for syllables [pɑ] and [tɕi] in the right two columns in 3c. The principle behind the number system for describing tone contours and Chao letters is that there are five levels by which the normal vocal range expresses contrastive pitch in tone (Chao 1930). The numbers 1-5 represent this range of pitch such that '1' is the lowest and '5' is the highest with the numbers in between representing intermediate levels of pitch. Similarly, the Chao letters represent this range visually. The five level pitches, from lowest to highest, are: '˩', '˨', '˧' '˦', and '˥'. Additionally, a tone category is typically transcribed with two of these units to indicate a change in pitch over time. For instance, a rising tone can be indicated with a pair of numbers with the first being lower than the second (as in tone 8 from (8c)). On the other hand, when the corresponding Chao letters are used to transcribe a rise, the left portion of the contour begins lower than the right portion: '˧˥'. However the two systems differ with regard to representation of level tones; level tones of duration similar to contour tones are represented with two of the same number whereas a single level Chao

letter represents both short and long duration pitches. In XÚ & ZHÀO (1984), modal or 'lax' phonation is represented with the benchmark (solid vertical line ' | ') on the right where as 'tense' phonation is represented with benchmark on the left.

XÚ & ZHÀO (1984:122-123) summarizes the phonological inventory differences between Jiànchuān Bái and Xǐzhōu Bái, the representative varieties of Central Bái and Southern Bái. I reproduce their summary with several adaptations for simplicity in explanation as follows in (9).

Fig. (9) Bái Phonological Inventories from XÚ & ZHÀO (1984)

(a) Initials:

Jiànchuān	*Xǐzhōu*
p, p^h, m, f, v, t, t^h, n, l, ts, ts^h, s, tɕ, $tɕ^h$, ɳ, ɛ, j, k, k^h, ŋ, x, ɣ	p, p^h, m, f, v, t, t^h, n, l, ts, ts^h, s, z, tɕ, $tɕ^h$, ɛ, j, k, k^h, ŋ, x, ɣ
[21]	[22]

(b) Finals:

Jiànchuān	*Xǐzhōu*
i, e, ɛ, ɑ, ɑo, o, u, ɣ, ɯ, ĩ, ẽ, ɛ̃, ɑ̃, õ, ṽ, ɯ̃, iɛ, iɑ, io, iɯ, ui, uɛ, uɑ, iɛ̃, iɑ̃, iõ, iɯ̃, uĩ, uɛ̃, uɑ̃	i, e, $e^ɪ$, ɑ, o, ou, u, ɣ, ɯ, ie, $ie^ɪ$, iɑ, io, iɯ, ui, ue, $ue^ɪ$, uɑ, uo
[30]	[19]

(b) Tones:

Jiànchuān	*Xǐzhōu*
33, <u>42</u>, 31, <u>55</u>, 55, 35, <u>44</u>, <u>21</u>	33, <u>42</u>, 31, 55, 35, <u>44</u>, <u>21</u>, 32
[8]	[8]

The initials in (9a) are arranged in the order that they appear in the original source modified with aspiration indicated by superscript <^{h}> for consistency with the other sources in this review. The inventories are similar with the addition of [z] in the Xǐzhōu dialect. The finals in (9b) are arranged in nearly the same order as they appear in the charts on page 122 with two exceptions. First, the main vowels are arranged from left-to-

right in loose cardinal ordering from high-front to low-central to high-back. Second, the rhotic vowel and diphthongs decreasing in sonority are not considered to be complex finals as originally categorized. Finally, the tones in (9c) are arranged in the same order with the tense categories appearing with underlines and the lax categories appearing unmarked.

3.1.3 DUÀN Líng (2008a)

DUÀN Líng (2008a) introduces ten varieties of Bái providing phonological inventories for each variety and a glossary of lexical items from four of these varieties. I reproduce the inventories of varieties of interest in this section with the adjustments for consistency mentioned in the last sub-section. The inventories for the varieties that are typically considered Central Bái varieties are reproduced in (10) and the inventories for the varieties that are typically considered to be Southern Bái varieties are reproduced in (11).

Fig. (10) Central Bái Phonological Inventories from DUÀN Líng (2008a)

(a) Initials:

Jiànchuān	*Hèqìng*	*Xiàyángcén*
p, p^{h}, m, f, v, t, t^{h}, n, l, ts, ts^{h}, s, tɕ, tɕ^{h}, ɕ, j, k, k^{h}, ŋ, x, ɣ, ʔ [22]	p, p^{h}, m, f, f^{h}, v, t, t^{h}, n, l, ts, ts^{h}, s, s^{h}, z, tɕ, tɕ^{h}, ɕ, ɕ^{h}, j, k, k^{h}, ŋ, x, x^{h}, ɣ, ʔ [26]	p, p^{h}, m, f, f^{h}, v, t, t^{h}, n, l, ts, ts^{h}, s, s^{h}, z, tʃ, tʃ^{h}, ʃ, ʃ^{h}, ʒ, tɕ, tɕ^{h}, ŋ, ɕ, ɕ^{h}, ʑ, k, k^{h}, ŋ, x, x^{h}, ɣ, ʔ [33]

(b) Finals:

Jiànchuān	*Hèqìng*	*Xiàyángcén*
i, y, e, ɛ, a, ɒ, o, ou, u, ɣ, ɯ, ie, iɛ, ia, io, iɯ, ui, uɛ, ua, yi ĩ, ỹ, ẽ, ɛ̃, ã, õ, õu, ũ, ỹ, ɯ̃, iɛ̃, iã, iõ, iɯ̃, uĩ, uɛ̃, uã, yɛ̃ [38]	i, y, e, ɛ, a, ɔ, ɔu, o, ou, u, ɣ, ɯ, ie, iɛ, ia, iɔ, iɯ, ui, uɛ, ua, uɔ, yi, ĩ, ỹ, ẽ, ɛ̃, ã, õ, õu, ũ, ỹ, ɯ̃, iẽ, iɛ̃, iã, iɯ̃, uĩ, uɛ̃, uã, uɔ̃, yẽ [42]	i, y, e, ɛ, a, o, u, ɣ, ɯ, iɛ, ia, io, iɯ, ui, uɛ, ua, ye, ỹ, uã [20]

(c) Tones:

Jiànchuān / *Hèqìng* / *Xiàyángcén*
33, 42, 31, 55, 55, 35, 44, 21 [8]

Fig. (11) Southern Bái Phonological Inventories from DUÀN Líng (2008a)

(a) Initials:

Zhōuchéng	*Qīlǐqiáo*	*Xiángyún*
p, p^h, m, f, v, t, t^h, n, l, ts, ts^h, s, z, tɕ, $tɕ^h$, ŋ̊, ɕ, j, k, k^h, ŋ, x, ɣ, ʔ [24]	p, p^h, m, f, v, t, t^h, n, l, ts, ts^h, s, z, tʃ, $tʃ^h$, ʃ, ʒ, tɕ, $tɕ^h$, ŋ̊, ɕ, j, k, k^h, ŋ, x, ɣ, ʔ [27]	p, p^h, m, f, v, t, t^h, n, l, ts, ts^h, s, z, tɕ, $tɕ^h$, ŋ̊, ɕ, j, k, k^h, ŋ, x, ɣ, ʔ [24]

(b) Finals:

Zhōuchéng	*Qīlǐqiáo*	*Xiángyún*
i, y, e, ɛ, a, ɔ, o, ou, u, ɣ, ɯ, ie, iɛ, ia, iɔ, iɯ, ui, uɛ, ua, uɔ, ye, ɣ̃ [22]	i, y, e, ɛ, a, ɔ, o, u, ɣ, ɯ, ie, iɛ, ia, iɔ, iɯ, ui, uɛ, ua, uɔ, yɛ, ɣ̃ [21]	i, y, e, ɛ, a, ɔ, ɔu, o, u, ɣ, ɯ, iɛ, ia, iɔ, io, iɯ, ui, uɛ, ua, uɔ, yɛ, ĩ, ỹ, ẽ, ɛ̃, ã, õ, õu, ɣ̃, ɯ̃, iɛ̃, iã, iõ, iɯ̃, uĩ, uɛ̃, uã, yɛ̃ [38]

(c) Tones:

Zhōuchéng / *Qīlǐqiáo*	*Xiángyún*
33, 42, 31, 55, 35, 44, 21, 32 [8]	33, 42, 31, 55, 35, 44, 21 [7]

This work treats these varieties as part of a dialect continuum. Prior to providing the reader with the phonological inventories, discussion begins with an introduction of the complete system of available initials, finals, and tones across the surveyed Bái varieties. The relevant information regarding non-contrastive variation for the items in these inventories is summarized as follows. First, initial [j] becomes voiced fricative [ʑ] in lax tone syllables. Second, final [i] becomes [ɿ] after dental sibilants. Third, tone [35] is specified as neither tense nor lax.

3.1.4 Wiersma (1990), (2003)

The work on Bái by Grace Wiersma includes a phonological description of Jiànchuān Bái differing minimally from description of the same dialect in XÚ & ZHÀO (1984). The inventory of the initials also includes 22 items, augmented with the addition of the zero-initial [ø]. The inventory of the finals is augmented to 31 items with the addition of the [iɑo] complex final category. The tones are the same except that the tense [55] tone is transcribed as [66], indicating "super high" as in Edmondson et al. (2001). The complete phonological inventory is reproduced in (12) for uniformity with the other sub-sections.

Fig. (12) Jiànchuān Phonological Inventory from Wiersma (1990), (2003)

(a) Initials [22]

p, p^h, m, f, v, t, t^h, n, l, ts, ts^h, s, tɕ, $tɕ^h$, ɕ, j, k, k^h, ŋ, x, ɣ, ø

(b) Finals [31]

i, e, ɛ, ɑ, ɑo, o, u, ɣ, ɯ, iɛ, iɑ, iɑo, io, iɯ, ui, uɛ, uɑ,
ĩ, ẽ, ɛ̃, ɑ̃, õ, ṽ, ɯ̃, iɛ̃, iɑ̃, iõ, iɯ̃, uĩ, uɛ̃, uɑ̃

(c) Tones [8]

33, 42, 31, 66, 55, 35, 44, 21

3.1.5 Fēng WĀNG (2006)

The primary intention of this monograph is to offer an account of the nature of the relationship between Proto-Bái and Old Chinese. The reconstruction of Proto-Bái is based on data from nine varieties, three of which – Jīnxīng (Jiànchuān), Dàshí (Hèqìng), and Zhōuchéng – can be considered "mainstream" Bái. The phonological inventories of these three dialects are provided in (13). Prior to presentation of the phonological inventories, Fēng WĀNG (2006:32) provides a general description of the common Bái

phonological system. In brief, the two noteworthy differences between this work and others can be understood as follows. First, pre-nuclear [j] is transcribed as [-i-] between a consonant and a vowel. Furthermore, all palatal initials must be followed by [-i-]. I return to the relevance of this statement in 3.6. Second, nasal consonants [n] or [ŋ] can appear in coda position. This is the only reference for mainstream Bái dialects I am aware of which transcribes final categories including both nasalized vowels and vowels followed by nasal codas. My own personal limited elicitation with a native speaker of Hèqìng Bái suggests that the coda constrictions described in Fēng WĀNG (2006) are produced but do not contrast with nasalized nuclear vowels. On the other hand, there are considerable disparities between the phonological inventories and lexical items in Fēng WĀNG (2006:40-43); I address these disparities in 3.1.9. Nevertheless, the data and descriptions of the phonological categories are relevant to the composite analysis of phonological contrast in Bái.

Fig. (13) Phonological Inventories of "Mainstream Bái" from Fēng WĀNG (2006)

(a) Initials:

Jīnxīng (Jiànchuān)	*Dàshí (Hèqìng)*	*Zhōuchéng*
p, p^h, m, f, v, t, t^h, n, l, ts, ts^h, s, tɕ, $tɕ^h$, ɕ, j, k, k^h, ŋ, x, ɣ, ʔ, ø [23]	p, p^h, m, f, v, t, t^h, n, l, ts, ts^h, s, s^h, z, tɕ, $tɕ^h$, ɕ, $ɕ^h$, j, tʂ, $tʂ^h$, ʂ, $ʂ^h$, ʐ, k, k^h, ŋ, x, ɣ, ø [30]	p, p^h, m, f, v, t, t^h, n, l, ts, ts^h, s, z, tɕ, $tɕ^h$, ɕ, j, k, k^h, ŋ, x, ɣ, ʔ, ø [24]

(b) Finals:

Jīnxīng (Jiànchuān)	*Dàshí (Hèqìng)*	*Zhōuchéng*
i, e, ɛ, a, ɑ, o, ou, u, ɣ, ɯ, yi iɑ, io, iɯ, iu, iou, ue, uɑ, uo ĩ, ẽ, ɑ̃, õ, ɣ̃, en, ien, iã, ian, iõ, iɯ̃, uĩ, uẽ, uen, uɛ̃, uɑ̃, uɑn, yɛ̃ [31]	i, e, a, ai, ɚ, o, ou, u, ɣ, ɯ, yi ia, iɚ, iou, ue, uo, ẽ, en, an, ã, õ, ɚ̃, ɣ̃, iẽ, ien, iã, ian, iõ, iɚ̃, uẽ, uen, uɑ̃, uɑn [33]	i, y, e, ɛ, a, o, ou, u, ɣ, ɯ, iɛ, ia, io, iou, iɯ, ui, uɛ, ua, yi, yɛ, ya [21]

(c) Tones:

Jīnxīng (Jiànchuān)		*Dàshí (Hèqìng)*		*Zhōuchéng*	
Modal	Non-Modal	Modal	Non-Modal	Modal	Non-Modal
55	66 [tense]	55		55	
33	44 [tense]	33	44 [tense]	33	44 [tense]
31	42 [laryn]	31	42 [laryn]	31	42 [laryn]
35	21 [harsh]	35	21 [harsh]	35	21 [breath]

The inventories include descriptive information on the phonological categories as well as a brief biography of the language consultant. The only noteworthy information presented with these inventories is specified for the Dàshí variety. In the Dàshí variety, the palatals are described as "in the variation stage" and can be transcribed as [ts^{j}, ts^{hj}, s^{j}, s^{hj}]. In brief, Fēng WĀNG (2006:41) is making the assumption that the palatals are the consequence of diachronic change from a stage where the palatals were palatalized dental sibilants. Although the description from Fēng WĀNG (2006) does not explicitly address this change in a clear and thorough manner, I believe that this kind of evidence is particularly important for my analysis of the distribution of the palatals and dental sibilants in this language.

3.1.6 ZHÀO Jīncān (2011)

The phonology section of this reference grammar (ZHÀO Jīncān 2011:34-40) of the Kāngfú variety of Hèqìng Bái is rather short, but provides the usual inventories of the initials, finals, and tones along with a complete syllable inventory. The complete phonological inventory is reproduced in (14).

Fig. (14) Phonological Inventory of Kāngfú Bái from ZHÀO Jīncān (2011)

(a) Initials [26]

p, p^{h}, m, f, f^{h}, v, t, t^{h}, n, l, ts, ts^{h}, s, s^{h}, z, tɕ, $tɕ^{h}$, ɕ, $ɕ^{h}$, j, k, k^{h}, ŋ, x, x^{h}, ɣ

(b) Finals [31]

i, ĩ, e, ẽ, æ, æ̃, ər, ə̃r, a, ã, au, ãu, o, õ, ɯ, ɯ̃, u, ũ, y, ỹ,
ia, iæ, iər, iau, ue, uæ, uər, ua, uo,
iã, iæ̃, iə̃r, iãu, iɯ̃, uæ̃, uə̃r, uã, uõ

(x) Tones [8]

33, 42, 31, 55, 55, 35, 44, 21

ZHÀO Jīncān (2011:34-40) provides some additional information about the inventories and relevant information is summarized in this paragraph. Like several other inventories, the apical vowel [ɿ] is treated as a non-contrastive variant of [i]. The vowel [ər] is described as a vowel in which the tongue "is placed in a position similar to what is necessary to produce a rhotic sound, but the r-coloring is not realized". The front vowels [e] and [y] are described with diphthong character [e^{i}] and [y^{i}] respectively. Although this phonetic characterization is not directly stated for many phonological inventories of Bái, I point out the diphthong characterization for these vowels because the impressionistic description is applicable to these vowels in many varieties of Bái I have observed first-hand.

3.1.7 ZHÀO Yànzhēn (2012)

The variety of Bái described in this work is the native variety of the author who was born and raised in Xīyáo village in Xiàguān, Dàlǐ. I refer to this variety as Zhàozhuāng Bái throughout this dissertation because this nomenclature is the Chinese pronunciation of the native Bái place name for this community. I have worked extensively with ZHÀO Yànzhēn and traveled to this community numerous times. The basis for my findings regarding the variation observed in the rime systems across Bái varieties stems from my regular interaction with the author, her work, and members of

her community. The complete phonological inventory from this reference (ZHÀO Yànzhēn 2012:19-21) is presented in (15).

(15) Phonological Inventory of Zhàozhuāng Bái from ZHÀO Yànzhēn (2012)

(a) Initials [23]

p, p^h, m, f, v, t, t^h, n, l, ts, ts^h, s, z, tɕ, $tɕ^h$, ɳ, ɕ, ʑ, k, k^h, ŋ, x, ɣ

(b) Finals [20]

ɿ, i, e, ɛ, a, ɔ, o, u, y, ɯ, ʌ, iɛ, ia, iɔ, io, iɯ, ui, uɛ, ua, uo

(c) Tones [6]

33, <u>42</u>, 55, 35, <u>44</u>, <u>21</u>

Noteworthy characteristics of the phonological inventory of Zhàozhuāng Bái can be summarized as follows. First, although ZHÀO Yànzhēn (2012:20) includes the apical vowel [ɿ] as a separate final, she states that it does not contrast with [i] and transcribes this sound with [i] for the examples used in the text. Second, the tonal inventory for this variety of Bái includes only six contrastive tones. Descriptions of nearby dialects typically include tones [31] and [32] as well. Third, the final [ʮ] is transcribed as [ʯ] (rounded apical vowel) after palatal initials. Fourth, the finals [e] and [o] are described as diphthongs [e^i] and [o^u], respectively.

<u>3.1.8 LǏ Zhèngqīng (2014)</u>

As mentioned in 2.3.8 this work represents the Xǐzhōu variety of Bái. There are some discrepancies between the items in the visual tables of the inventories for each category (LǏ Zhèngqīng 2014:38-45) and their characterizations in the relevant descriptions of these items . The corrected phonological inventory for this variety based

on the original lists, descriptions, and correspondences with other available inventories of Xǐzhōu introduced in this chapter is presented in (16).

Fig. (16) Phonological Inventory of Xǐzhōu Bái from LǏ Zhèngqīng (2014)

(a) Initials [21]

p, p^h, m, f, v, t, t^h, n, l, ts, ts^h, s, z, tɕ, $tɕ^h$, ɕ, j, k, k^h, ŋ, x

(b) Finals [21]

ɿ, i, ɛ, ə, ɑ, ɑo, o, ou, u, y, ɯ, v, iɛ, iə, iɑ, iɑo, iou, iɯ, uɛ, uə, uɑ

(c) Tones [7]

33, 42, 55, 35, 44, 21, 32

The phonological inventory in (11) differs from others in the following noteworthy respects. First, the inventory of initials lacks the voiced velar fricative [ɣ]. This initial is marginal in many varieties of Bái, particularly those around the Ěrhǎi Lake, only occurring before back vowels [ɯ] or [ə] (ZHÀO Yànzhēn 2005). Accordingly, the initial [ɣ] in other varieties corresponds to [j] (ex. [ɣɯ^{44}] as opposed to [jɯ^{44}] for 'to eat') throughout the glossary portion of LǏ Zhèngqīng (2014). Second, the vowel [ɛ] in this variety corresponds to [e] in most other descriptions. Third, the vowel [ə] corresponds to either [ɛ] or [e^{ɪ}] in other descriptions.

3.1.9 Summary of Initial-Final Descriptions

The primary characteristic of the phonological inventory format presented in this section is the asymmetrical treatment of the pre-nuclear glides. In brief, glide [j] is both an initial and the medial glide of complex finals whereas pre-nuclear [u] (and sometimes [y]) is treated consistently as the medial glide of complex finals. The origin of this methodological decision in contrastive transcription is not entirely clear; however I offer

two considerations. The first is the treatment of nuclear [y] as derived from combinations of palatal initials [tɕ, tɕ^{h}, ɕ, j] and final [ui]. The second is based on the typical decision made in descriptions of the phonological systems of modern Chinese varieties which requires treating palatals and dental sibilants as contrastive in order to treat the apical vowel [ɿ] as a variant of /i/. Note that these considerations are not necessarily mutually exclusive.

Discussion begins with the theory of the derived nuclear [y]. The Jiànchuān inventories from XÚ & ZHÀO (1984) and Wiersma (1990), (2003) all lack this nuclear vowel, whereas other descriptions of Jiànchuān Bái include it. Final [ui] can combine with both the dental sibilants [ts, ts^{h}, s] and palatal initials [tɕ, tɕ^{h}, ɕ, j] in these descriptions, but not in any other descriptions I have examined. Of these two consonant classes, only the dental sibilants can occur with the final [ui] in Zhàozhuāng Bái. On the other hand, these combinations are attested in Kāngfú Bái but ZHÀO Jīncān (2011) notes that medial [u] becomes [y] after the palatals. Furthermore, the lexical items transcribed along the aforementioned conventions in XÚ & ZHÀO (1984) and Wiersma (1990), (2003) correspond to lexical items with nuclear [y] in other descriptions (ex. the word ‘water ’ in Jiànchuān Bái is transcribed as [ɕui^{33}] in XÚ & ZHÀO (1984), but as [ɕyi^{33}] in Fēng WĀNG (2006) and [ɕy^{33}] in Allen (2004). An odd characteristic of nuclear [y] for many speakers of Bái is that the rounding seems to end before the vowel production is complete, this is perhaps the reason why some inventories include finals such as [yi] or [ye]. Additionally, the decision for transcribing [y] as [jui] in XÚ & ZHÀO 1984 may also be in part related to their proposed Bái romanization using <y> for [j]. Above all other concerns, the fact that XÚ & ZHÀO (1984) in particular is seen as a reference or

standard for describing Bái may have inclined other researchers to include [j] as both an initial and medial for complex finals.

The other consideration regarding the glide asymmetry comes from practices observed in the descriptions of modern Chinese varieties. Although Initial-Final phonological systems are sufficient for contrasting all possible syllables, the motivation behind any given inventory is often left ambiguous. For instance, it is unclear if the goal is to list surface forms of the attested initials and finals for a given language, to present all the phonemic initials and finals, or even to present initials and finals to account for rhyming patterns in that language. As a consequence, there can be multiple analyses for the phonemics of a phonological inventory presented in the Initial-Final model; this ambiguity has been referred to as "the non-uniqueness of phonemic solutions of phonetic systems" (Chao 1934, YĪ & DUĀNMÙ 2015).

Non-uniqueness in Standard Chinese has been most explored with regard to the phonemic status of the palatals [tɕ, tɕ^{h}, ɕ]. In that language the three palatals [tɕ, tɕ^{h}, ɕ] are in complementary distribution with the velars [k, k^{h}, x], the dentals [ts, ts^{h}, s], and the retroflexes [tʂ, tʂ^{h}, ʂ] (DUĀNMÙ 2007, Lu 2014). The palatals occur before the high front vowels [i] and [y] and their glide counterparts [j] and [ɥ], respectively. On the other hand, while the velars, dentals, and retroflexes are in contrastive distribution with one another, they never occur before the high front vowels [i] and [y] and their glide counterparts. This distribution has led to several different phonemic analyses of the palatals in Standard Chinese. A table presenting a summary of the solutions and the rationales behind those solutions from Lu (2014:45) is presented in (17).

Fig. (17) Possible Analyses of Palatals in Standard Chinese

Analysis	*Rationale*
(a) Surface palatals derived from underlying velars or dentals /k, k^h, x/ /ts, ts^h, s/ → [tɕ, $tɕ^h$, ɕ] e.g., Cheng (1968)	Etymological relationships from Middle Chinese
(b) Surface palatals derived from underlying velars /k, k^h, x/ → [tɕ, $tɕ^h$, ɕ] e.g., Chao (1934), Xue (1986), Lin (1989), Chiang (1992), Wu (1994)	Word games; Onomatopoeia; Historical residue
(c) Surface palatals derived from underlying dentals /ts, ts^h, s/ → [tɕ, $tɕ^h$, ɕ] e.g., Hartman (1944), Duanmu (2007)	Surface realization of consonant-glide combinations
(d) Surface palatals derived from underlying palatals /tɕ, $tɕ^h$, ɕ/ → [tɕ, $tɕ^h$, ɕ] e.g., Tung (1954), Cheng (1973), Yip (1996)	Limited role of economy; Richness of the base

Interestingly, the phonemic status of the palatals in Bái is subject to this exact same problem. Dell (1981) assumes analysis (17c), but nearly all other descriptions either tacitly assume or directly treat the palatals along the lines of analysis (17d). Although some descriptions transcribe palatals and nuclear glides before a nuclear vowel (ex. [tɕia] 'to receive'), most descriptions do not follow this convention (ex. [tɕa] 'to receive') thereby making the limited phonological environment of the palatals appear to be less limited. Furthermore, the majority of descriptions assume that the palatals and dental sibilants need to be contrastive to condition the allophonic variation of the high front vowel [i] and the apical vowel [ɿ]. Consequently, it is not possible for the phonological system to simultaneously treat the apical vowel [ɿ] as an allophone of [i] conditioned by a re-write rule such as [i] → [ɿ]/ $C_{[\text{dental sibilant}]}$_# and treat the palatals as allophones of the dental sibilants conditioned by a re-write rule such as $C_{[\text{dental sibilant}]} \rightarrow C_{[\text{palatal}]}$ / #_i. Throughout this dissertation I argue that Bái phonology requires analysis (17c), but my proposal differs considerably from Dell (1981) in that the fricative features spread from

onset to rime, whereas Dell (1981) assumes that the apical vowel [ɿ] is in allophonic distribution with the high back unrounded vowel [ɯ].

Tangentially related to the issues presented in (17) is the perceived frication on initial [j]~[ʑ] and the perceived lack of frication on pre-medial [u] described for the same phonological inventory. Although this might seem like convincing evidence that these two classes of glides need asymmetrical treatment, I argue otherwise. The fact that no inventory includes both initial [j] and initial [ʑ] suggests that these two sounds are free variants. Accordingly, the frication does not need to be specified as phonemically contrastive in terms of distinctive features. Second, the fricative variant is described as conditioned by lax tones in DUÀN Líng (2008a). Third, this frication is much weaker than the frication of initial [v] or any other fricative initial and is often not observable in spectral samples. In brief, the weak and non-contrastive nature of frication in [ʑ] does not justify asymmetrical treatment of pre-nuclear glides in analysis of phonemic contrast.

Although the asymmetrical treatment of glides is the primary characteristic shared by each of the inventories reviewed in this chapter, there are both minor transcriptional differences (such as selecting either [a] or [ɑ] for the low back unrounded vowel) and major differences in total number of discrete segments (such as total number of low vowels). I classify Bái varieties into four groups based on mutual intelligibility and overall phonological similarity with regard to the aforementioned differences. These groups are Ěrhǎi Bái, Jiànchuān Bái, Hèqìng Bái and "Periphery" Bái.

The varieties which I refer to as "Ěrhǎi Bái" are classified as Southern Bái in most of the literature and are spoken in close proximity to the Ěrhǎi Lake in the Dàlǐ City area of the Dàlǐ Bái Autonomous Prefecture. The comprehensive summary of the

phonological inventories of the Ěrhǎi Bái varieties for the sources reviewed in this section is presented in (18). The varieties grouped into Jiànchuān Bái or Hèqìng Bái are those spoken in their respective counties, and comprehensive summaries for these phonological inventories for the sources reviewed in this section are presented in (19) and (20) respectively. Varieties spoken in other counties are grouped into "Peripheral Bái". I do not re-tabulate the phonological inventories for these varieties, but summarize the contrasts attested in the reviewed descriptions in 3.4. The comprehensive summaries for the phonological inventories are organized as follows. The inventories of initials represent the most typical units which are actually contrastive based on the information from Allen (2004). Although that work is reviewed in the next section, the contrastive analysis in that work is explicit and explanatory of the majority of the observed disparities across the references reviewed in this section. The components differing from reference to reference are described in text for explanatory and visual simplicity. The inventories of finals only include the non-nasalized finals because the gaps between the nasalized and non-nasalized finals are not informative of any phonological restrictions. The inventories of tones are described as in Fēng WĀNG (2006) due to the explicit clarity in that work.

Fig. (18) Summary of Ěrhǎi Bái Inventories

(a) Initials

Shared [21]: p, p^h, m, f, v, t, t^h, n, l, ts, ts^h, s, z, tɕ, $tɕ^h$, ɕ, j, k, k^h, ŋ, x

- Qǐlíqiáo Bái (3.1.3) includes the alveopalatals [tʃ, $tʃ^h$, ʃ, ʒ]
- [n] → [ɳ] / #_i
- [ɣ] is an initial in every source except LǏ Zhèngqīng (2014)

(b) Finals

Nine-Vowel: i, y, e, ɛ, a~ɑ, ɔ~ɑo, o~ou, ɯ, u
Ten-Vowel: i, y, e, ɛ, a~ɑ, ɔ~ɑo, o, ou, ɯ, u

- Each inventory also includes syllabic [ɣ]
- Each description suggests no contrast between [i] and [ɿ]
- The shared set of complex finals is [iɛ, ia, io~iɔ, iɯ, uɛ, ua, uo~uɔ]
- Zhàozhuāng Bái contrasts complex finals [iɔ] and [io]
- The pair of non-high front vowels [e, ɛ] can also be [e, $e^ɹ$] or [ɛ, ə]

(c) Tones

Modal	*Non-Modal*
55	
33	44 [tense]
32	42 [laryngeal]
31	
35	21 [breathy]

- The Zhōuchéng inventory of 3.1.5 does not include tone [32]
- The Zhàozhuāng inventory of 3.1.7 does not include tones [32] and [31]
- The Xǐzhōu inventory of 3.1.8 does not include tone [31]

The summary of Ěrhǎi Bái initials in (18a) can be understood as follows. All descriptions include the set of 21 specified initials. Since an inventory can either have [j] or [ʑ], I simply list [j] in the list of shared initials. Similarly, since there is no contrast between initial [ɳ] and [n] before [i] in Ěrhǎi Bái, I simply list [n] in the list of shared initials. As mentioned in 3.1.8, initial [ɣ] is marginal in Ěrhǎi Bái and is not attested in the description of LǏ Zhèngqīng (2014). Furthermore, I do not include the null-initial or

glottal stop in the inventory of shared initials because each reference treats this item differently. It is unclear why WĀNG Fēng (2006) includes both because neither is attested in the lexical items in the glossary for this source. Finally, the Qīlǐqiáo variety of DUÀN Líng (2008a) includes the alveopalatal series of initials. The description of the same dialect in Allen (2004) suggests that these initials are allophonic with the dental sibilants before [u].

The summary of Ěrhǎi Bái finals in (18b) can be understood as follows. The inventories surveyed in this section include either nine or ten nuclear vowels. Variants which are non-contrastive variants are indicated by the '~' symbol. Aside from the Zhàozhuāng variety, the other descriptions include medial [-i-] and [-u-] complex finals with both vowels from the pair of non-high front vowels. That is, those inventories include both [ie] and [iɛ] whereas Zhàozhuāng only includes [iɛ].

The tone categories in (18c) are more straightforward than the initials and finals. The complete set of tones contains eight contrastive categories. The Zhàozhuāng variety has six tones, missing categories [31] and [32]. The seven-tone varieties are missing one of these two categories.

Fig. (19) Summary of Jiànchuān Bái Inventories

(a) Initials

Shared [20]: p, p^h, m, f, v, t, t^h, n, l, ts, ts^h, s, tɕ, $tɕ^h$, ɕ, j, k, k^h, ŋ, x, ɣ

(b) Finals

Seven-Vowel: i, e, ɛ, a~ɑ, ɑo~ɒ, o, u, ɯ

- Each inventory also includes syllabic [ɣ]
- Each description suggests no contrast between [i] and [ɿ]
- Final [y] is treated as contrastive with other vowels except in the inventories of XÚ & ZHÀO (1984) and Wiersma (1990), (2003)
- The shared set of complex finals is [iɛ, ia~iɑ, io, iɯ, ui, uɛ, uɑ~ua]
- Most finals have nasalized counterparts

(c) Tones

Modal	*Non-Modal*
55	66 [tense]
33	44 [tense]
31	42 [laryngeal]
35	21 [breathy]

- Each description has the same tonal system, some note that tone category [66] is uncommon and mostly occurs in recent Chinese loanwords from the *Qù* tone.

The style of presentation of the summary in (19) is the same as (18). Since the descriptions represent nearly identical varieties, variation is mostly typographical. The nature of [y] for the sources that do not include this item is addressed earlier in this sub-section. One major difference across descriptions of Jiànchuān Bái is the inclusion of coda nasals in Fēng WĀNG (2006).

Fig. (20) Comparison of Hèqìng Bái Segmental Inventories

(a) Initials

Shared [28]: p, p^h, m, f, f^h, v, t, t^h, n, l, ts, ts^h, s, s^h, z, tɕ, $tɕ^h$, ɕ, $ɕ^h$, j, k, k^h, ŋ, x, x^h, ɣ

- The inventory from Fēng WĀNG (2006) is most deviant. Aspirated fricatives [f^h] and [x^h] are not included. The inventory is augmented with the retroflexes [tʂ, $tʂ^h$, ʂ, $ʂ^h$, ʐ].

(b) Finals

Ten-vowels: i, y, e, ɛ~æ, ə~ɔ, a, ɔu~au, o~ou, u, ɯ

- ZHÀO Jīncān (2011) does not include [ɣ]
- The shared set of complex finals includes [iɛ, iə˞, ia, iɯ, ue, uɛ, uə˞, ua]
- Most finals can be nasalized
- Fēng WĀNG (2006) includes [ai] which is not found in the others

(c) Tones

Modal	Non-Modal
55	66 [tense]
33	44 [tense]
31	42 [laryn]
35	21 [harsh]

Much like (19), the variation attested across the inventories compared in (20) is limited because they represent nearly identical varieties. The differences across surveyed varieties are summarized in bullet-point form below the inventories. The variety described in Fēng WĀNG (2006) is particularly interesting for three reasons. First, the palatals are described as being in "transition", phonetically realized as palatalized dental sibilants. Second, the aspirated fricatives [f^h] and [x^h] are not included in this inventory. The implicational hierarchy for aspirated fricatives from Jacques (2011) based on a large survey of data across languages suggests that these contrasts would be lost before the dental [s^h] and palatal [$ɕ^h$]. Third, much like the Jiànchuān inventory from Fēng WĀNG

(2006), the variety of Hèqìng in that reference also transcribes both nasalized vowels and nasal codas.

The next section introduces many of the same inventories presented under slightly different phonological assumptions.

3.2 Allen (2004)

As noted earlier, Allen (2004) is the culmination of a two-year collaborative project from 1999 and 2001 between the Yunnan Minority Language Commission (YMLC) and SIL International, East Asia Group. As can be inferred from the other sources reviewed in the previous section, the numerous varieties of Bái differ considerably in terms of their phonological systems. The approach to phonological description in this work is similar to the works in the traditional initial-final model, with three minor differences in descriptive assumptions. First, pre-nuclear glides are treated differently based on syllable position. Second, allophonic variation is directly expressed by re-write rules. Third, since the descriptions were prepared in a coordinated fashion, the stylistic norms are consistent across inventories. The phonological inventories of Ěrhǎi Bái are summarized in (21). Those of Jiànchuān Bái and Hèqìng Bái are summarized in (22). Those of the four "Peripheral" Bái varieties are summarized in (23).

Fig. (21) Ěrhǎi Bái

	Zhōuchéng (ZC)	*Qīlǐqiáo (QLQ)*
Initials	p, pʰ, m, f, v, t, tʰ, n, l, s, z, ts, tsʰ, ɳ, ɕ, tɕ, tɕʰ, j, k, kʰ, ŋ, x, ɣ, w [24]	p, pʰ, m, f, v, t, tʰ, n, l, s, z, ts, tsʰ, ɕ, tɕ, tɕʰ, j, k, kʰ, ŋ, x, ɣ, w [23]
Finals	i, e, ɛ, y, a, ɣ, ɯ, u, o, ɔ, iɛ, ia, iɔ, ue, uɛ, ua, uɔ [17]	
Tones	33, 55, 44, 31, 32, 42, 21, 35 [8]	

Fig. (22) Jiànchuān and Hèqìng Bái

	Jiànchuān (JC)	*Hèqìng (HQ)*
Initials	p, p^{h}, m, f, v, t, t^{h}, n, l, s, ts, ts^{h}, ɕ, tɕ, tɕ^{h}, j, k, k^{h}, ŋ, x, ɣ, w [22]	p, p^{h}, m, f, v, t, t^{h}, n, l, s, s^{h}, z, ts, ts^{h}, ɕ, ɕ^{h}, tɕ, tɕ^{h}, j, k, k^{h}, ŋ, x, x^{h}, ɣ, w [26]
Finals	i, e, ɛ, y, ɣ, a, ɯ, u, o, iɛ, ia, iɯ, ue, uɛ, ua, ou [16/32]	i, e, ɛ, y, a, ɯ, u, o, ɔ, iɛ, ia, ou, ɔu, ue, uɛ, ua, uɔ [17/33]
Tones	33, 55, 44, 31, 42, 21, 35, 66 [8]	33, 55, 44, 31, 42, 21, 35 [7]

Fig. (23) "Peripheral" Bái

	Xiángyún (XY)	*Yúnlóng (YL)*
Initials	p, p^{h}, m, f, v, t, t^{h}, n, l, s, z, ts, ts^{h}, ɕ, tɕ, tɕ^{h}, j, k, k^{h}, ŋ, x, ɣ, w [23]	p, p^{h}, m, f, v, t, t^{h}, d, n, l, s, s^{h}, z, ts, ts^{h}, dz, ɕ, ɕ^{h}, tɕ, tɕ^{h}, dʑ, j, ɥ, k, k^{h}, g, ŋ, x, x^{h}, ɣ, w [26]
Finals	i, e, ɛ, y, ɣ, a, ɯ, u, o, ou, iɛ, ia, iɔ, ue, uɛ, ua, uɔ [17/33]	i, e, ɛ, y, a, ai, ɣ, ɯ, u, o, ɔ, iɛ, ia, iɔ, ue, uɛ, ua, uɔ, yɛ [20]
Tones	33, 55, 44, 31, 42, 21, 35 [7]	33, 55, 44, 31, 42, 21, 35 [7]

	Lánpíng (LP)	*Ěryuán (EY)*
Initials	p, p^{h}, m, f, v, t, t^{h}, n, l, s, ʐ, ts, ts^{h}, ɕ, tɕ, tɕ^{h}, j, k, k^{h}, ŋ, x, ɣ, w [23]	p, p^{h}, m, f, v, t, t^{h}, n, l, s, z, ts, ts^{h}, ɕ, ɳ, tɕ, tɕ^{h}, j, ʂ, ʐ, tʂ, tʂ^{h}, k, k^{h}, ŋ, x, ɣ, w [28]
Finals	i, e, ɛ, y, a, ao, ɯ, u, o, ɔ, iɛ, ia, iɯ, ue, uɛ, ua, uɔ [17/34]	i, e, ɛ, y, a, ɣ, ɯ, u, o, ɔ, iɛ, ia, iɔ, ue, uɛ, ua [16]
Tones	33, 55, 44, 31, 42, 21, 35, [7]	33, 55, 44, 31, 42, 21, 35 [7]

Relevant comments on the inventories from Allen (2004) can be summarized as follows. Instead of using the typical inventory categories 'initials' and 'finals', Allen 2004 divides syllables into 'consonants' and 'vowels'; however, these categories are nearly equivalent to 'initials' and 'finals' in other sources. The presence of two numbers in the lower right corner of the vowels cell of a dialect inventory indicates that that there are both oral and nasal categories; the left number counts all attested oral categories and the right number counts all attested oral and nasal categories. The inventories in Allen

(2004) note allophonic variants for several consonant and vowel categories; these variants as specified for each dialect introduced in this section are tabulated in (24).

Fig. (24) Allophonic Variation in Allen (2004)

Segment	Allophone and Environment	Dialects
/i/	/i/ → [ɿ] / {s, s^h, z, ts, ts^h}_#	HQ, JC, YL, QLQ, XY, ZC, LP, EY
/u/	/u/ → [ʏ] / {f,v}_#	HQ
/n/	/n/ → [ɳ] / #_i	QLQ
/s/	/s/ → [ʃ] / #_u	QLQ
/s/	/s/ → [ʃ] / #_ʏ	YL
/ts/	/ts/ → [tʃ] / #_u	QLQ
/ts^h/	/ts^h/ → [tʃ^h] / #_u	QLQ
/k/	/k/ → [k^j] / #_{i, e, ɛ}	XY, EY
/k^h/	/k^h/ → [k^{hj}] / #_{i, e, ɛ}	EY
/k/	/k/ → [k^j] / #_i	ZC
/ɣ/	/ɣ/ → [ʁ] /#_$V_{[back]}$	YL
/j/	/j/ → [ʝ] /#_i	LP

The allophonic variation tabulated in (19) sheds light on some of the discrepancies observed across the inventories previously introduced in this chapter. It is unclear if the inventories introduced in the previous section are supposed to list all surface variants of sub-syllabic constituents or if they are supposed to list all phonological categories. On the other hand, the inventories in Allen (2004) are understood to list phonological categories and provide their allophonic variants. If allophony can be incorporated into Bái phonemics, then several segments need not be treated as separate phonemes. For instance, the alveopalatals [ʃ, tʃ, tʃ^h] can be treated as variants of the dental sibilants [s, ts, ts^h].

However, despite the consistent, phonemic approach taken to phonological description in this work, I argue that this format of phonological analysis is inferior to the original proposal I introduce in section 3.4. First, it is uneconomical to specify pre-nuclear glides as both initials and constituents of complex finals. Although this

approach offers symmetric treatment of the glides, it is unnecessary if the phonological environments are made more explicit. Second, the gaps in combinations between pre-nuclear glides and nuclear vowels appear to be random in this presentational format. Similar to the majority of the phonological descriptions introduced in 3.1, the descriptions in Allen (2004) do not include pre-nuclear [i] or [y] following the palatals. This blurs the relevant phonological environments and leads to a phonemic analysis where [i] is allophonic with the apical vowel [ɿ].

3.3 Dell (1981)

La langue bai: phonologie et lexique (Dell 1981) is the first phonology and lexicon of Bái using rule-based phonemics.[12] The original data presented in this work represents a variety of Ěrhǎi Bái. According to the text, the data were collected in 1966. The informant described in the text is referred to by the initials G.K.C and grew up around Dàlǐ Prefecture; however, I have learned through personal communication with François Dell that this informant is from Xǐzhōu. This section summarizes the phonological description in Dell (1981) as follows. Sub-section 3.3.1 summarizes the syllable structure approach to phonological description from this work and introduces Dell's inventory of initials and finals. Sub-section 3.3.2 discusses the syllable inventory from Dell (1981). Sub-section 3.3.3 summarizes the inventory of tones introduced in this work. Sub-section 3.3.4 summarizes this work, with some reinterpretations for consistency with the other surveyed sources.

[12] This work does not specify the nature of the phonemic framework explicitly, but the concepts referenced are typical of the Western phonological tradition contemporary with the time of writing. This work is in French and I provide a loose translation of content sentences and certain terms throughout my summary of the original text.

3.3.1 Syllable Structure and Phonemic Contrast in Dell (1981)

Dell describes Bái phonology in comparison to Chinese. He states that morphemes generally lack alternations and are monosyllabic. In addition, he states that syllables can be divided into initials (18 in total, Dell 1981:23) and finals (23 in total, Dell 1981:25-29). I reproduce the inventories of initials and finals in (25) and (26) respectfully.

Fig. (25) Xǐzhōu Bái Initials

p' [p^h]	t' [t^h]	ts' [ts^h]	k' [k^h]
p	t	ts	k
m	n		ng [ŋ]
f		s	x
v		z	
	l	∅	

Dell (1981) employs a typewriter-friendly notation instead of IPA to represent sounds; for instance, the text uses the apostrophe < ' > to express aspiration instead of IPA [^{h}]. Furthermore, the velar nasal [ŋ] is transcribed as <ng>. There are two alternations mentioned in the description of the initials. First, the voiceless dental sibilants [ts, ts, s] have allophonic variants [tɕ, $tɕ^h$, ɕ] preceding the high front vowels [i] and [y] while the voiced dental fricative [z] remains [z] in all contexts. Second, the null initial [*initiale zero*] represented by [∅] is generally a glottal stop [ʔ] except when preceding final [ɯ], in which case it becomes a voiced velar fricative [ɣ]. This is the same environment that [ɣ] appears in the other surveyed varieties of Ěrhǎi Bái.

Discussion in Dell (1981) then turns to finals. All finals are open, and there is no oral-nasal vowel contrast on finals. Dell (1981) distinguishes two types syllable structures with regard to finals: CV and CVV. Syllables of type CV include all monophthongs and diphthongs in which the first V is not a high vowel – including contrasts such as [ei, œy,

ou]. Syllables of type CVV are those with medial glides [-i-, -u-, -y-]. The inventories of these two final types are presented with minor modifications for simplicity in (26).

Fig. (26) Xǐzhōu Bái Finals from Dell (1981)

Final V of CV syllables

	Front		Back		Syllabic
Height	Unrounded	Rounded	Unrounded	Rounded	
Close	i	y	w [ɯ]	u	ɣ
Close-Mid	e [ei]		ö [öy]	o [ou]	
Open-Mid	ɛ		œ [ʌ]	ɔ	
Open			a		

Final V_2 of CVV syllables

V_1 is [i/j]			V_1 is [u/w]			V_1 is [y/ɥ]
	w [ɯ]	o [ou]	e	ö [öy]	o [ou]	
ɛ	œ [ʌ]	ɔ	ɛ	œ [ʌ]		ɛ
	a			a		

The inventory of finals in (26) is larger than the majority of inventories for Ěrhǎi Bái. However, Dell (1981:25) states that some of these nuclear vowels reflect surface realizations of allophonic variants for particular combinations of initials and/or tone categories. For instance, the sounds [ɯ] and [ö] are not actually contrastive. Orthographic final <w> is treated as default as it occurs with null-initial and the velars. When orthographic final <w> appears after dental sibilants, it represents the apical vowel [ɿ], which is limited to co-occurrence with this set of initials. Orthographic final <ö> is used with the labial, dental, and palatal initials. The text lists three examples (each with Dell's tone category 6) to demonstrate this distribution: <w> 'to be called' [ɣɯ], <kw> 'freeze' [kɯ], and <tsw> 'needle' [tsɿ]. However, the syllable inventory chart (reproduced in (27)) treats <w> and <ö> as contrastive for two purposes. The first purpose is to capture the impressionistic lowering of this vowel as the result of the combination of Dell's tone

category 7 and the spread of nasalization from the initial <ng>. The second reason, which I argue to be problematic in chapter 4, is to distinguish nuclear [ɿ] and [ɯ] after the dental sibilants. The reinterpreted phonemic system of Xǐzhōu Bái from Dell (1981) is presented in (28).

3.3.2 Syllable Inventory from Dell (1981)

Dell (1981:22) provides a syllable inventory chart of attested and non-attested syllables as vectors of the complete inventories of initials (25) and finals (26). The syllable inventory provided in the text is reproduced in (27) with minor modifications. White cells are valid phonotactic possibilities whereas gray cells are invalid phonotactic possibilities. An attested syllable is represented by '+', and an unattested syllable is represented by '-' for a given vector.

Fig. (27) Xǐzhōu Bái Syllable Inventory from Dell (1981)

	y	yɛ	ia	iɛ	œ	io	iɔ	iw	i	w	ö	a	e	ɛ	œ	ɔ	o	v	u	ua	ue	uɛ	uö	uœ	uo
p	-	-	+	+	+	-	+	+	+	-	+	+	+	+	+	+	-	-	+	-	-	-	-	-	+
p'	-	-	+	+	+	-	+	-	+	-	+	+	+	-	+	+	-	-	+	-	-	-	-	-	-
m	-	-	-	+	+	-	+	+	+	-	+	+	+	-	+	-	-	-	+	-	-	-	-	-	-
f	-	-	-	-	-	-	-	-	-	-	+	+	+	-	+	-	-	+	-	-	-	-	-	-	-
v	-	-	-	-	-	-	-	-	-	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-
t	-	-	+	+	-	-	-	+	+	-	+	+	-	+	+	+	+	+	+	-	+	+	-	-	-
t'	-	-	-	+	-	-	+	-	+	-	+	+	-	+	-	+	+	+	+	-	+	-	-	-	+
n	-	-	+	+	-	+	+	-	+	-	+	+	+	+	+	+	-	+	+	-	-	-	-	-	-
l	-	-	+	-	-	-	+	+	+	-	+	+	+	+	-	+	-	+	+	-	+	+	+	-	-
k	-	-	-	-	-	-	-	-	-	+	-	+	+	+	+	+	+	+	+	+	+	+	-	+	+
k'	-	-	-	-	-	-	-	-	-	+	-	+	+	-	+	+	+	+	+	+	+	+	-	+	-
ng	-	-	-	-	-	-	-	-	-	+	+	+	+	-	+	+	-	+	-	-	-	-	-	-	-
x	-	-	-	-	-	-	-	-	-	+	-	+	+	+	+	+	+	-	+	+	+	-	-	-	+
ts	+	+	+	+	+	+	+	+	+	+	+	+	-	+	+	+	+	+	+	+	+	-	+	+	+
ts'	+	-	-	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	-	+	+	-
s	+	-	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	-	+	-	-	+
z	-	-	-	-	-	-	-	-	+	+	+	+	+	-	+	-	-	+	+	-	-	-	+	-	-
ø	+	+	+	+	+	+	+	+	+	+	-	+	-	+	+	+	+	+	+	+	+	+	-	+	-

The syllable inventory presented in Dell 1981:22 has 18 initials and 25 finals, which combine to yield a total of 450 possible syllables. Given that Dell explicitly provides phonotactic information as indicated by gray cells in (27), there are 327 possible syllable types in his analysis of Xǐzhōu Bái, of which 232 combinations of initials and

finals correspond to attested syllables (as indicated with '+' for a vector of an initial and a final). The attested syllable to possible syllable ratio is 232:327 or roughly 71%.

3.3.3 Tone System from Dell (1981)

The description of the tonal system of Xǐzhōu Bái from Dell (1981) differs considerably from any other references surveyed in this dissertation. The description states that every syllable has a tone and each syllable needs to be distinguished into two types: pp – preceding a pause [*qui précèdent pas immédiatement une pause*] and NPP – not preceding a pause [*qui précèdent pas immédiatement une pause*].

The tonal system, adapted from Dell (1981:33), is tabulated in (28) with minor differences from the original description. The complete set of tones is only available for type pp; tones 3 and 4 do not contrast in the NPP context. Because the impressionistic pitch differs considerably for this source compared with others, I have included both the contours from Dell (1981:33) and their correspondences with typical IF descriptions in the table. The description of the tone system from Dell (1981) includes duration information based on 68 tokens of monosyllabic repetitions of basic vocabulary items. No minimally contrastive set was specified in the description. Furthermore, the 1000-item glossary does not include any items which can belong to a minimally contrastive sets distinguished exclusively by tone.

Fig. (28) Xǐzhōu Bái Tonal System from Dell (1981)

Tone Number	1	2	3	4	5	6	7	8
Contour	44	33	22	21	41	23	212	55ʔ
Corresponding IF	55	44	33	31	42	35	21	66
Ratio out of 68 tokens	9	13	12	7	3	9	10	5
Average Duration in Seconds	0.26	0.27	0.27	0.21	0.2	0.36	0.39	0.15

This description of the tone system is interesting in several ways. First, despite the fact that Xǐzhōu Bái is part of the Ěrhǎi Bái grouping, the tone system of Xǐzhōu as described in Dell (1981) resembles the characterization of the Jiànchuān Bái tone system in (19c). Second, the merger between tones 3 and 4 is dictated by context in this description. Phonological contrast between these two categories has been lost in many Ěrhǎi Bái varieties, such as the Zhàozhuāng variety as described in ZHÀO Yànzhēn (2012). Results from my own survey of Ěrhǎi Bái varieties presented in section 6.4 suggest that this loss is ongoing in many communities around the Ěrhǎi Lake. Third, tone 7 is described as [212] with a free variant of [211]; this category corresponds to [21] in most other descriptions, and the third number potentially represents breathiness, but this is not made explicitly clear in the description.

3.3.4 Summary and Reinterpretation of Dell (1981)

Although the description of Xǐzhōu Bái from Dell (1981) is in a phonemic framework which appeals to popular notions in phonology such as phonemic economy and syllable structure, there are two major outstanding issues regarding the phonological description in this work which need to be addressed. These issues are compatibility with prior work and representative accuracy. These two issues are interrelated, and the summary of the phonological system in (29) highlights some of the primary concerns.

Fig. (29) Summary of Xǐzhōu Bái as Described in Dell (1981)

(a) Initials

Total (18): p, p^h, m, f, v, t, t^h, n, l, ts, ts^h, s, z, k, k^h, ŋ, x, ø

- Null-initial [ø] becomes [ɣ] before [ɯ], otherwise [ʔ]
- Dental sibilants become palatals before [i] and [y]

(b) Finals

Ten Vowels: i, y, ei, ɛ, ʌ, a, ɔ, ou, ɯ, u

- Syllabic [ɣ] sounds like [ɣ] after labiodentals, but has a constricted vocalic realization in other contexts.[13]
- Apical vowel [ɿ] is considered a variant of <ö> which is non-contrastive with [ɯ].
- Unlike the other varieties of Ěrhǎi Bái reviewed in this chapter, the variety described in Dell 1981 has a three-way contrast between [ei, ɛ, ʌ] instead of two of these three vowels. I have observed these productions for some Xǐzhōu speakers, but I proposed in 3.9.1 that [ei] and [ɛ] are non-contrastive variants dictated by tone.
- The inventory of complex finals includes 12 categories: [yɛ, ia, iɛ, iœ, io, iɔ, iw, ua, uɛ, uö, uœ, uo]

(c) Tones

55	55ʔ [glottal]
33	44
31	42
35	21 [breathy?]

The contrasts generated by the concatenations of items in the inventories of initials and finals deviate from nearly every other available reference. Most deviant is the treatment of the apical vowel [ɿ]. While the majority of sources treat this vowel as an allophone of [i], Dell (1981) treats this vowel as part of the three-part non-contrastive set of phones [ɿ]~[ɯ]~[ö]. Furthermore, this work treats [e], [ɛ] and [ʌ] as contrastive with one another, but offers no set of lexical items which minimally contrast if tones are

[13] The final [ɣ] is described as an open vowel with some consonantal constriction in the beginning of production.

considered. I return to the relevance of this three-way vowel contrast in chapter 6. Finally, this work transcribes the tonal system in a different, but not incompatible, manner from most other references. The transcribed contours of the tonal system introduced in (28) are translated into typical categories from the other IF descriptions. I have not been able to find any community of Ěrhǎi Bái speakers who contrast the high level glottalized tone. It is possible that this tonal contrast has been lost between the time of elicitation of the data (1966) and the present.

3.4 Summary and Unified Interpretation of Prior Works

As mentioned earlier in this chapter, I consider there to be four groups of mainstream Bái: Ěrhǎi Bái, Jiànchuān Bái, Hèqìng Bái, and "Periphery" Bái. I have reviewed and summarized the phonological inventories of these groups throughout this chapter. Section 3.1 summarizes these inventories in the typical Initial-Final framework (format 1). Section 3.2 summarizes these inventories in a modified Initial-Final framework which treats pre-nuclear glides as both distinct initials and constituents of complex finals (format 2). Section 3.3 summarizes the phonological decomposition of Xǐzhōu Bái offered in Dell (1981) which derives palatals from dental sibilants in contexts of complex finals. In this section I reinterpret this data into inventories of consonants, (pre-nuclear) glides, vowels, and tones for the four groups of Bái; the inventories are presented in (30).

Fig. (30) Inventories of Segments and Tones for Four Groups of Bái

Ěrhǎi Bái

Consonants [18-19]:	[p, p^h, m, f, v, t, t^h, n, l, ts, ts^h, s, z, k, k^h, ŋ, x, (ɣ)]
Glides [3]:	[j, w, ɥ]
Vowels [9]:	[i, y, e, ɛ~ə~ʌ, a, ɔ, o, u, ɯ]
Tones [6-8]:	[33, 55, 44, 42, 21, 35, (31, 32)]

Jiànchuān Bái

Consonants [18]:	[p, p^h, m, f, v, t, t^h, n, l, ts, ts^h, s, k, k^h, ŋ, x, ɣ]
Glides [3]:	[j, w, ɥ]
Vowels [9]:	[i, y, e, ɛ, a, ɔ, o, u, ɯ]
Tones [8]:	[33, 55, 44, 31, 42, 21, 35, 66]

Hèqìng Bái

Consonants [21]:	[p, p^h, m, f, f^h, v, t, t^h, n, l, ts, ts^h, s, s^h, z, k, k^h, ŋ, x, x^h, ɣ]
Glides [3]:	[j, w, ɥ]
Vowels [10]:	[i, y, e, ɛ, ə~ʌ, a, ɔ, o, u, ɯ]
Tones [8]:	[33, 55, 44, 31, 42, 21, 35, 66]

Periphery Bái

Usual consonants [18]:	[p, p^h, m, f, v, t, t^h, n, l, ts, ts^h, s, z, k, k^h, ŋ, x, ɣ]
Other consonants [12]:	[b, d, f^h, s^h, tʂ, tʂh, ʂ, $ʂ^h$, ʐ, dz, ɡ, x^h]
Glides [3]:	[j, w, ɥ]
Vowels [9]:	[i, y, e, ɛ, a, ɔ, o, u, ɯ]
Tones [7]:	[33, 55, 44, 31, 42, 21, 35]

The inventories in (30) can be summarized as follows. From the review in this chapter it is evident that the phonological systems of these four groups of Bái share most of the same contrastive units. These inventories offer a simple summary of the segments and tones used in varieties classified into these four groups throughout the sources reviewed in this chapter. Furthermore, the variation attested and described for varieties within the groups can be interpreted by the number of discrete units for each phonological category and items between commas specified for these four groups. That is, the units in parentheses are not attested in each variety of a given group. For instance,

varieties of Ěrhǎi Bái differ in total number of contrastive tone categories and the tones which are not attested in some of these varieties are indicated as such within parentheses. On the other hand, some contrastive units appear differently across varieties of the same group. This is indicated with the '~' symbol between items in between commas. For example, one of the vowels in Ěrhǎi Bái is pronounced [ɛ] by some subset of speakers, [ɚ] by another subset of speakers, and [ʌ] by still another subset of speakers. Note that some descriptions include off-glide diphthong units such as [ɑo] or [ou]. Although the inventories in (30) exclude such diphthongs, it is possible to form such rimes with two of the items from these inventories. However, in chapter 6 I argue that these diphthongs have nuclear vowel monophthong variants in underlying representation. Furthermore, vowels are contrastively specified for nasality in the Jiànchuān and Hèqìng varieties.

The inventories in (30) only include consonants which contrast with one another. Accordingly, I do not treat the palatal consonants [tɕ, tɕ^{h}, ɕ, ɕ^{h}, ʑ, ɳ̡] as distinct units in the groups of consonants because in the next chaper I demonstrate that they are non-contrastive with combinations of dental continuants [ts, ts^{h}, s, s^{h}, z, n] and front glides [j] and [ɥ].[14] This is further supported by the "intermediate stage of palatalization" of the segments corresponding to palatals in the Dàshí variety decribed in Fēng WĀNG (2006) (these segments are described as [ts^{j}, ts^{hj}, s^{j}, z^{j}]). In my discussion of contrast and feature specification in chapter 5 I do not get into detail regarding the contrast for each of the consonants of periphery Bái. In fact the remainder of this dissertation only examines the contrasts observed in Jiànchuān, Hèqìng (Kāngfú and Dàshí varieties), and Ěrhǎi Bái.

[14] I refer to the class of the dental sibilants and dental nasal as 'continuants'. Some of the sources considered in this dissertation assume that the series of palatals includes a nasal [ɳ̡] item in addition to the sibilants. My analysis of palatalization in 7.1 assumes that both the sibilants and nasal become palatalized.

This chapter reviews the large body of available phonological descriptions of Bái. Unfortunately these descriptions are subject to a host of problems. The biggest problem is transcription practices biased by perceived genetic relationship of Bái (specifically with regard to the nature of transcription of palatal initials and medial [-i-] from complex finals). Although this is a problem for synchronic phonological analysis, this is not particularly problematic for lexical data used in historically-oriented or sentence-level grammar research; that is, as long as a contrast can be distinguished it does not matter if the nature of the contrast is somehow obscured. Second, many of these sources are not properly edited. It is often the case that a phonological inventory will list certain items which are not found in any of the lexical glosses later in that same reference. Third, much of this work is prepared without concern for compatibility with other sources. It is not always obvious or easy to figure out the correspondences between different synchronic descriptions of modern Bái varieties in the different formats described in 3.1.9, 3.2, 3.3.2. This section has offered a uniform notation of the contrastive units in Bái varieties. These units and their concatenation with one another are the subject of inquiry for the remainder of this dissertation.

Chapter 4. Syllable Structure in Bái

The approach I assume for representing phonological contrast in Bái assumes onset-rime syllable structure in which any pre-nuclear glides are strictly affiliated to the onset. Furthermore, my analysis requires that underlying representations of phonological forms contrastive with one another – in the case of Bái these phonological forms are simply two or more given syllables – can only include the absolute minimal amount of specification in terms of articulator-based features and linearized ordering of these features in relation to one another. While opponents to such an approach may argue that this strategy is seeking phonemic economy simply for elegance, I demonstrate that avoiding or ignoring underspecification leaves many gaps in the space of possible syllables unexplained. This chapter offers a visual representation of attested syllables within this predicted space for the four formats of syllable structure reviewed in the previous chapter. This chapter is structured as follows. Section 4.1 offers a review of the literature on the sub-syllabic affiliation of pre-nuclear glides. Section 4.2 compares the ratio of attested to possible syllables for the Zhàozhuāng variety of Bái predicted by the three assumed syllable structure formats in previous descriptions. Section 4.3 introduces my original proposal. Section 4.4 summarizes evidence from other aspects of Bái phonology independent from phonotactic well-formedness. The discussion is summarized in section 4.5.

4.1 Sub-Syllabic Affiliation of Pre-nuclear Glides

As I have shown throughout the previous chapter, the largest discrepancy across prior phonological descriptions of Bái is the categorization of pre-nuclear glides. In this chapter I argue that Bái has a $C^{G}VX$ syllable structure. This structure consistently treats pre-nuclear glides as constituents of the onset and not as constituents of the rime in Bái. Nearly all prior work offers the opposite treatment, at worst specifying these segments as high vowels or at best redundantly specifying these segments as glides and as high vowels. The glide-vowel distinction is a major topic of inquiry in phonological theory (Harris & Kaisse 1999, Yip 2003, Padgett 2007). In terms of acoustics, these two classes of sounds are characterized by similar spectral resonances and are sometimes collectively referred to as 'vocoids' or 'vocalic segments' when the glide-vowel distinction is not assumed (Goldsmith 2011:169). Although research has shown that glides and high vowels can be distinguished by articulatory and acoustic properties in some languages,[15] most phonological representations of this distinction either take the shape of specification by distinctive features or through sub-syllabic affiliation of the vocalic segment.

Several proposals have been made to designate the glide-vowel distinction in terms of features. I summarize some of the major proposals by date of earliest publication. Chomsky & Halle (1968) and Padgett (2007) use the binary feature [vocalic] in which [+vocalic] represents a vowel and [–vocalic] represents a glide. Clements (1985) and Halle (1995) use the binary feature [consonantal] in which [+consonantal] represents a glide and [–consonantal] represents a vowel. Ladefoged (2007) uses the binary feature [syllabicity] in which [+syllabicity] represents a vowel and [–syllabicity] represents a

[15] Padgett (2007) lists two specific examples in the literature. First, Chitoran (2002) finds that vowels are longer in duration than glides in Romanian. Second, Maddieson & Emmorey (1985) reports a stronger degree of constricture for glides compared with vowels in Amharic, Yoruba, and Zuni.

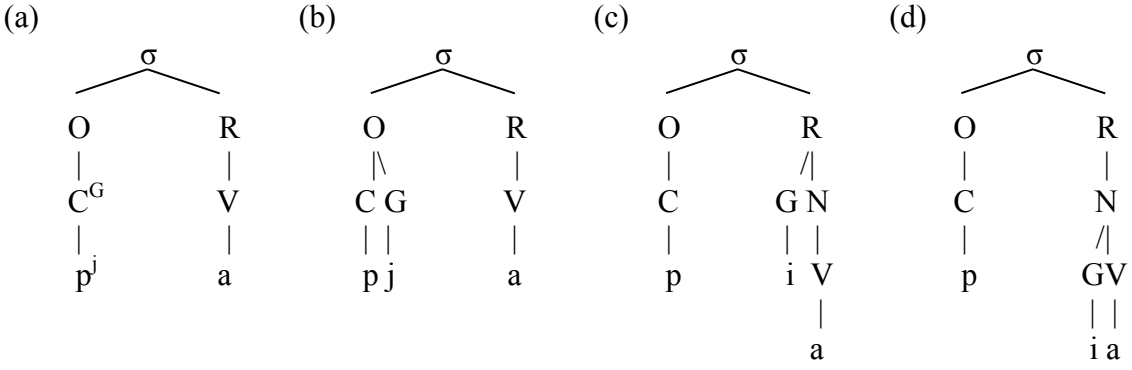
glide. Although Padgett (2007) provides support that these segments require different representations in terms of distinctive features, most recent work is in favor of using syllable structure to produce the phonological distinction between glides and vowels.

The syllable structure approach can be summarized as follows. In these kinds of theories high vowels and glides share the same representation in terms of distinctive features and are distinguished exclusively by whether or not the segment is affiliated to the nucleus of the syllable (Goldsmith 2011). In brief, affiliation to the nucleus yields a high vowel whereas affiliation to the onset or coda of a syllable yields a glide. As the focus in this sub-section is on pre-nuclear glides, the remainder of discussion focuses on distinguishing vowels and glides before a nuclear vowel.

Most theories of the syllable assume that syllables are divided into two constituents: onsets and rimes (Goldsmith 2011:170). To appreciate this division with regard to pre-nuclear glides let us consider the two Bái syllables <pa^{44}> 'collapse' and <pia^{44}> 'eight'.[16] In the case of the first word [pa], this division is clear; the segment [p] is part of the onset and the segment [a] is part of the rime. However, the sub-syllabic division of the second word [pia] is less obvious. The major possibilities discussed in the literature, adapted from Yip (2003:781), are replicated in (31) for the Bai word <pia^{44}> 'eight'.

[16] Since I select these two syllables from the glossary of ZHÀO Yǎnzhēn (2012), I make no assumption of the author's intended phonological analysis and cite the lexical items as IPA orthographic variants indicated by curved brackets. I follow this practice in all cases when citing lexical data from original sources.

Fig. (31) Onset-Rime Model



Explanation of (31) is as follows. Syllables (σ) are divided into an onset (O) and a rime (R). Each representation of the syllable in (31) differs in internal placement of consonants (C), glides (G), and vowels (V). Representation (31a) illustrates the case in which the glide is a secondary articulation on the onset. Representation (31b) illustrates the case in which the glide is the second consonant in an onset cluster. The glide cannot contribute weight to the syllable in either of these two representations. Representations (31c) and (31d) assume that glides are part of the rime. The difference between these two models is the contribution of the glide to the weight of a syllable. In the case of (31c) the pre-nuclear glide contributes weight to the syllable – the pre-nuclear glide and nuclear vowel form a bimoraic diphthong – and in (31d) the pre-nuclear glide does not contribute weight to the syllable – the pre-nuclear glide and nuclear vowel combine to form a monomoriac diphthong.

Two other syllable structure configurations offer additional possibilities regarding the potential affiliation of pre-nuclear glides – flat structure (Clements & Keyser 1983, Pierrehumbert & Nair 1995) and glide gemination. In a flat structure syllable configuration, the relevant CGV syllable types do not have any sub-syllabic constituents

such as onset and rime and the three segmental units are completely independent of one another within a syllable. On the other hand, the gemination option assumes that onset and rime are authentic units; however, the glides are linked to both constituents instead of either one or the other. While these configurations provide us with options which may reflect phonetic reality more accurately than those schematized in (31), I advocate that Bái requires the onset-rime configuration of (31a). The typical initial-final format of description and Dell (1981) assume configuration (31c) while Allen (2004) assumes (31b) for syllables without a specified consonant in the onset and (31c) for syllables which specify an onset consonant.

4.2 Attested and Possible Syllables in Zhàozhuāng Bái

This section compares the tabulation of syllable inventories according to the assumed sub-syllabic affiliation of pre-nuclear glides for each the four formats of introduced in the previous chapter. The attested to predicted possible syllables dictated by the assumptions of these formats are compared based on a list of all attested syllables from a digital version of ZHÀO Yànzhēn (2012). This list was generated in Microsoft Excel after removing all the original Chinese text and verified for errors with the native speaker author, Zhào Yànzhēn. The complete list of attested syllables with lexical examples for each syllable type is provided in Appendix C. There are 232 attested syllable types of the 4960 syllable tokens in this grammar. The inventory of attested syllables in this grammar based on the original initial-final decomposition of syllables in ZHÀO Yànzhēn (2012) in format 1 is presented and summarized in 4.2.1. This syllable inventory is modified according to format 2 in 4.2.2. This syllable inventory modified

according to the format of Dell (1981) (format 3) is presented and summarized in 4.2.3. The implications of this comparison are summarized in 4.2.4.

4.2.1 Zhàozhuāng Bái Syllable Inventory Format 1

This format assumes the inventories of initials and finals in ZHÀO Yànzhēn (2012:19-21). This format follows the typical assumptions of the initial-final model of syllable description which treats pre-nuclear glides as part of the rime as in (31c) but treats the palatals and the glide [j] as part of the onset as in (31b). These initials and finals are reproduced in (32) and the table of attested to possible syllables is provided in (33). There are some atypical combinations in this variety of Bái which are addressed in the text following the table in (33).

Fig. (32) Inventory of Initials and Finals in Zhàozhuāng Bái

(a) Initials [23]: p, p^h, m, f, v, t, t^h, n, l, ts, ts^h, s, z, tɕ, $tɕ^h$, ɳ, ɕ, ʑ, k, k^h, ŋ, x, ɣ

(b) Finals [20]: ɿ, i, e, ɛ, a, ɔ, o, u, y, ɯ, v, iɛ, ia, iɔ, io, iɯ, ui, uɛ, ua, uo

Fig. (33) Syllable Inventory Format 1

	a	e	ɛ	o	ɔ	ɯ	ɿ	i	ia	iɛ	io	iɔ	iɯ	u	ua	ui	uɛ	uo	v	y
p	+	+	+	+	+	+	-	+	+	+	-	+	+	+	-	-	-	+	-	-
p^h	+	+	+	+	+	+	-	+	+	+	+	+	+	+	-	-	-	-	-	-
m	+	+	+	-	+	+	-	+	-	+	+	+	+	+	-	-	-	-	-	-
f	+	+	+	+	-	+	-	-	-	-	-	-	-	-	-	-	-	-	+	-
v	+	+	-	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-	+	-
t	+	+	+	+	+	+	-	+	-	+	+	-	+	+	-	+	-	+	+	-
t^h	+	+	+	+	+	+	-	+	-	+	+	+	+	+	+	+	-	+	+	-
n	+	+	-	+	+	+	-	-	-	-	-	-	-	-	-	-	-	-	+	-
l	+	+	+	+	+	+	-	+	+	+	+	+	+	+	+	+	-	+	+	-
ts	+	+	+	+	+	+	+	-	-	-	-	-	-	-	-	-	-	-	+	-
ts^h	+	+	+	+	+	+	+	-	-	-	-	-	-	-	-	-	-	-	+	-
s	+	+	+	+	+	+	+	-	-	-	-	-	-	-	-	-	-	-	+	-
z	-	+	+	+	+	+	+	-	-	-	-	-	-	-	-	-	-	-	+	-
tɕ	+	-	+	+	+	+	-	+	-	-	-	-	-	+	+	-	+	+	-	+
$tɕ^h$	+	-	+	+	+	+	-	+	-	-	-	-	-	+	+	-	+	+	-	+
ɕ	+	-	+	+	+	+	-	+	-	-	-	-	-	+	+	-	+	+	-	+
ʑ	+	-	+	+	+	+	-	+	-	-	-	-	-	-	-	-	+	-	-	+
ɳ	+	-	+	+	+	+	-	+	-	-	-	-	-	-	-	-	-	-	-	-
k	+	-	-	+	+	+	-	+	-	+	-	-	-	+	+	+	+	+	+	-
k^h	+	-	-	+	+	+	-	+	-	+	-	-	-	+	+	+	+	+	+	-
ŋ	+	-	-	+	+	+	-	+	-	+	-	-	-	-	-	-	-	-	+	-
x	+	-	+	+	+	+	-	+	-	-	-	-	-	+	+	+	-	+	-	-
ɣ	-	-	-	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-
null	+	+	+	+	+	-	-	-	-	-	-	-	-	+	+	+	+	+	-	-

The syllable inventory table in (33) is organized as follows. The categories of initials are listed in the leftmost column and the categories of finals are listed in the topmost row, vectors of these initials and finals represent available syllable combinations by concatenation of units in the inventories of initials and finals. In total there are 480 possible combinations and 232 of these combinations represent attested syllables (attested combinations are indicated by "+", unattested combinations are indicated by "-"). The ratio of attested to possible syllables, 232:480 (or 48.3%), demonstrates that much of the space available from concatenating the initial and final units is unutilized. The syllable structure assumed in Dell (1981) as discussed in 4.2.3 and my own proposal as discussed in 4.2.4 account for many of these systematic gaps. In particular note that the dental sibilants, dental nasal, and the palatals do not combine with medial [-i-] complex finals;

this continuous gap leaves 100 syllable cells completely unusable. Furthermore, there are two sets of finals which do not co-occur with the same initials in this analysis: [i~ɿ] and [y~v]. I argue that the first segments from these two sets are specified in underlying representation whereas the second two of these sets are derived from onset-to-rime spreading from the preceding consonant; this is examined at length in chapter 7. Additionally, make note of the attested and unattested syllable combinations highlighted in gray in (33). Combinations of the velars [k, k^h, ŋ, x] and front vowels [i, iɛ] are innovative in this variety of Bái. In most varieties of Bái the velars cannot co-occur with [i], instead these attested syllables typically have nuclear vowel [e]. Furthermore, the velars [k, k^h, ŋ] typically co-occur with the nuclear vowel [ɛ], but in this variety the velars are palatalized [k^j, k^{hj}, $ŋ^j$] before nuclear vowel [ɛ]. For the remainder of the discussion I specify these syllable cells as attested "+"types from ZHÀO Yànzhēn (2012) but keep these innovative cells and their corresponding non-innovative cells highlighted as they deviate from the general phonotactic norms of Bái. The next sub-section presents a very similar syllable inventory table with the glides also included in the inventory of initials.

4.2.2 Zhàozhuāng Bái Syllable Inventory Format 2

Format 2 as introduced in 3.2 differs slightly from format 1. The difference is symmetrical treatment of pre-nuclear glides. Glides can redundantly behave as the onset of a syllable as schematizied in (31b) and as consituents of the rime as in (31c). The syllable inventory table based on this format is presented in (34). There are several redundant cells in this format as well.

Fig. (34) Syllable Inventory Format 2

	a	e	ɛ	o	ɔ	ɯ	i	ia	iɛ	io	iɔ	iɯ	u	ua	ui	uɛ	uo	v	y
p	+	+	+	+	+	+	+	+	+	-	+	+	+	-	-	-	+	-	-
p^h	+	+	+	+	+	+	+	+	+	+	+	+	+	-	-	-	-	-	-
m	+	+	+	-	+	+	+	-	+	+	+	+	+	-	-	-	-	-	-
f	+	+	+	+	-	+	-	-	-	-	-	-	-	-	-	-	-	+	-
v	+	+	-	-	-	+	-	-	-	-	-	-	-	-	-	-	-	+	-
t	+	+	+	+	+	+	+	-	+	+	-	+	+	-	+	-	+	+	-
t^h	+	+	+	+	+	+	+	-	+	+	+	+	+	+	+	-	+	+	-
n	+	+	-	+	+	+	-	-	-	-	-	-	-	-	-	-	-	+	-
l	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	-	+	+	-
ts	+	+	+	+	+	+	$	-	-	-	-	-	-	-	-	-	-	+	-
ts^h	+	+	+	+	+	+	$	-	-	-	-	-	-	-	-	-	-	+	-
s	+	+	+	+	+	+	$	-	-	-	-	-	-	-	-	-	-	+	-
z	-	+	+	+	+	+	$	-	-	-	-	-	-	-	-	-	-	+	-
tɕ	+	-	+	+	+	+	+	-	-	-	-	-	+	+	-	+	+	-	+
$tɕ^h$	+	-	+	+	+	+	+	-	-	-	-	-	+	+	-	+	+	-	+
ɕ	+	-	+	+	+	+	+	-	-	-	-	-	+	+	-	+	+	-	+
ʑ~j	+	-	+	+	+	+	+	#	#	#	#	#	-	-	-	#	-	-	-
ŋ̩	+	-	+	+	+	+	+	-	-	-	-	-	-	-	-	-	-	-	-
k	+	-	-	+	+	+	+	-	+	-	-	-	+	+	+	+	+	+	-
k^h	+	-	-	+	+	+	+	-	+	-	-	-	+	+	+	+	+	+	-
ŋ	+	-	-	+	+	+	+	-	+	-	-	-	-	-	-	-	-	+	-
x	+	-	+	+	+	+	+	-	-	-	-	-	+	+	+	-	+	-	-
ɣ	-	-	-	-	+	+	-	-	-	-	-	-	-	-	-	-	-	-	-
w	+	+	+	+	-	-	-	-	-	-	-	-	+	#	#	#	#	-	-
ɥ	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	-	-	+
null	+	+	+	+	+	-	-	-	-	-	-	-	#	#	#	#	#	-	-

The primary differences between the syllable inventory table in (33) and the syllable inventory table in (34) can be summarized as follows. The apical vowel is not an independent final in Allen (2004) and this sound is derived as an allophonic variant of [i] after the dental sibilants; the relevant cells reflecting this allophonic relationship are filled with the '$' symbol. Initial [ʑ] is treated as a free variant of glide [j] as these segments do not contrast. Furthermore, the inventory of initials is augmented with the glides [w] and [ɥ]. In total there are 26 rows and 19 columns giving us a space of 494 possible syllables. However, since many rows are redundantly specified (i.e. the combinations of a glide and vowel, and a null onset and glide diphthong such as [ua] and [wa] are equivalent) as indicated by the "#" symbol, the possible syllable space is reduced to 472. This ratio of

attested to possible syllables is only slightly better than format 1 at 232:472 or approximately 49.1%, although most of the gaps are the same. While the symmetrical treatment of pre-nuclear glides seems more reasonable than the asymmetrical treatment from format 1, this treatment does not improve economy with regard to the space of possible syllables.

4.2.3 Zhàozhuāng Bái Syllable Inventory Format 3

The format of Dell (1981) uses the smallest possible number of initials (all single consonants) and a nearly equivalent number of finals as the other formats. The palatals are derived in environments preceding [i] and [y]; the model of syllable structure assumed in this work is (31c). This format requires [v] and [y] to be contrastive and requires two final categories [ɯ^1] and [ɯ^2] to distinguish syllable types consisting of dental sibilant onsets with nuclear [ɯ] and the sound typically transcribed as an apical vowel.[17] Tabulation of the attested syllables from Zhàozhuāng Bái in this format is presented in (35).

[17] Dell (1981) notes that these rimes are questionably contrastive for combinations with other onsets. In this exploration of the data [ɯ^2] effectively serves the purpose of the apical vowel but in Dell (1981) this category represents a lowered and centralized [ɯ].

Fig. (35) Syllable Inventory Format 3

	a	e	ɛ	o	ɔ	ɯ	ɯ[2]	i	ia	iɛ	io	iɔ	iɯ	u	ua	ui	uɛ	uo	v	y	yɛ
p	+	+	+	+	+	+	-	+	+	+	-	+	+	+	-	-	-	+	-	-	-
p^h	+	+	+	+	+	+	-	+	+	+	+	+	+	+	-	-	-	-	-	-	-
m	+	+	+	-	+	+	-	+	-	+	+	+	+	+	-	-	-	-	-	-	-
f	+	+	+	+	-	+	-	-	-	-	-	-	-	-	-	-	-	-	+	-	-
v	+	+	-	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-	+	-	-
t	+	+	+	+	+	+	-	+	-	+	+	-	+	+	-	+	-	+	+	-	-
t^h	+	+	+	+	+	+	-	+	-	+	+	+	+	+	+	+	-	+	+	-	-
n	+	+	-	+	+	+	-	+	+	+	+	+	+	-	-	-	-	-	+	-	-
l	+	+	+	+	+	+	-	+	+	+	+	+	+	+	+	+	-	+	+	-	-
ts	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	-	+	+	+	+	-
ts^h	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	-	+	+	+	+	-
s	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	-	+	+	+	+	-
z	-	+	+	+	+	+	+	-	-	-	-	-	-	-	-	-	-	-	+	-	-
k	+	-	-	+	+	+	-	+	-	+	-	-	-	+	+	+	+	+	+	-	-
k^h	+	-	-	+	+	+	-	+	-	+	-	-	-	+	+	+	+	+	+	-	-
ŋ	+	-	-	+	+	+	-	+	-	+	-	-	-	-	-	-	-	-	+	-	-
x	+	-	+	+	+	+	-	+	-	-	-	-	-	+	+	+	-	+	-	-	-
ɣ	-	-	-	-	+	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
null	+	+	+	+	+	-	-	+	+	+	+	+	+	+	+	+	+	+	-	+	+

This format has 19 rows and 21 columns and offers a possible syllable space of 399 syllables. This ratio 232:399 (approximately 58.1%) is already better than the previous analyses but Dell (1981) also accounts for many of the missing syllables with phonotactic generalizations. The syllable inventory table from Dell (1981) shades out all combinations of velars and finals beginning with [i], combinations of labials and finals beginning with [u], and combinations of labiodentals and all finals beginning with vowels [i, u, y]; these phonotactic exemptions change the ratio to 232:331 or approximately 70%. While this approach is both more economical and explanatory than the prior two analyses, I suggest in 4.3 that the environments can be made more explicit and my original proposal improves the ratio of attested to possible syllables such that the attested gaps can be considered accidental.

4.2.4 Summary of Three Prior Syllable Structure Formats

The inferred distribution from sources assuming syllable inventory formats 1 and 2 as introduced in this section suggest that the palatals are contrastive with both the velars and the dental sibilants as these segments generally appear in contrastive environments in lexical glosses – <ka^{44}> ‘warehouse’, <tsa^{44}> ‘plan’, <tɕa^{44}> ‘to receive’. The distribution of these series of initials is compared in (36) before finals <i>, <ɿ>, <a>, and complex final <-ia> using lexical items from the representative Jiànchuān variety (as listed in the glossary of XÚ & ZHÀO 1984).

Fig. (36) Distribution of Relevant Initiails in Typical IF Descriptions

	<i>	<ɿ>	<a>	<-ia>
Dental Sibilants <ts, ts^{h}, s, z>	-	<tsɿ^{44}> ‘son’	<tsa^{44}> ‘plan’	-
Palatals <tɕ, tɕ^{h}, ɕ, ʑ/j>	<tɕi^{44}> ‘queen ant’	-	<tɕa^{44}> OR <tɕia^{44}> ‘to receive’	
Velars <k, k^{h}, x, ɣ>	-	-	<ka^{44}> ‘warehouse’	-

The distribution from (36) can be summarized as follows. Of these three classes, only the palatals can co-occur with nuclear vowel <i> and only the dental sibilants can co-occur with a nuclear apical vowel <ɿ>; these kinds of analyses assume that the apical vowel [ɿ] is an allophonic variant of /i/. For Initial-Final descriptions assuming Tibeto-Burman affiliation, these three classes each contrast before simple finals such as <a> and none of these classes can combine with <-i-> medial complex finals such as <-ia>. On the other hand, Initial-Final descriptions assuming relationship with Sinitic (implicitly or explicitly) contrast the dentals and velars before simple finals and do not contrast either of these two classes with the palatals; that is, the palatals can only combine with complex finals with medial <-i-> (and sometimes <-y->). As mentioned in 3.1.9, authors perhaps

follow these conventions because they are unsure if the palatals are allophonic with the dentals or the velars, as words in Bái with palatal consonants have historical relationships with both the dental sibilants and the velars.

Dell (1981), on the other hand, commits to a Bái phonological system in which the palatals are allophones of the dentals. The phonemic analysis from Dell (1981:23-25) states that [i] and [ɿ] are not allophonic and that the palatals are allophonic variants of the dental continuants conditioned before high front vowels. The distribution for the same five lexical items from (36), augmented by the lexical items contrasting the relevant consonant classes before the non-contrastive vowel phoneme pair [ɯ^{1}]~[ɯ^{2}] according to the analysis of Dell (1981), is re-tabulated in (37).

Fig. (37) Distribution of Dentals, Palatals, and Velars from Dell (1981)

	[i]	[ɯ]~[ö]	[a]	[-ia]
Dentals/Palatals [ts, ts^{h}, s, z, n]	/tsi/→[tɕi] 'queen ant'	/tsɯ/→[tsɿ] 'son'	/tsa/→[tsa] 'plan'	/tsia/→[tɕia] 'to receive'
Velars [k, k^{h}, x, ɣ, ŋ]	-	/kɯ/ → [kɯ] 'old'	/ka/→[ka] 'warehouse'	-

I agree with Dell (1981) that the palatals are derived from the dental continuants and not the velars, but my analysis of the distribution of these consonant classes is considerably different. In my analysis, the apical vowel [ɿ] is not an allophone of any vowel phoneme. I reinterpret this segment as syllabic [z̩] which I hypothesize to be derived though fricative spreading, described in the next section. In brief, the relevance of feature spreading is that removing environment [ɯ]~[ö] offers no contrastive context before high vowels for the palatals and the velars. That is, the palatals can be equally considered as allophonic variants of the velars or the dental continuants in most varieties

of Bái. However, Zhàozhuāng Bái is innovative such that the velars and palatals must be contrastive.

4.3 Proposed Syllable Structure

I mention throughout this chapter that Bái syllable structure affiliates pre-nuclear glides to the onset. The syllable structure template for this language is [$C^{G}VX$] such that 'C' is a consonant, '^{G}' is a glide, 'V' is a vowel, and 'X' is either a different vowel or a lengthened variant of the 'V' in nuclear position. In brief, the syllable is parsed into onset and rime constituents such that the material in the [C^{G}] belongs to the onset and the material in [VX] belongs to the rime. In chapter 6, I propose that some syllables are heavy, requiring both positions, and other syllables are light, simply requiring the single 'V' position as dictated by tone. I ignore tone for the present discussion and assume that all syllable types are heavy to illustrate certain restrictions. The remainder of this section tabulates the possible syllables as specified by the concatenation of underlying consonant, glide, and vowel units to the attested surface syllables as explored in the previous section.

Since we have observed and discussed numerous gaps in the syllable inventory of Zhàozhuāng Bái in the previous three sub-sections, I provide a revised account of the phonological inventory for this variety of Ěrhǎi Bái for two reasons. First, the analysis reflects innovations observed in this variety of Bái. Second, the improved detail helps understand particular gaps in the possible syllable inventory. The revised inventory of contrastive units is provided in (38).

Fig. (38) Revised Segmental Inventory for Zhàozhuāng Bái

Consonants [17-18]:	[p, p^{h}, m, f, v, t, t^{h}, n, l, ts, ts^{h}, s, z, k, k^{h}, ŋ, x, (ɣ)]
Glides [3]:	[j, w, ɥ]
Vowels/Rimes [9]:	[iː, ei, ɛː, aː, ɔː, ou, uː, yː, ɯː]

For presentational ease I tabulate syllables with "simple" onsets (those consisting of a single consonant or no consonant) in (39) and syllables with "complex" onsets (those consisting of either a glide or a consonant and glide combination) in (41). The syllable inventory table in (39) has 19 rows and 9 columns. The extra onset category represents the null-onset.

Fig. (39) Syllable Inventory Format 4 – Simple Onsets

	a:	ei	ɛ:	ou	ɔ:	ɯ:	u:	y:	i:
p	+	+	+	+	+	+	+	-	+
p^h	+	+	+	+	+	+	+	-	+
m	+	+	+	-	+	+	+	-	+
f	+	+	+	+	-	+	-	-	-
v	+	+	-	-	-	+	-	-	-
t	+	+	+	+	+	+	+	-	+
t^h	+	+	+	+	+	+	+	-	+
n	+	+	-	+	+	+	-	-	ŋi:
l	+	+	+	+	+	+	+	-	+
ts	+	+	+	+	+	+	tʃu:	tɕy:	tɕi:
ts^h	+	+	+	+	+	+	$tʃ^hu$:	$tɕ^hy$:	$tɕ^hi$:
s	+	+	+	+	+	+	ʃu:	ɕy:	ɕi:
z	-	+	+	+	+	+	-	-	-
k	+	-	$k^jɛ$:	+	+	+	+	-	+
k^h	+	-	$k^{hj}ɛ$:	+	+	+	+	-	+
ŋ	+	-	$ŋ^jɛ$:	+	+	+	-	-	+
x	+	-	+	+	+	+	+	-	+
ɣ	-	-	-	-	+	+	-	-	-
null	+	+	+	+	+	+	+	+	+

Given the numbers of rows and columns there is space for 171 possible syllables. Attested combinations are indicated with the '+' symbol, unattested combinations are indicated with the '-' symbol. Since the velars do not productively combine with the palatal glide [j], I treat the palatalized velars as variants of the combination of these consonants with [ɛ] as this palatalization is an innovation. Furthermore, because the palatals [tɕ, $tɕ^h$, ɕ, ŋ] do not contrast with the dental continuants [ts, ts^h, s, n], I treat these sounds as allophonic before [i] so the syllable vectors of the dental continuants and [i] are filled with the palatalized variants. Although ZHÀO Yànzhēn (2012) does not transcribe

alveopalatal onsets [tʃ, tʃ^{h}, ʃ] for the relevant syllable types described in (39), these sounds are produced with the tongue body further back than the palatals [tɕ, tɕ^{h}, ɕ]; this process is outlined in 7.12. For the simple onsets, the attested-to-possible syllable ratio for these kinds of syllables is 131:171 or roughly 77%. Discussion turns to accounting for attested to possible vectors of complex onsets and finals.

Due to the syllable structure I assume for Bái, combinations of consonants and glides are treated as onsets before a nuclear vowel. The table in (40) lists the combinations of consonants and glides attested in Zhàozhuāng Bái.

Fig. (40) Typical Onset Inventory for Ěrhǎi Bái

C	C^{j}	C^{w}	Notes
p	+	(+)	Onset [p^{w}] is only found in loanwords from Chinese[18]
p^{h}	+	-	
m	+	-	
f	-	-	
v	-	-	
t	+	+	
t^{h}	+	+	
n	ȵ	-	
l	+	+	
ts	tɕ	+	
ts^{h}	tɕ^{h}	+	
s	ɕ	+	
z	ʑ	-	[ʑ] is not contrastive with [j]
k	-	+	
k^{h}	-	+	
ŋ	-	-	
x	-	+	
ɣ	-	-	

Generalizations regarding the ability for consonants and glides to co-occur can be summarized as follows. Glide [ɥ] is not productive and does not combine with consonants preceding a nuclear vowel. Furthermore, the labiodentals and voiced velars

[18] An example is of this onset is found in the first syllable of the Chinese loanword [p^{w}o:^{44} l^{w}o:^{42}] ‘pineapple’ from ZHÀO Yǎnzhēn (2012:262).

cannot co-occur with any pre-nuclear glides. On the other hand, the dentals can co-occur with each of the glides. Combinations of dental sibilants and front glides become palatals. The combination of glides with the other classes of consonants is restricted by place. Generally, labial consonants cannot occur with the labial glide [w] (aside from recent loanwords) and velar consonants cannot occur with the palatal glide [j] (aside from non-contrastive innovation). In brief, combination options of nasals and glide [w], all consonants and glide [ɥ], and consonants and glides sharing the same primary articulator (such as labials and glide [w]) are all unattested and ruled out as possible syllables through language-specific phonotactic restrictions. With these generalizations in place we can consider the possible syllable combinations of CG and G onsets with rimes in (41).

Fig. (41) Syllable Inventory Format 4 – CG and G combinations

	a:	ei	ɛ:	ou	ɔ:	ɯ:
j~ʑ	+	X	+	+	+	+
w	+	+	+	+	-	-
ɥ	-	-	+	-	-	-
p^{j}	+	X	+	-	+	+
p^{hj}	+	X	+	+	+	+
m^{j}	-	X	+	+	+	+
t^{j}	-	X	+	+	-	+
t^{w}	-	+	-	X	+	-
t^{hj}	-	X	+	+	-	+
t^{hw}	-	+	-	X	+	-
$n_{ʲ}$	+	X	+	+	+	+
l^{j}	+	X	+	+	+	+
l^{w}	+	+	-	X	+	-
tɕ	+	X	+	+	+	+
$tʃ^{w}$	+	(-)	+	X	+	-
$tɕ^{h}$	+	X	+	+	+	+
$tʃ^{hw}$	+	(-)	+	X	+	-
ɕ	+	X	+	+	+	+
$ʃ^{w}$	+	(-)	+	X	+	-
k^{w}	+	+	+	X	+	-
k^{hw}	+	+	+	X	+	-
x^{w}	+	+	-	X	+	-

The inventory of glide or consonant-glide combination onsets in Zhàozhuāng Bái includes 22 items. Note that rimes [i], [u], and [y] cannot co-occur with these kinds of

onsets. This leaves six possible specified rime with these onsets: [aː], [ei], [ɛː], [ou], [ɔː], and [ɯː]. In total the ratio of attested to possible syllables is 86:132, the attested syllables take up approximately 65.1% of the available space in the table. However, many of the gaps can be explained and, therefore, removed from the available space. These explicable gaps are indicated by an 'X' in the syllable inventory. For instance, there are large systematic gaps between syllables with the equivalent glide in the onset and vowel in the coda position of the rime (ex. syllables such as *[t^{j}ei] or *[t^{w}ou] are consistently unattested), this is discussed in further detail in 6.5. In total there are at least 20 and at most 23 pricinipled systematic gaps depending on if the dental sibilant and [w] combinations are interpreted as palatalized. Since these gaps are principled, the available syllable space is reduced to at least 109. Therefore, the revised ratio of attested to available syllables in (41) is 86:109 thus the attested syllables combining glide onsets with vowels and consonant-glide onsets with vowels make use of approximately 78.8% of the available syllable space.

I have shown that the [C^{G}VX] syllable structure format of phonological decomposition configuration can offer better coverage of the attested to possible syllables than the prior formats through specification of the phonological units in (38) within this fixed syllable structure. However, note that I have not accounted for syllables with rimes transcribed with the apical vowel <ɿ> nor the labiodental nucleus <ʏ>. My analysis of these syllable types assumes that these syllables have no specified nuclear vowel in underlying representation. In brief, these syllables are derived from a procedure which takes specific features from an onset and spreads those features into the rime. For example, the syllable [tsʐ̩] is derived from an underlying /ts/ in my proposal. The process

is somewhat elaborate and is thoroughly explained in 7.2. An appealing consequence of this spreading analysis is that all syllables with such nuclear segments can be accounted for without any unexplained gaps. Although this chapter has focused on the phonotactic possibilities from Zhàozhuāng data, the majority of the phonotactic generalizations can be observed in the other varieties of Mainstream Bái. While there are larger gaps in attested contrastive syllables for oral and nasal rimes in Jiànchuān and Hèqìng Bái, there is no principled reason in the phonology why certain onset and rime combinations have only one option for vowel nasalization. I speculate that this is largely dependent on whether such lexical items were nasalized in the original Chinese borrowing. Aside from these gaps which are probably interrelated with borrowed lexical items, the segmental combinations of consonants, glides, and vowels are largely the same across these varieties. The next section presents additional evidence for the proposed Bái syllable structure independent of phonotactic generalizations.

4.4 Additional Evidence for Bái-Specific Generalizations

The literature on sub-syllabic constituency of pre-nuclear glides suggests that constituency can be inferred from surface sound patterns, sound change, poetry, speech errors, and word games (Ohala 1986, Yip 2003). In this section I consider rhyming patterns in poetry and reduplication (which resemble generalizations regarding word games). These patterns are thoroughly documented in DUÀN Líng (2008a) and I only present a brief outline of the relevant data because the patterns are regular and exceptionless. The rhyming patterns observed in Bái poetry are discussed in sub-section 4.4.1. The Bái reduplication patterns are introduced in sub-section 4.4.2. The relevant generalizations are summarized in 4.4.3.

4.4.1 Rhyming Patterns in Bái Poetry

There are three major genres of Bái poetry. In the Chinese language reference on Bái poetry, *Báizú Qǔcí Gélǜ Tōnglùn* [白族曲词格律通论] (DUÀN Líng 1997:35), these genres are referred to as *Dǎgē* 打歌, *Hànqǔ* 汉曲, and *Báiqǔ* 白曲. These genres have different kinds of restrictions regarding number of syllables in a line, number of lines in a stanza, and which syllables need to rhyme. Despite these differences across genres, two syllables are considered to be good rhyming pairs if the nuclear vowel belongs to one of five groups described in DUÀN Líng (1997:35) tabulated in (42) and contrastive nasalization does not affect ability to rhyme. The table in (42) is organized as follows. The five groups are listed in the top row. These rhyme groups are transcribed in the Bái orthography as in the original source in the middle row. My reinterpretation of these phonological categories into specified segments within the $C^{G}VX$ syllable template is listed in the bottom row.

Fig. (42) Rhyme Groups in Bái (DUÀN Líng 1997)

	Group [i:]	Group [ɛ:]	Group [a:]	Group [u:]	Group [e:]
Orthographic Rime Groups	<i>, <ei>, <ui/y>	<ai>, <er>, <uai>, <uer>, <iai>, <ier>	<a>, <ua>, <ia>	<u>, <o>, <io>, <iou>, <ou>, <ao>, <uo>, <v>	<e>, <ie>, <ɿ>
Phonological Rime Groups	[Ci:], [Ce:], [C^{w}e:], [Cy:]	[Cɛ:], [Cɚ:], [C^{w}ɛ:], [C^{w}ɚ:], [C^{j}ɛ:], [C^{j}ɚ:]	[Ca:], [C^{w}a:], [C^{j}a:]	[Cu:], [Co:], [C^{j}ɔ:], [C^{j}o:], [Cɔ:], [Cɑo], [C^{w}o:], [Cɣ:]	[Cɯ:], [C^{j}ɯ:], [Cʐ̩:]

The rhyme grouping in (42) suggests that pre-nuclear glides do not impact ability to rhyme in Bái. This is borne out in the poetic excerpts discussed in the text. Furthermore, some nuclear segments are able to rhyme with others. While it is not clear

from the table in (42) alone why so many nuclear vowels can rhyme with one another, it is clear that this generalization is supposed to accommodate a wide range of varieties as the poetic excerpts are attributed to a wide span of Bái communities.

There are two important generalizations to note from the information in (42). First, the presence or absence of pre-nuclear glides does not affect the ability to rhyme thereby supporting our proposal that pre-nuclear glides are affiliated with the onset. Second, the nuclear [ʐ̩] (as indicated by [Cʐ̩:]) can rime with [ɯ] but not [i]. This suggests more similarity between these two rimes than rimes [ʐ̩] and [i] thereby presenting evidence against the common assumption that [i] and [ʐ̩] are allophones of the same rime category (either directly stated or tacitly implied in many works). Discussion in the next sub-section outlines similar patterns observed in Bái reduplication data.

4.4.2 Reduplication in Bái

Reduplication is a productive word-formation process in Bái. In this section I introduce one type of reduplication in Bái which I refer to as "L~L" reduplication. In "L~L" reduplication, a disyllabic base becomes tetrasyllabic through epenthesis of two reduplicant syllables, one after each base syllable. The reduplicant syllables consist of onset [l] and the rime of the base syllable. DUÀN Líng (2008b) presents 93 examples of L~L reduplication and I select nine of these examples (tones omitted) for discussion as reproduced in (43).

Fig. (43) Examples of Bái L~L Reduplication

	Base	Surface Reduplicant	Notes
(a)	[pi pa]	[pi li pa la]	No change
(b)	[ts^{h}u kɯ]	[ts^{h}u lu kɯ lɯ]	No change
(c)	[ti t^{j}o]	[ti li t^{j}o lo]	Pre-nuclear [j] in second syllable not copied
(d)	[pe xɛ]	[pe le xɛ lɛ]	No change
(e)	[s^{w}ɛ kɛ]	[s^{w}ɛ lɛ kɛ lɛ]	Pre-nuclear [w] in first syllable not copied
(f)	[ɕy ɣɯ]	[ɕy li ɣɯ lɯ]	Nuclear [y] from first syllable becomes [i] in reduplicant.
(g)	[p^{h}i k^{hw}ɛ]	[p^{h}i li k^{hw}ɛ lɛ]	Pre-nuclear [w] in second syllable not copied
(h)	[pi sz̩]	[pi li sz̩ lɯ]	Nuclear [z̩] becomes [ɯ] in reduplicant
(i)	[p^{j}ɛ ka]	[p^{j}ɛ lɛ ka la]	Pre-nuclear [j] in first syllable not copied

Two important generalizations regarding the L~L reduplication data can be summarized as follows. First, pre-nuclear glides from the base never appear in the reduplicant (43c,e,g,i) regardless of whether the pre-nuclear glide was present in the first or second syllable of the base. Second, if the nucleus of the base is not a possible syllable following onset [l], a repair is made. Since [ly] is not a possible syllable in Bái, the nucleus of the reduplicant becomes unrounded [i] (43f). Since [lz̩] is not a possible syllable in Bái, the nucleus of the reduplicant becomes vowel [ɯ] (43h), which I argue in chapter 7 to the default epenthetic vowel. This repair is particularly important because it further supports the proposal that [i] and [z̩] are dissimilar in phonological representation and do not belong to the same phoneme.

4.4.3 Summary of Relevant Generalizations

The independent, but related, patterns of rhyming and reduplication support the generalizations regarding underlying representations and syllable structure in Bái discussed throughout 4.3. The patterns are regular and consistent with the predictions we have made about the phonological system of Bái. However, some work in phonological theory suggests that the onset-rime distinction is unnecessary (Pierrehumbert & Nair

1995, Yip 2003) since pre-nuclear glides have been shown to have variable treatment in speech error data. Although I am not aware of such data available for Bái and even if the patterns exhibit inconsistent patterning for the pre-nuclear glides (or the spread fricatives, epenthetic vowels, etc), this kind of evidence simply suggests that speakers can make errors in the transduction between the gestural score produced by the articulatory system and the linearization and specification of underlying articulator-based feature bundles in phonological representation. While this kind of data can support an argument for generalizations regarding distributions, such inconsistent patterns are simply less persuasive than a phonemic analysis dependent on syllable structure which can dictate why certain syllables are possible while others are not attested.

4.5 Discussion

This section compares the syllable inventory possibilities of the four different formats of phonological decomposition introduced in this chapter as applied to the Zhàozhuāng variety. Although I have provided support for my proposal appealing to phonemic economy and coverage of attested syllables within the scope of possible syllables, the other formats have their own strengths. Treating the palatals as distinct from the dental sibilants is not trivial. It both allows the apical vowel [ɿ] to be an allophone of [i] and also explains why the place of articulation for these consonants is different than the place of dental sibilants (i.e. this configuration helps explain why the palatals [tɕ, tɕ^{h}, ɕ] do not appear as palatalized dental sibilants [ts^{j}, ts^{hj}, s^{j}]). Furthermore, those formats of phonological description provide a manner to represent all contrasts in Bái without needing to discretely decompose the phonological system into consonants, glides, and vowels. Accordingly, it is not surprising that formats 1 and 2 are appealing to

many researchers and are assumed in nearly all recently published work on the language despite the fact that the analysis offered by Dell (1981) format 3 predates the majority of Bái language references in common circulation.

However, upon tabulation of possible syllable vectors, the biggest weakness of these formats is made explicitly clear – these formats cannot explain why large numbers of syllables cannot occur. Format 3 is a step in the right direction in this regard. The coverage of attested to possible syllables is improved considerably if the palatals are treated as allophonic variants of the dental sibilants. However, there are two weaknesses with the format and analysis in Dell (1981). First, the small amount of data considered (1000 lexical items) leads to ambiguity of true contrast due to lack of true minimal sets. Second, the phonological environments fom Dell (1981), while logical and typical of phonological systems, do not reflect the reality of sub-syllabic constituency in this language as reflected by the generalizations of rhyming and reduplication data.

This chapter serves the purpose of providing phonological architecture to representations of phonetic transcription. In section 4.3 I suggest that the sub-syllabic configuration in my analysis provides for a more economical account of segmental phonemics. This is accomplished by treating the palatals as allophonic variants of the dental continuants and treating the rimes transcribed with the apical vowel <ɿ> and the labiodental nucleus <ɣ> as derived from feature spreading to fill underspecified content in the rime of a syllable. The account I present in this chapter describes the former and alludes to the latter. I address both of these processes in detail in chapter 7 through visual presentation of phonological representation which I refer to as Articulator Instruction Phonemics. This method of presentation is formalized in chapter 5.

Chapter 5. Representing Bái Contrast in AIP

This chapter presents an original format for visual presentation of the representation of phonological contrast combining components from the following works: Ladefoged & Halle (1988), Browman & Goldstein (1989), Halle (2005), Kehrein & Golston (2004), Sān DUĀNMÙ (2008), Golston & Kehrein (2015), Sān DUĀNMÙ (2016). I refer to this format as 'Articulator Instruction Phonemics' or 'AIP'. The assumptions I follow in analysis of phonological contrast are summarized as follows. Phonological contrasts are generated through linear-ordered instructions in the form of binary feature values along articulator-based feature tiers. These instructions affiliate to fixed positions in syllable structure and can spread to other positions under particular conditions. Although relevant contrasts in Bái phonology are the focus of this dissertation, the AIP method of visualizing phonological contrast can be applied to any language data. The assumed phonological architecture maintained in the phonological analysis of Bái is outlined in section 5.1. Section 5.2 offers an introduction of feature specification for the segments of Bái in articulator-based features. Section 5.3 expresses the contrast between syllables with and without pre-nuclear glides in AIP tabulation. Section 5.4 concludes this chapter with reference to the application of this framework to the underlying specification of rimes in chapter 6 and spreading processes in chapter 7.

5.1 Assumed Phonological Architecture

The phonological inventories and syllable inventory tables introduced in chapter 3 suggest that the inconsistent treatment of pre-nuclear glides, palatal consonants, and

syllable nuclei transcribed as fricatives has lead to ambiguities in the synchronic representation of phonological contrast for this language. Before I delve into these inconsistencies, discussion begins with an informal definition of contrast as expressed in (44).

(44) Informal Definition of Contrast

> Sounds A and B are contrastive if and only if they can distinguish meaning in the same environment.

For instance, the sounds [d] and [t] are contrastive in English because they distinguish the words *do* [du] and *too* [tu] when placed in the same environment (phonological environment '#_u' which is expressed as word-initial position before the vowel sound [u] in words). On the other hand, these sounds are not contrastive with the tap [ɾ] in particular varieties of English (including my own) because, although these sounds differ in manner of production, there are no environments shared between the tap [ɾ] and the stops [d] and [t]. In brief, the tap only occurs in contexts between two vowels in which the second is unstressed, as in the word *butter* [ˈbʌ.ɾɚ]). Conversely, the sounds [d] and [t] are never produced in such contexts for speakers who speak varieties of English in which tapping applies: the word *butter* is not pronounced [ˈbʌ.tɚ] for tapping speakers. Furthermore, most people who speak English do not feel that the tap is a distinct sound from either [d] or [t] as is supported by the absence of a distinct letter for this sound in English orthography. In brief, any two sounds are considered to be contrastive if they distinguish meaning in the same environment (i.e. [d] and [t] are contrastive before vowels) and non-contrastive if they do not distinguish meaning in the same environment (i.e. [t] and [d] become [ɾ] in between a stressed and a stressless vowel).

As I explain in chapters 3 and 4, the environments required to describe sounds as contrastive are either blurred or inaccurate in the transcriptions of Bái syllables in prior research. In chapter 4 I demonstrate that these environments can be made explicit within the well-defined [$C^{G}VX$] syllable template. This template not only makes phonological environments simple to describe, it also helps explain certain patterns of linear ordering for the gestures made in the production of well-formed Bái syllables. In this chapter I offer an account of linearization of feature bundles corresponding to segments and tonal units in monosyllabic morphemes. This linearization procedure provides a mechanism to affiliate feature bundles to particular syllable positions as necessary to generate contrastive syllables. In chapters 6 and 7 I further show that this mechanism, along with necessary underspecification (in the sense of Archangeli 1988, Keating 1988, Rice 1995) of particular elements in underlying representation facilitates definition of the range of possible variation attested in contrastive surface syllables across speakers of Bái.

This section outlines the assumed phonological architecture through AIP visualizations with the particular purpose of defining the major kinds of contrasts observed in Bái. Discussion begins in 5.1.1 with an introduction to the mapping between underlying and surface representations. Sub-section 5.1.2 introduces the nature of articulator-based features. Sub-section 5.1.3 introduces the assumed timing units and syllable structure architecture. Sub-section 5.1.4 summarizes the broader consequences of this framework in the relevant literature.

5.1.1 Underlying and Surface Representations

I assume a generative model of phonology which uses distinctive features and syllable structure to generate phonological contrasts. Discussion throughout this

dissertation assumes both underlying and surface representations, but these levels of representation have not been explicitly introduced until this sub-section as the characterizations of these levels are typical of most theories of phonology. In the previous section, I suggest that to optimize economy surface representations are derived from a minimal amount of specified information in corresponding underlying representations. Aside from accounting for possible and impossible phonological forms, this economy optimization has another desirable consequence – we do not need to commit to a strictly linear model of phonological specification.

Most phonological frameworks with substantial numbers of subscribers in the field assume that the phonological component of grammar applies transformations from an underlying representation to a surface representation. These mappings are called *derivations* and are typically formatted as follows. Underlying representations and surface representations are transcribed as sequences of phonetic cover symbols representing bundles of features corresponding to morphemic roots such that the underlying representation is specified in between slashes '/ /', the surface representation is specified in between brackets '[ ]', and the mapping between these two forms is indicated by an arrow symbol. Generally mappings are described from underlying to surface so that the relevant mappings for the English words 'cats' and 'dogs' are formalized as /kæt+z_{Plural}/ → [kæts] and /dɔg+z_{Plural}/ → [dɔgz], respectively. These examples illustrate two important generalizations regarding phonological mappings. First, shared underlying forms can have multiple surface realizations. The noun pluralizing morpheme /z_{Plural}/ corresponds to [s] in 'cats' and [z] in 'dogs'; the selection of one surface realization over the other is determined by the context. Second, some

linearization must be assumed in phonological representations. The pluralizing morpheme /z_{Plural}/ generally does not stand alone and must be concatenated with a preceding noun root. Furthermore, the sequencing of the sounds in 'cat' must be specified in the linear order represented by the following subscript numbers /k_1 $æ_2$ t_3/ because reversing the /t/ and the /k/ yields the morpheme /t_1 $æ_2$ k_3/ → [tæk] 'tack' which is contrastive with 'cat'.

Linear ordering is implied based on the left-to-right ordering of phonetic cover symbols, but is not always necessary and sometimes impedes the accuracy of representations. For instance, the discussion of pre-nuclear glides in Bái suggests that the glide constrictions are coarticulated with consonants before non-high vowels; an underlying representation of /pja/ in which /p/ is produced before /j/ is therefore misleading and does not reflect simultaneous production of these two units in phonetic reality. Accordingly, several examples of underling representations in this dissertation use sub-script numbers to indicate obligatory ordering. While most generalizations about the nature of surface representations are directly observable, the true nature of underlying representations can only be inferred. Relevant generalizations about these levels of representation are summarized in (45).

Fig. (45) Relevant Generalizations about Underlying and Surface Representations

Underlying Representations	Surface Representations
• Contrastive constituents are defined as feature bundles	• Contrastive and non-contrastive constituents can be defined as feature bundles
• Unaffected by syllable structure	• Syllable structure can dictate transformations
• Linear ordering of constituents needs to be inferred based on contrastive minimal pairs or sets	• Linear ordering of constituents is straightforward and directly observable

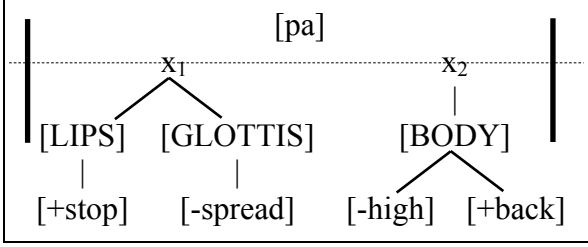
Theories of Generative Phonology generally assume that any segment or suprasegmental unit (i.e. tone) is actually a bundle of features; this generalization is true for both underlying and surface representations (Hale, Hissock & Reiss 2007). Underlying representations are generally believed to be unaffected by syllable structure and linear ordering of segmental and suprasegmental material needs to be inferred. Conversely, linear ordering of phonological constituents can be directly observed in surface representation. Furthermore, syllable structure requirements can dictate how strings of feature bundles are parsed into syllables and other phonological processes observed at this level. Despite the fact that these generalizations are maintained throughout the theoretical phonological literature, it is unclear just what mechanisms determine linear ordering and feature affiliation to sub-syllabic constituents in Bái due to an impoverishment of alternations in this language. That is, the theories about syllable structure and phonemic alternations are largely derived from language data which is typologically different from languages like Bái. In brief, strings of phonological data considered from these languages are typically polysyllabic, describe inflectional and sometimes nonconcatenative morphological paradigms, and have smaller numbers of tone categories (and require simpler feature specifications for their contrastive tones). In contrast, nearly all morphemes are monosyllabic in Bái and there is no productive tone sandhi in this language. Throughout the remainder of discussion I assume that bundles of features corresponding to segmental and tonal productions are minimally specified in linear order in underlying representations. The nature of articulator-based features is introduced in the next sub-section.

5.1.2 Articulator-based Features

Distinctive feature theories differ considerably with regard to the set of available features, the geometry or organization of these features, and availability of unary or binary specifications. The AIP framework strictly uses features which represent gestures of the articulatory system. Furthermore, all features are binary and bound to unary articulator nodes. These binary specifications are further bound to time slots specified in minimally specified linear order. The nature of the AIP framework is illustrated by the example syllable [pa] (without any tone or vowel lengthening) in (46) through both abstract and tier-based schematics. For simplicity the remaining AIP tables in this chapter follow the tier-based format.

Fig. (46) Abstact and Tier-based Schematics of [pa] in AIP

Abstract



Tier-based

	[p	a]
[ARTICULATOR]—[Gesture]	x_1	x_2
[LIPS]—[stop]	+	
[BODY]—[high]		-
[BODY]—[back]		+
[GLOTTIS]—[spread]	-	

The same information is provided in each of the schematic diagrams in (46). In both diagrams, a timing slot branches into a unary articulator which then branches to one or more features each taking binary specifications. The complete, finite set of articulator-based features is provided in (47). The ordering of specified feature bundles can be specified in timing units (which correspond to 'x' in the schematics). The affiliation of features to one bundle or another is dictated either by syllable structure or the avoidance of impossible feature combinations. For instance, in (46) the feature bundles for [p] and [a] must be specified in the observed order because Bái only has CV syllables and not VC

syllables. On the other hand, if we consider a syllable like [pʲa], then the feature bundles corresponding to the segments [i] and [a] must be ordered in relation to one another because the tongue body cannot be specified as [+high] and [-high] simultaneously. At the same time the bundle for [i] does not need to linearize with [p] because glides can coarticulate with stops in the syllable structure template defined for Bái. Discussion now turns to the nature of the articulator-based features used in this framework. The table of available features is provided in (47).

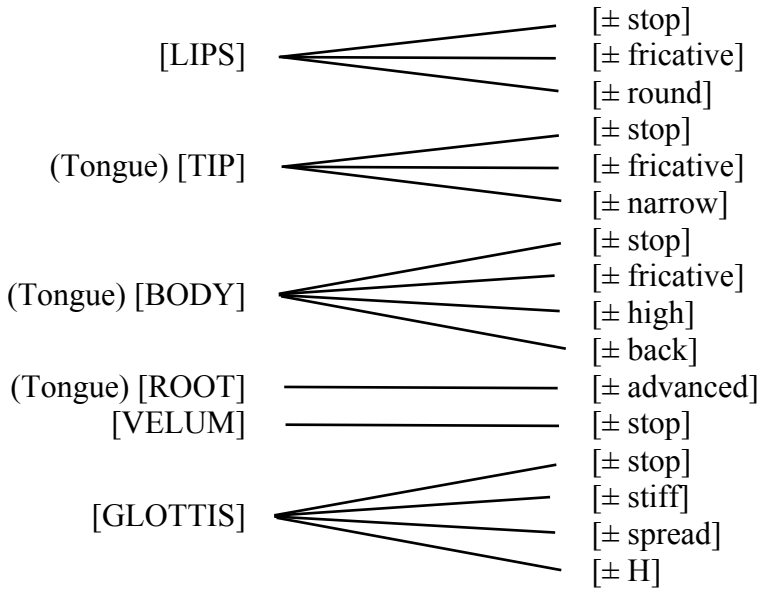
Fig. (47) Set of Articulator-based Features (adapted from Sān DUĀNMÙ 2016)

[ARTICULATOR]	[Manner]	[Others]
[LIPS]	[stop], [fricative]	[location], [round]
[TIP]	[stop], [fricative]	[location], [narrow]
[BODY]	[stop], [fricative]	[high], [location]
[ROOT]		[advanced]
[VELUM]	[stop]	
[GLOTTIS]	[stop]	[stiff], [spread], [H]
[LARYNX]		[raised]

Sān DUĀNMÙ (2016) proposes an original feature system through a systematic and rigorous comparison of attested contrasts across several hundred phonological inventories. This work reviews the well-known and commonly-cited feature systems ranging from Jakobson, Fant & Halle (1952), Chomsky & Halle (1968), Clements (1985), Clements & Hume (1995), Browman & Goldstein (1989), Halle (1995), and Ladefoged (2007). These systems vary considerably from one another in nearly all aspects; each theory has a different total number of features, offers different availability of binary and/or unary feature specifications, and uses features characteristic of auditory, acoustic, and/or articulator properties. Sān DUĀNMÙ (2016) demonstrates that all contrasts in languages of the world can be generated by features strictly defined as gestures of the articulators. The finite set of available features consists of a combination of one of the

unary articulators in the left column and one of the gesture features in either the 'manner' or 'other' columns with the exception of the [location] feature which collapses two or more binary constriction locations. Bái only uses one of these features ([BODY]—[back]), so I choose not to address the nature of these location features in this discussion. The subset of features used in Bái phonology are presented in abstract representation in (48) followed by discussion of deviations from common distinctive features in the literature.

Fig. (48) Subset of Articulator-based Features used in Bái Phonology



Bái phonology uses six of the available articulators and in total needs 16 features to generate each of the attested contrasts. I briefly introduce the features in (48) which are not necessarily commonly assumed. Positive values of the features [stop] and [fricative] reflect stops (complete closure) and fricatives (closure with slight opening), as expected, but affricates are specified with positive values for both of these features. Such specification is somewhat unusual because a sound is generally not simultaneously described as being a stop and a fricative. This specification can be motivated as follows.

Affricates in Bái pattern as single consonants beginning with a stop constriction followed by a fricative constriction. That is, there is no contrast between [st] and [ts] in the onset of a Bái syllable. Accordingly, there is no need to order these two features in underlying representation nor is there a need to introduce an additional feature to distinguish these kinds of consonants from stops or fricatives. Another rationale for this double positive specification comes from Sān DUĀNMÙ (2016:171) who argues that this specification is possible because [fricative] represents an edge constriction of an articulator independent of the constriction gesture made by [stop]. This means that a sound which acts as a single contrastive unit can simultaneously be specified for [stop] and [fricative] with the ordering dictated by restrictions of the articulatory tract. The dental/alveolar lateral [l] is typically represented with a [+lateral] feature specification; the feature theory introduced here replaces this feature with [+narrow] under the assumption that lateral consonants are made with a narrowed tongue tip (Ladegfoged 1980:492, Sān DUĀNMÙ 2016:142). Nasality is specified by [VELUM]—[±stop] which describes the action of the velum during oral or nasal production; that is, a closed velum [+stop] prevents air from entering the nasal cavity whereas an open velum [-stop] releases air through the nasal tract. Since voicing and aspiration are defined by gestures of the glottis, voicing is specified as [±stiff] in which [+stiff] vocal cords represents the gesture producing voiceless constrictions and [-stiff] vocal cords represents the gesture producing voicing. Aspiration, on the other hand, reflects spreading of the vocal cords. Specified [+spread] produces aspiration whereas [-spread] yields an absence of aspiration. Pitch is the consequence of cricothyroid movement as is represented with [GLOTTIS]—[H]; I return to the description of this feature in chapter 6. Discussion in the next sub-section turns to the

mapping between underlying feature specifications and surface environments in syllable structure.

5.1.3 Underlying-to-Surface Mappings as Phonological Contrast

Bái is a language in which nearly all morphemes are monosyllabic and alternations between phonologically contrastive units are not obvious because these changes are not conditioned by adjacent morphemes. My descriptions of synchronic phonological processes in Bái assumes that features can spread from onset-to-rime (fricative, round, nasal spreading), rime-to-onset (palatalization and other vocoid spreading), and nucleus-to-coda (vowel and/or tone lengthening compensation). I explain these processes in chapters 6 and 7 but define the procedure by which features map surface environments in syllable structure for the remainder of this section. The phonological contrasts in underlying and surface representations are specified as bundles of articulator-based features affixed to timing slots (schematized as 'x'). At the level of surface representation the timing slots are fixed and correspond to the onset (x_{ons}), nucleus (x_{nuc}) and coda (x_{cod}) positions of the syllable.[19] On the other hand, the ordering and feature specification is underspecified as much as possible in underlying representation. The transformations from underlying-to-surface mappings generally manifest themselves in the form of spreading across the ordered timing slots to the three fixed timing slots specified by syllable structure. I discuss the mechanics of the feature specification, timing slots, syllable structure, and linearization through schematic representation of underlying-to-surface mappings in the next section; however, I introduce the format of formal AIP tables for the remainder of this sub-section. The

[19] I choose not to use the positions CVX to avoid confusion of timing slot 'x' and the 'X' position from the syllable structure template, however, the CVX positions are exact equivalents to the syllable structure timing slots x_{ons} x_{rim} x_{cod}.

format of AIP analysis uses parallel underlying and surface representation "AIP tables" as in (49).

Fig. (49) Underlying-to-Surface AIP Tables

Underlying

	/		/
	x_1	$x_{...}$	x_n
[LIPS]—[stop]			
[LIPS]—[fricative]			
[LIPS]—[round]			
[TIP]—[stop]			
[TIP]—[fricative]			
[TIP]—[narrow]			
[BODY]—[stop]			
[BODY]—[fricative]			
[BODY]—[high]			
[BODY]—[back]			
[ROOT]—[advanced]			
[VELUM]—[stop]			
[GLOTTIS]—[stop]			
[GLOTTIS]—[stiff]			
[GLOTTIS]—[spread]			
[GLOTTIS]—[H]			

Surface

	[		]
	x_{ons}	x_{nuc}	x_{cod}
[LIPS]—[stop]			
[LIPS]—[fricative]			
[LIPS]—[round]			
[TIP]—[stop]			
[TIP]—[fricative]			
[TIP]—[narrow]			
[BODY]—[stop]			
[BODY]—[fricative]			
[BODY]—[high]			
[BODY]—[back]			
[ROOT]—[advanced]			
[VELUM]—[stop]			
[GLOTTIS]—[stop]			
[GLOTTIS]—[stiff]			
[GLOTTIS]—[spread]			
[GLOTTIS]—[H]			

The AIP tables in (49) are structured as follows. The phonological form, either underlying or surface (as appropriately indicated by slashes or brackets), appears in the top right corner box. Directly below the phonological form are timing slots. In underlying representation, these timing slots are ordered left-to-right from 1 to *n* in which *n* represents the total number of articulator instruction feature bundles; I return to the nature of specification of underlying timing slots in the next section. Since the focus in this dissertation is on the mappings between underlying and surface structures in monosyllabic morphemes, the underlying timing slots and surface representations have, at most, the three slots dictated by syllable structure in the AIP tables presented

throughout discussion in the next section 5.2. The leftmost column lists unspecified articulator-based features. The tables in (49) offer the exhaustive inventory of articulator-based features used in Bái; however, underlying-to-surface mappings in AIP tables generally use a small subset of these features because only the features absolutely required by minimum specification of attested contrasts should be included in a given table. Although the top-to-bottom ordering of the features in (49) is loosely determined by height in the articulatory tract, the abstract nature of these features requires no set ordering; I simply use this ordering in AIP tables for simplicity and consistency.

5.1.4 Summary of Framework

It is commonly assumed that strings of segments and suprasegmental material are defined as bundles of specified distinctive features in phonological theory (Hale, Hissock, & Reiss 2007). Feature theories in the literature classify distinctive features by acoustic properties, auditory properties, articulatory properties, or some combination of these three kinds of properties. The AIP framework argues for a system of phonological features strictly defined by articulatory principles. In doing so, the nature of mapping underlying to surface representations is understood to directly reflect changes, or "instructions", sent from phonological component of grammar to the articulatory system. This is a particularly appealing because it facilitates transduction between phonology and gestural mappings through direct statement-based instructions (i.e. [LIPS]—[+round] instructs the articulatory system to make a rounding gesture of the lips), it makes use of the finite number of articulator-based features attested across languages of the world, and it complements the motor theory of speech perception which hypothesizes that the objects of speech perception are a speaker's intended gestures (Liberman & Mattingly 1985). In

brief, the articulator-based features introduced in this section simultaneously appeal to a variety of concerns in representations of phonological contrast. The next section addresses issues of feature specification.

5.2 Feature Specification of the Contrastive Consonants in Bái

With a brief summary of articulator-based features outlined for the reader, discussion is redirected to the feature specifications of the phonologically contrastive units in Bái. Because vowel inventories and tone systems differ across communities of speakers I do not get into detail about the specification of vowels and tones until chapter 6. In this section, however, I define the principle by which features are assigned to underlying bundles of phonologically contrastive units – the components typically referred to as consonants, glides, vowels, tones, etc. In doing so I offer feature specification for each of the consonants and allude to the specification of glides, vowels and tones.

Theories of feature specification vary considerably with regard to how many or how few features need to be specified for a given phonological unit (Archangeli 1988, Keating 1988, Dresher 2009). However across theories there is a consensus that if any two given units contrast meaning in a defined environment, those two units need to be specified differently in terms of features (Sān DUĀNMÙ 2016:156). The approach to feature assignment in this dissertation assumes a considerable amount underspecification and can be summarized as follows. For any two given units which are demonstrated to be contrastive, the features of those two units should be specified in a manner which minimally distinguishes them from one another in terms of the gestures corresponding to

those units. To make the situation simple, assume that each of the consonants in Bái (listed in (50)) is contrastive before a single vowel such as [a], for instance.

Fig. (50) Bái Consonants [21]

[p, p^h, m, f, f^h, v, t, t^h, n, l, ts, ts^h, s, s^h, z, k, k^h, ŋ, x, x^h, ɣ]

This inventory includes stops, fricatives, affricates, nasals, and a lateral segment. For a given articulator, only stops and affricates contrast for aspiration, fricatives exhibit a three-way contrast among voiced, voiceless unaspirated, and voiceless aspirated, and the nasals and lateral do not contrast for phonation. I specify the features for each consonant under the assumed approach in (51). The fricatives which are marked with a '*' symbol are not found in each variety of Bái. The varieties which lack these fricatives require different feature assignments for the other fricatives of the same place (i.e. the specified features required to distinguish the three-way contrast [f]-[f^h]-[v] are not the same as those required to distinguish the two-way contrast [f]-[v]); the revised feature assignment for the varieties with reduced inventories of fricatives is addressed in the discussion following the table.

Fig. (51) Feature Specification for Bái consonants

[p]	[LIPS]—[+stop]; [GLOTTIS]—[-spread]
[p^h]	[LIPS]—[+stop]; [GLOTTIS]—[+spread]
[m]	[LIPS]—[+stop]; [VELUM]—[-stop]
[f]	[LIPS]—[+fricative]; [GLOTTIS]—[-spread]
[f^h]*	[LIPS]—[+fricative]; [GLOTTIS]—[+spread]
[v]	[LIPS]—[+fricative]; [GLOTTIS]—[-stiff]
[t]	[TIP]—[+stop]; [GLOTTIS]—[-spread]
[t^h]	[TIP]—[+stop]; [GLOTTIS]—[+spread]
[n]	[TIP]—[+stop]; [VELUM]—[-stop]
[l]	[TIP]—[+narrow]
[ts]	[TIP]—[+stop],[+fricative]; [GLOTTIS]—[-spread]
[ts^h]	[TIP]—[+stop],[+fricative]; [GLOTTIS]—[+spread]
[s]	[TIP]—[+fricative]; [GLOTTIS]—[-spread]
[s^h]*	[TIP]—[+fricative]; [GLOTTIS]—[+spread]
[z]*	[TIP]—[+fricative]; [GLOTTIS]—[-stiff]
[k]	[BODY]—[+stop]; [GLOTTIS]—[-spread]
[k^h]	[BODY]—[+stop]; [GLOTTIS]—[+spread]
[ŋ]	[BODY]—[+stop]; [VELUM]—[-stop]
[x]	[BODY]—[+fricative]; [GLOTTIS]—[-spread]
[x^h]*	[BODY]—[+fricative]; [GLOTTIS]—[+spread]
[ɣ]	[BODY]—[+fricative]; [GLOTTIS]—[-stiff]

The consonant inventory in (51) includes each of the underlying consonants that can fill the C slot in the C^GVX syllable structure. The phonation specifications for the five classes – stops, fricatives, affricates, nasals and laterals need to be specified as minimally distinct from the gestures made by the movable articulators. Since nasal consonants are specified by a stop closure at their movable articulator and these segments are contrastive with the oral stops, this contrast is simply indicated by the feature which distinguishes these segments: [VELUM]—[-stop]. While nasals are voiced by default, underspecification of [stiff] allows for some variability in voicing in production. Furthermore consider the difference in specification between the stops/affricates and the fricatives. The two-way contrast in stops and affricates only needs to be specified by [spread] while the three-way contrast in fricatives is specified by [spread] for the

voiceless fricatives and specified by [-stiff] for the voiced fricatives. While the vocal cords are stiff during production of voiceless fricatives, redundant specification [+stiff] blocks the ability for any variability in voicing quality. Interestingly, the Jiànchuān and Ěrhǎi varieties lack the aspiration contrast for voiceless fricatives so the remaining fricatives (voiced and voiceless) are only specified for [stiff]. Furthermore, the Jiànchuān variety does not contrast the dental fricatives [s] and [z], and accordingly [s] is specified as [TIP]—[+fricative] for speakers who lack the aforementioned contrast.

Discussion of specification in this section concludes with a brief summary regarding feature specification of glides, vowels, and tones. I follow a common assumption (Goldsmith 2011) that glides and vowels are not distinct in terms of features. Accordingly the combined class of glides and vowels are strictly defined in terms of the gestures which distinguish the complete set of contrasts from one another. For instance, although vowels are generally voiced, the specified feature [GLOTTIS]—[+stiff] is not included in the feature bundles for these units. This means that glides/vowels are only specified for backness and height of the tongue body and the rounding of the lips. The underspecification of features on the glides/vowels is crucial for two reasons. The features of the tone categories make use of the feature [GLOTTIS]—[stiff] typically representative of voicing and since tone features must map to the nucleus (and coda if applicable) in syllable structure, the features for nuclear vowels cannot be in conflict with the tone features. On the other hand, the glides need to be able to co-articulate with consonants before a nuclear vowel in the onset position of a syllable. This similarly means that specifications for voicing may conflict for a given onset consonant and therefore such conflict needs to be avoided in the underlying representation of vowel

segments. The specification of vowels and tones is elaborated on further in chapter 6. The next section previews some aspects of the specification of these contrastive units.

5.3 Contrasting CV and CGV Syllables in Bái

This section presents a formalization of the contrast between syllables with and without a pre-nuclear glide in the AIP framework. Although the nature of feature bundles is intended to be generalizable across languages, underlying and surface phonological representations are subject to certain language-specific properties. First, lexical items are represented by language-specific strings of feature bundles. For instance, although English and Bái (or any two given languages) have an item in their lexicons meaning 'eight', the phonological representations for these items must differ considerably because this item is produced as [eit] in English and [$p^{j}a:^{44}$] in Bái. Although transformations between a shared underlying form and these two surface representations are possible in theory, the amount of changes which would need to be proposed make the possibility of a shared underlying representation nearly impossible. Second, transformations from underlying representations to surface representations are subject to language-specific phonotactic generalizations. These considerations are particularly important to the discussion in this section because there are two language-specific generalizations which critically shape the nature of underlying-to-surface mappings in Bái. First, virtually all morphemes in Bái correspond to a single syllable with a specified tone. Second, high vowels specified before nuclear vowels in underlying representation affiliate to the onset of a surface syllable in Bái. I summarize the relevance of these generalizations regarding ordering of feature bundles in underlying representations in (54), but first present AIP tables representing the underlying-to-surface mappings for monosyllabic morphemes

/pa^{44}/→ [pa:^{44}] ‘collapse’ in (52) and /pia^{44}/ → [p^{j}a:^{44}] ‘eight’ in (53) to illustrate these principles.

Fig. (52) Underlying-to-Surface Mapping for /pa^{44}/ → [pa:^{44}]

Underlying

	/pa^{44}/			
	x_1	x_2	x_2	x_3
[LIPS]—[stop]	+			
[BODY]—[high]		-		
[BODY]—[back]		+		
[ROOT]—[advanced]		-		
[GLOTTIS]—[spread]	-			
[GLOTTIS]—[H]			-	
[GLOTTIS]—[stiff]			+	

Surface

	[pa:^{44}]		
	x_{ons}	x_{nuc}	x_{cod}
[LIPS]—[stop]	+		
[BODY]—[high]		-	:
[BODY]—[back]		+	:
[ROOT]—[advanced]		-	:
[GLOTTIS]—[spread]	-		
[GLOTTIS]—[H]		-	
[GLOTTIS]—[stiff]		+	

Tone: {[-H],[+stiff]}$_{2,3}$ {[-H],[+stiff]}$_{2,3}$

Template: C^G V X C^G V X

Segment: p_1 a_2 p_1 $a_{2,3}$

Fig. (53) Underlying-to-Surface Mapping for /pia^{44}/ → [p^{j}a:^{44}]

Underlying

	/pia^{44}/				
	x_1	x_1	x_2	x_2	x_3
[LIPS]—[stop]	+				
[BODY]—[high]		+	-		
[BODY]—[back]		-	+		
[ROOT]—[advanced]			-		
[GLOTTIS]–[spread]	-				
[GLOTTIS]—[H]				-	
[GLOTTIS]—[stiff]				+	

Surface

	[p^{j}a:^{44}]		
	x_{ons}	x_{nuc}	x_{cod}
[LIPS]—[stop]	+		
[BODY]—[high]	+	-	:
[BODY]—[back]	-	+	:
[ROOT]—[advanced]		-	:
[GLOTTIS]—[spread]	-		
[GLOTTIS]—[H]		-	
[GLOTTIS]—[stiff]		+	

Tone: {[-H],[+stiff]}$_{2,3}$ {[-H],[+stiff]}$_{2,3}$

Template: C^G V X C^G V X

Segment: p_1 i_1 a_2 p^j_1 $a_{2,3}$

The AIP tables follow the format introduced in 5.1.3. I include a syllable structure template with tone and segmental information to facilitate the mapping of feature bundles in underlying specification to fixed positions in surface representations corresponding to syllable structure. Since the AIP framework avoids speculation of feature specification and linear ordering to accommodate correspondences between underlying and surface representations, the absolute minimal amount of feature specification and ordering of feature bundles as possible is included in underlying representation. However, the $C^{G}VX$ template for Bái defines certain aspects of the necessary ordering. For instance, this template affiliates pre-nuclear glides to the onset (C^{G}), affiliates the vowel with highest sonority to the nucleus (V), and affiliates the tone features to the nucleus (V) and coda (X). This is in line with research in prosodic theories of contrast from Kehrein & Golston (2004) and Golston & Kehrein (2015) which state that an onset, nucleus, or coda has a single set of laryngeal features and that each margin of a syllable has a single unordered set of vocalic features, respectfully. Accordingly, a feature bundle in underlying representation includes the underspecified specifications of either a consonant, vowel, or tone unit and not some combination of features from these three units. Given these considerations, the principles by which I specify linear ordering of feature bundles in underlying representation are summarized in (54).

Fig. (54) Principles of Linear Ordering

i. Any two feature bundles in a morpheme with opposing binary values specified for at least one articulator-based feature must be ordered
ii. For two or more segmental feature bundles in a morpheme, the bundle corresponding to the most sonorous segment is ordered after any other bundles
iii. Bundles of tone features are independent from segmental bundles, but ordering is licensed by feature bundles corresponding to V or X positions

Principle (54i) is a variant of the No Contour Principle (Sān DUĀNMÙ 1994) which states that a feature cannot have opposing binary values within a single time slot. Consider the required ordering of the bundles corresponding to /i/ (subscript 1) and /a/ (subscript 2) in underlying representation for (53), for instance. These two segments must be ordered as /i/ includes feature specifications [+high] and [-back] for the tongue body whereas /a/ includes opposing features [-high] and [+back] for the tongue body. That is, the tongue body cannot simultaneously be [+high] and [-high] nor [+back] and [-back]. On the other hand, the feature bundles corresponding to /p/ and /i/ in (53) need not be ordered and are affiliated to the same time slot (both have subscript 1) because there is a feature bundle corresponding to /a/ (with subscript 2) specified after these bundles for this monosyllabic morpheme. In brief, the bundles corresponding to /p/ and /i/ can freely appear in alternating positions in underlying representation. This principle also dictates the ordering between tone feature bundles which correspond to contour tones (i.e. a rising tone is represented by two bundles of tone features, the first bundle is specified as [GLOTTIS]—[-H] and the second bundle is specified as [GLOTTIS]—[+H]). Feature specification for tonal contrasts is further addressed in discussion of principle (54iii) and in 6.3.1.

Principle (54ii) assigns linear specifications to segmental feature bundles based on sonority. Since all phonological forms in Bái fit into the fixed syllable structure template [C^{G}VX], the ordering of segmental feature bundles is dictated by phonological forms the of exemplar items in the Bái lexicon. In brief, for two or more segmental feature bundles, the bundle with the highest sonority (non-vocoid consonant (C) > vocoid (G) > non-vocoid vowel (V)) must be assigned to a time slot proceeding the time slot of any other

segmental bundles. This assignment procedure ensures that vocoid segments occupy the nucleus of a syllable if a non-vocoid vowel is not specified in the underlying representation of a syllable (i.e. the required mapping is /p_1 i_2/ → [pi] instead of /p_1 i_1/ → [p^j_]) and that consonant and glide feature bundles are not linearized relative to one another preceeding a non-vocoid vowel (i.e. the required mapping is /p_1 i_1 a_2/ → [p^ja], an underlying representation /p_1 i_2 a_3/ would not necessary map to [p^ja]). This ordering dictated by sonority is required because the feature bundles of any two given ordered constituents may not have opposing values for articulator-based features. For instance, the primary mechanism for the ordering of constituents provided by principle (54i) offers no formal procedure to order consonants and vowels since obstruents (such as [k]) and non-vocoid sonorants (such as [l]) do not have any incompatible features with vowels; that is, the position and height of the tongue body (as specified by opposing binary values for [±back] and [±high], respectively) do not conflict for vowels and the aforementioned classes of consonants in Bái. Furthermore, since research in Articulatory Phonology (notably Browman & Goldstein 1990) shows that the configuration of tongue body anticipates a vowel through the production of a preceeding consonant in consonant-vowel sequences, contradictory specification does not reflect articulatory reality and, therefore, stipulation of such contradictory specification is not a suitable strategy to derive the surface ordering of phonological constituents.

Principle (54iii) dictates the assignment of tone feature bundles. With regard to the specification of tone features, I list the bundles for these features after the bundle for the segment corresponding to the V position of the syllable template (although any bundles with the same subscript are interchangeable). Since the weight of a syllable is

directly determined by the phonologically specified tone in Bái and long level tones are not appreciably longer in duration than contour tones, long level tones occupy two time slots – the first of which corresponds to the V position in the syllable template and the second of which corresponds to the X position in the syllable template. I follow this practice because the lengthened specification of tone features triggers vowel lengthening which, accordingly, does not require contrastive underlying specifications for long and short vowels. In AIP tables, lengthening or spreading across surface syllable timing slots is indicated by the colon which implies that the adjacent feature specification is spread from that position into the position occupied by the colon. I justify the relationship between tone and vowel duration in chapter 6 with examples from various tone categories.

5.4 Summary

This chapter presents an outline of the mappings between underlying and surface representation in Bái phonology, partially through the assistance of AIP tables. Although this framework is applied to the phonological system of Bái in this description, this format of analysis is intended to be able to model phonological contrast in any language. Most of the architecture was independently developed in prior phonological research to handle a wide-range of inquiries, but the culmination of the selected architecture offers an explanatory account of the mappings between the underlying representation of speech gestures and surface forms dictated by syllable structure. Principle (i) from (54) is particularly elegant for dictating why certain bundles must be ordered in relation to one another. Furthermore, the mappings from underlying to surface representation in Bái are dictated by principles (54ii) and (54iii) and are supported by the generalizations regarding

syllable structure introduced in chapter 4, but are not necessarily maintained across other languages.

The phenomena examined in the next two chapters illustrate the mapping of underlying bundles of features to fixed positions in a surface syllable according to the principles introduced in (54). Because the features of vowels and tones are non-conflicting it is not obvious whether or not those units are distinct from one another in underlying representation. However, the approach to analysis of phonological contrast promoted in this dissertation, which is committed to optimizing economy in underlying representations of phonological forms, suggests that tone categories and vowel categories should be defined in distinct underlying bundles. This distinction simultaneously optimizes economy of total finite contrastive units and reduces the space of possible predicted syllables (i.e. we can search for and identify systematic gaps in terms of combinations of consonants, vocalic segments, and tones instead of consonants and combined vowel-tone units). Furthermore, the spreading processes introduced in chapter 7 not only reduce, but require, a minimal amount of phonological specification in underlying representation. Any unnecessary overspecification can block spreading and, as a consequence, reduce the ability of the grammar to generate surface syllables in a manner which is economical and considerate of the principled gaps in the language.

Chapter 6. Underlying Specification of Contrastive Rimes in Bái

This chapter presents an articulator-based feature account of the major distinct types of vowel and tone systems across varieties of Bái. Although I present a summary of the phonological inventories from the consulted references in 3.4, I have offered little analysis with regard to phonological representation of these contrastive categories. Furthermore, despite statements about the existence of variation across speakers in specific communities, I have offered little detail and analysis of this variation. As I define in this chapter, contrastive rimes consist of all of the phonological content specified after an onset consonant or consonant-glide combination. In underlying representation this includes the specified tone category along with monophthongs, diphthongs, and nasalized variants of these two kinds of vocalic units. Section 6.1 presents an outline for specification of articulator-based features for the vowel systems for two different varieties of Bái based on the attested contrasts from the textual sources introduced in chapter 3. Section 6.2 offers a feature-based account of the Ěrhǎi Bái system supported by primary phonetic data. Section 6.3 introduces the nature of tone feature specification. Section 6.4 presents an account of the variation attested in the tone systems across Ěrhǎi Bái. This chapter concludes in section 6.5.

6.1 Outline of Feature Specification for Bái Vowel Systems

I have suggested in the AIP tables from chapter 5 that the lexically specified tone categories determine the weight of a rime. Because most tones are long, requiring features on both the [V] and [X] slots of the rime, monophthongs are spread to fill the

duration of both slots [V :] whereas the nuclear vowel of a diphthong fills the V slot and the off-glide fills the X slot. However, diphthongs in Bái generally do not contrast with monopthongs in any case. I explore the absence of this contrast first through an articulator-based feature description of the vowel inventory for the Jiànchuān variety. Before I detail my proposed feature specification, I describe the nine-rime system of Jiànchuān Bái in (55). I assign numbers to refer to these rimes and their correspondences in other varieties of Bái as a kind of shorthand throughout the remainder of this chapter.

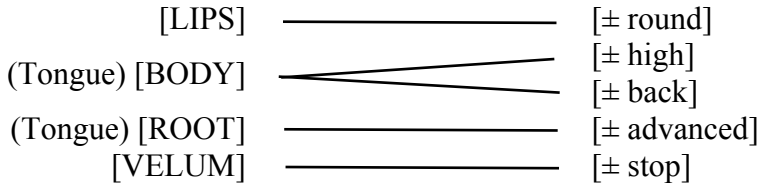
Fig. (55) Nine-Rime System of Jiànchuān Bái

Rime Number	Transcriptions	[V]	[V X]	Example
1	<ɪ>	[i]	[i :]	[pi:^{55}] ‘left’
2	<e>	[e]	[e :]	[pe:^{44}] ‘to walk’
3	<ɛ>	[ɛ]	[ɛ :]	[pɛ:^{44}] ‘one hundred’
4	<a>, <ɑ>	[ɑ]	[ɑ :]	[pɑ:^{44}] ‘big bowl’
5	<ao>, <ɑo>, <ɔ>	[ɔ]	[ɔ :] or [ɑ o]	[kɑo^{31}] ‘to write up’
6	<o>, <ou>	[o]	[o :] or [o u]	[pou^{44}] ‘uncle’
7	<u>	[u]	[u :]	[pu:^{44}] ‘to apply lacquer’
8	<ɯ>	[ɯ]	[ɯ :]	[pɯ:^{44}] ‘a set’
9	<y>	[y]	[y :]	[tɕy:^{33}] ‘mouth’

For each rime category designated in the leftmost column, I offer a comparison of the possible transcriptions of this category from the references consulted in chapter 3 in the second column from the left, the monophthong (or short) variant of this category in the middle column, the lengthened or possible diphthong variants of this category in the second column from the right, and an example taken from either XÚ & ZHÀO (1984) or Allen (2004) in the rightmost column.[20] Discussion turns to specifying the segments in the [V] slot in terms of distinctive features; the available features for the vowel contrasts are listed in (56).

[20] XÚ & ZHÀO (1984:11) treats /o/ as a phoneme with [ɔ] as an allophonic variant when the syllable has tone [21] and [ou] as an allophonic variant when the syllable has any of the other tones. This is not problematic for my proposal because rimes [ɑo] and [ɔ] do not contrast for syllables with tone [21] in the glossary of this reference.

Fig. (56) Articulator-based Features for Vocalic Contrasts in Bái



There are various proposals in distinctive feature theories with regard to the nature and number of features required to specify height and backness in vowel systems (Jakobson et al. 1952, Chomsky & Halle 1968, Sān DUĀNMÙ 2015). From a purely descriptive point of view it appears that Bái has four levels of height, potentially three levels of backness depending on the actual position of [ɯ] and [ɑ] in the speech of a given speaker, and contrastive rounding for high vowels. The nine nuclear vowels for Bái are listed in the table in (57) with descriptive characterizations. The left item for a given vector of height and backness is unrounded and the right item for a given vector is rounded.

Fig. (57) Typical Bái Nuclear Vowels [9]

	Front	Central	Back
Close	[i] [y]		[ɯ] [u]
Close-mid	[e]		[o]
Open-mid	[ɛ]		[ɔ]
Open		[ɑ]	

Distinctive feature theories differ considerably in specification of vowel height and backness. Although this is an interesting (and highly debated) area of inquiry, the analysis of the Bái vowel system is not problematic for binary specification of tongue body gestures [back] and [high] if a binary specification of an [advanced] gesture for the tongue root can also be assumed. Two possible analyses of the nine-rime system can be specified as follows in (58).

Fig. (58) Possible Specifications of the Nine-Rime System

a.

				[BODY]			
				[-back]		[+back]	
				[LIPS]—[round]			
				-	+	-	+
[BODY]	[+high]			[i]	[y]	[ɯ]	[u]
	[-high]	[ROOT]	[+advanced]	[e]		[o]	
			[-advanced]	[ɛ]		[ɑ]	[ɔ]

b.

				[BODY]			
				[-back]		[+back]	
				[LIPS]—[round]			
				-	+	-	+
[BODY]	[+high]	[ROOT]	[+advanced]	[i]	[y]	[ɯ]	[u]
			[-advanced]	[e]		[o]	
	[-high]			[ɛ]		[ɑ]	[ɔ]

The specifications in (58) can be understood as follows. My analysis of feature specification for the vowels assumes that any two sounds which are contrastive with one another are required to be specified as minimally distinct from one another in terms of distinctive features. For instance, it is unnecessary to specify the vowels as voiced or voiceless ([GLOTTIS]—[± stiff]) because there is no contrast between voiced and voiceless vowels in Bái (and such a contrast is questionable in any given language). On the other hand, rounding ([LIPS]—[± round]) must be specified for the high vowels and low back vowels otherwise it would not be possible to distinguish nuclear [i] from [y] and nuclear [ɑ] from [ɔ]. While there are four characteristic levels of vowel height and potentially three characteristic levels of vowel backness in Bái, there is no need to specify all these levels in terms of distinctive features. The three-way distinction in backness can be reduced into a binary distinction for [BODY]—[back] because lip rounding can characterize the minimal contrast between [ɑ] and [ɔ] if [ɑ] is specified as a back vowel. On the other hand, the interpretation of advanced position of the tongue root with regard

to vowel height is somewhat more abstract because Bái does not make any obvious use of binary specifications for a [ROOT]—[advanced] gesture in any phonological processes. It seems that specifications (58a) and (58b) are both possible to distinguish each of the nuclear vowels from one another.

I assume specification (58a) in my analysis because the feature [+high] on a nuclear vowel triggers spreading of the specified distinctive features from the tongue body and lips into the onset for the palatalization of the dental continuants. Although front vowels also trigger palatalization in some varieties of Bái (consider [kɛ:^{35}] → [k^{j}ɛ:^{35}] 'to fear' in the Zhàozhuāng variety, for instance), the middle level of vowels [e] and [o] do not trigger palatalization so a more basic distinction should be made to contrast the highest level of vowels [i, y, u] from the middle level of vowels [e, o] instead of contrasting the mid level of vowels [e, o] with the lowest level of vowels [ɛ, ɑ, ɔ].[21] The opposite account would assume that the more complex specification [BODY]—[+high] and [ROOT]—[+advanced] is required to trigger palatalization.

The nuclear vowels corresponding to rime numbers 1-4, 6, and 8-9 each have contrastive nasalized counterparts. Certain syllables with nasalized rimes in Jiànchuān and Hèqìng varieties from Fēng WĀNG (2006) are transcribed with coda constrictions; however given the absence of contrasts in nasal place between these constrictions and with nuclear nasalized vowels, I propose that the oral-nasal contrast on nuclear vowels is simply specified by a binary specification for [VELUM]—[stop] in underlying representation. Syllables with nasal onsets do not contrast nasalization on nuclear vowels; the feature [VELUM]—[-stop] spreads from onset to rime in these cases (this is also true

[21] The vowel [ɯ] does not trigger palatalization, but this is because this vowel is generally underspecified for tongue body features except in certain cases (explanation on its function as the default epenthesis vowel is provided in chapter 7).

for the Ěrhǎi Bái varieties which do not have contrastive nasalization). If a vowel is diphthongal or lengthened to compensate for the length requirement of a tone category, then the nasalization is also spread. In total there are sixteen contrastive nuclear vowels for Jiànchuān Bái: [i, ĩ, e, ẽ, ɛ, ɛ̃, ɑ, ɑ̃, ɔ, o, õ, u, ɯ, ɯ̃, y, ỹ]. Examples of this contrast are provided in (59).

Fig. (59) Contrastive Oral-Nasal Nuclear Vowels in Jiànchuān Bái

Rime Number	Oral Vowel Example	Nasal Vowel Example
1	[pi:^{55}] ‘left’	[pĩ:^{55}] ‘salt’
2	[pe:^{44}] ‘to walk’	[pẽ:^{44}] ‘dinner’
3	[pɛ:^{44}] ‘one hundred’	[pɛ̃:^{44}] ‘to support’
4	[pɑ:^{44}] ‘big bowl’	[pɑ̃:^{44}] ‘(a kind of container)’
5	[kɑo^{31}] ‘to write up’	
6	[pou^{44}] ‘uncle’	[põu^{44}] ‘to repay’
7	[pu:^{44}] ‘to apply lacquer’	
8	[pɯ:^{44}] ‘a set’	[pɯ̃:^{55}] ‘instance’
9	[tɕy:^{33}] ‘mouth’	[tɕ^{h}ỹ:^{33}] ‘to call (name)’

The description of the Kāngfú variety spoken in Hèqìng prefecture (ZHÀO Jīncān 2011) describes a ten-rime vowel system. This ten-rime vowel system is specified in (60) with different assigned rime numbers than the Jiànchuān system from (55) and (60) because the categories do not always correspond. The attested correspondences between the Kāngfú system and the Jiànchuān system are provided in the second column from the left with example syllables (Kāngfú on left, Jiànchuān on right). The transcription of each segment in the text is presented in the middle column. The two columns on the right include short and long variants of these rime categories. The articulator-based feature specifications for the vowels in this system are tabulated in (61).

Fig. (60) Ten-Rime System of Kāngfú

Rime Number	Correspondence	Transcription	[V]	[V X]
1	1 [pĩ:^{55}]:[pĩ:^{55}] ‘salt’		i	[i :]
2	2a [pe:^{33}]:[pẽ:^{44}] ‘dinner’		e	[e :]
3	2b [pɛ^{21}]:[pe^{21}] ‘skin’	<æ>	ɛ	[ɛ :]
4	3 [pʌ:^{44}]:[pɛ:^{44}] ‘one hundred’	<ər>	ʌ	[ʌ :]
5	4 [pa^{42}]:[pɑ:^{42}] ‘breast’		a	[a :]
6	5 [pau^{55}]:[pɑo^{55}] ‘to wrap’	<au>	ɔ	[a u]
	6 [kau^{44}]:[ko:] ‘foot’			
7	ɣ [so:^{42}]:[s^{w}ʐ^{w}:^{42}] ‘mountain’		o	[o :]
8	7 [xu:^{33}]:[xu:^{33}] ‘good’		u	[u :]
9	8 [pɯ^{44}]:[pɯ^{44}] ‘north’		ɯ	[ɯ :]
10	9 [tɕ^{h}ỹ:^{55}]:[tɕ^{h}ỹ:^{33}] ‘to call (name)’		y	[y :]

Kāngfú rimes 4 and 7 are particularly interesting. The vowel for rime 4 is transcribed with a coda [r], but I argue that this rhoticism does not need to be specified in terms of features. First, ZHÀO Jīncān (2011:34) characterizes the production of this nuclear vowel such that the tongue is placed in a position similar to what is necessary to produce a rhotic sound without achieving complete realization of the r-coloring. Second, this vowel can be distinguished the other vowels using existing features; therefore, introduction of a new category is redundant and unnecessary. Accordingly, I re-interpret this sound as the tense, back, unrounded vowel [ʌ]. As for rime 7, while the specification of this vowel in terms of articulator-based features is straightforward, this vowel does not correspond with [o] in the other varieties. Instead, this rime generally corresponds to syllabic [ɣ̩] or only appears in innovative vocabulary; I expand on this in section 7.2.

Fig. (61) Features of the Vowel Segments in Kāngfú Bái

				[BODY]—[back]			
				[-]		[+]	
				[LIPS]—[round]			
				-	+	-	+
[BODY]	[+high]			[i]	[y]	[ɯ]	[u]
	[-high]	[ROOT]	[+advanced]	[e]		[ʌ]	[o]
			[-advanced]	[ɛ]		[ɑ]	[ɔ]

The Kāngfú variety uses a larger amount of the possible vowel space than the Jiànchuān variety. Furthermore, each nuclear vowel can be specified for contrastive nasalization and the contrasts are all productively distinct from one another in this variety with many minimal pairs. The next section introduces a survey of the synchronic variation in the vowel systems of Ěrhǎi Bái varieties based on my own acoustic measurements and impressionistic transcriptions of Ěrhǎi Bái speakers.

6.2 Acoustic Variation in the Vowel Systems of Ěrhǎi Bái

The majority of Ěrhǎi Bái varieties have a nine-rime system, these vowels generally correspond regularly with the nine-rime Jiànchuān system introduced in (55). There are two major patterns which I refer to as type A and type B which primarily differ in the segmental value of rime 3; I compare the correspondences between these patterns in (62).

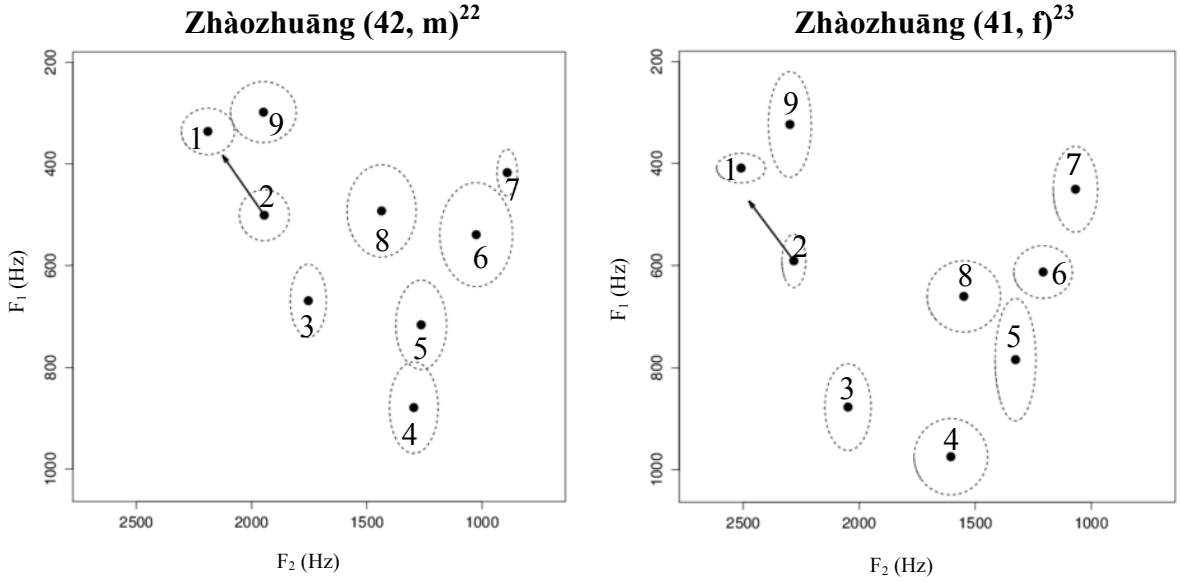
Fig. (62) Correspondences Between Two Ěrhǎi Bái Vowel Systems

Rime Number	Transcriptions	Type A	Type B
1	<i>	[i]	[i]
2	<e>	[ei]	[e]
3	<ɛ>, <ɚ>, <ə>, <ʌ>	[ɛ]	[ɚ]-[ʌ]
4	<a>, <ɑ>	[ɑ]	[ɑ]
5	<ao>, <ɑo>, <ɔ>	[ɔ]	[ɔ]
6	<o>, <ou>	[o]	[o]
7	<u>	[u]	[u]
8	<ɯ>	[ɯ]	[ɯ]
9	<y>	[y]	[y]

Type A is characterized by a low front realization for rime 3 [ɛ] and a diphthongized variant of rime 2 [ei]. I present plots of the acoustic vowel space for two type A vowel system speakers from Zhàozhuāng in (63). The data were collected by asking these speakers (and 14 others) to provide the Bái equivalents of several Chinese words. The words were selected with prior expectation to elicit each of the nine rime

categories produced after unaspirated stops [p, t, k] (and palatal affricate [tɕ] for rime 9 [y]). It was not possible to get minimally contrastive types. The measurements for the plots were extracted from the first two formants at the midpoint of vowel production for monophthongs and the 20% and 80% intervals for diphthongs. The plots present un-normalized averages of the F_1 and F_2 values for the measured tokens of each vowel type, the token count for each type considered appears in the relevant footnotes.

Fig. (63) Un-normalized Vowel Plots For Two Type A Speakers (1.5 SD)

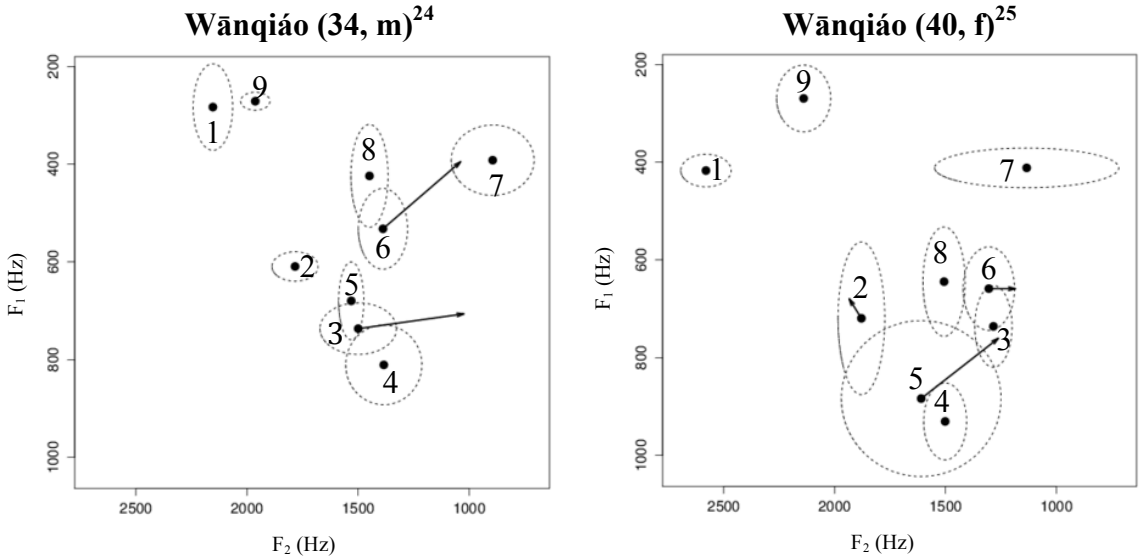


The syllabary of the Zhàozhuāng variety, as explored in chapter 4, suggests that this variety is innovative with regard to the nature of rime 2 such that this vowel has shifted to rime 1 after the velars [k, k^h, ŋ, x]. This is interesting because the velars cannot co-occur with [i] in most varieties of Bái. Furthermore, the velars [k, k^h, ŋ] appear as palatalized variants [k^j, k^{hj}, $ŋ^j$] before nuclear vowel [ɛ]. The vowel plots in (63) suggest that Zhaòzhāng speakers exhibit strong diphthongization for rime 2 and make active use

[22] *n* = 79. 5 tokens for rime 7, 8-10 tokens for other cateories
[23] *n* = 95. 8-16 tokens for each category.

of the low front vowel space (consider the distributions of rimes 2 and 3 in (63) above). Type B speakers, on the other hand do not optimize this space. Vowel plots of two type B speakers from Wānqiáo are compared in (64).

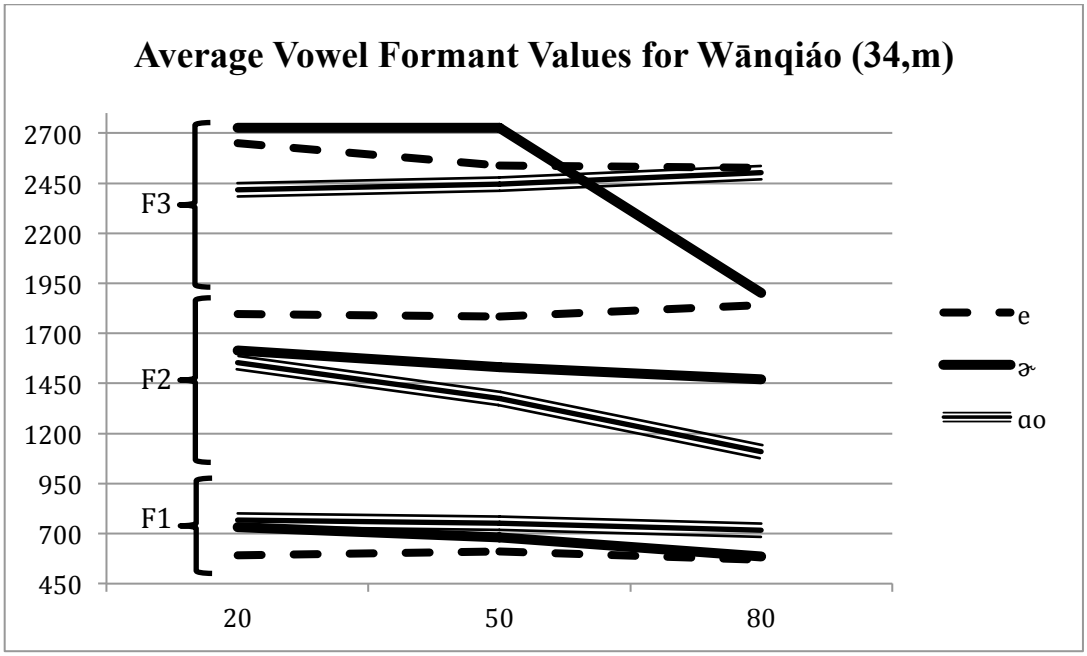
Fig. (64) Un-normalized Vowel Plots for Two Type B Speakers (1.5 SD)



The vowel plots for these two type B speakers cluster their vowels in the low and back portion of the vowel space. Note that rime 3 for the male speaker is considerably more centralized for the female speaker. This rime is characterized by r-coloring for the male speaker. R-coloring is marked by a decline in F_3 over production of a vowel (Alwan et al. 1997, Mielke 2013). I compare the vowel formants for rimes 2, 3, and 5 at 20%, 50%, and 80% intervals of the vowel for this speaker in (65) to illustrate the decline in F_3 for rime 3 which is not found for the other rime types of in its periphery (rimes 2 and 5).

[24] *n* = 102. 7-20 tokens for each category.
[25] *n* = 82. 7-11 tokens for each category.

Fig. (65) Change in Formants Through Syllable Production (Wānqiáo 34, m)



Although rhoticism is perhaps used to enhance the distinction between this rime and other back vowels for speakers with Type B rimes, there is no need to specify rhotism in feature representation because the unrounded back specification characterized by [ʌ] is sufficient to distinguish this vowel from the others in terms of distinctive features. This is particularly appealing, as this rhoticism serves no function in the morphophonology of this language so such specification is redundant and uneconomical. Furthermore, prior research (Keating 1988, Rice 1995) suggests that this underspecification reflects tendencies for variable tongue positions – this is a desirable consequence because it reflects the observed patterns of synchronic variation across varieties of Ěrhǎi Bái. That is, the vowel category is pronounced as rhotic for some speakers, non-rhotic for other and intermediately rhotic for others (as is described for Kāngfú Bái).

Aside from the productions of these four speakers, I have observed patterns that can be categorized as Type A and Type B from (62) across communities around the Ěrhǎi Lake in my elicitation of vowel data. However, a very small portion of speakers, specifically those from Xǐzhōu, produce the three-way range of vowels [e]-[ɛ]-[ʌ]. Their phonemically contrastive set of vowels generally patterns as Type B ([e]-[ʌ]), but there are some productions of either [e] or [ɛ] for rime category 2. However, it may not be possible to find exact minimal pairs between [e] and [ɛ] in Xǐzhōu especially if tone categories must be included to define contrastive phonological environments; for instance, [se^{33}] 'to wash' and [sɛ^{31}] 'small' have different tones. In brief, the phonetic vowel system of Xǐzhōu resembles that of conservative Kāngfú, but the vowels of interest [e, ɛ, ʌ] do not correspond with that conservative variety (ex. the aforementioned lexical items both have nuclear [e] in Kāngfú and I cannot find other correspondences in the texts or through elicitation). I return to this inquiry later in my discussion of the tone categories in Bái.

6.3 Specification of Tone Features

I have proposed throughout this dissertation that the short-long distinction in rimes is dictated by lexically specified tone categories in underlying representation. Although I have visualized these length distinctions in AIP tables in chapter 4 and presented non-contrastive short-long variants of nuclear vowels in chapter 5, I have yet to offer a thorough analysis of the Bái tone system. The remainder of this chapter presents my original analysis of the two major tone systems for Bái – common Jiànchuān-Hèqìng Bái and the Ěrhǎi Bái tone systems. Throughout the discussion I assume that tones are represented by articulator-based features, but use the Chao tone numbering system to

refer to the categories of tone systems in Bái as shorthand in the interest of space and ease of readability. Discussion begins in section 6.3.1with an introduction to the features used to represent the Bái tonal contrasts. The common Jiànchuān-Hèqìng tone system is introduced in section 6.3.2 with reference to the previous literature.

6.3.1 Articulator-based Features for Tone Specification

Discussion begins with a brief descriptive summary of the contrastive tone categories in Bái varieties. There are nine contrastive categories in total, although any given variety only uses at most eight of these categories. The descriptive generalizations for the complete inventory of tonal contrasts based on the primary descriptive sources reviewed in chapter 3 and the instrumental research reviewed in 2.4 are summarized in (66).

Fig. (66) Descriptive Generalizations of the Tone Categories in Bái

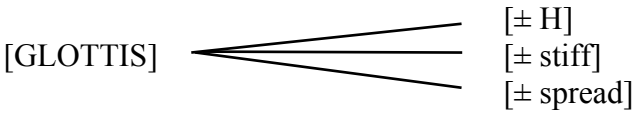
Tone Category	Description	Example
[66]	"Higher than typical high level", non-modal	[tɕi:^{66}] 'to mail' (JC-HQ)
[55]	High level, modal	[tɕi:^{55}] 'much, many'
[44]	Mid level, non-modal	[tɕi:^{44}] 'queen ant'
[42]~[53]	High falling, non-modal, variable glottalization	[tɕi:^{42}] 'to chase'
[35]	Rising, inconsistently described for modality	[tɕi:^{35}] 'nervous'
[33]	Low level, modal	[tɕi:^{33}] 'to pull'
[32]	Mid falling, modal, variable glottalization	[tɕi:^{32}] 'arrow' (EH)
[31]	Low level/falling, modal, variable breathiness	[tɕi:^{31}] 'earth'
[21]	Low, short, consistently breathy, non-modal	[tɕi^{21}] 'flag'

The descriptions of the tone categories in (66) are intended to represent tendencies observed across speakers in the mainstream Bái-speaking area. There are discrepancies across communities and speakers within communities. For instance, while the common Jiànchuān-Hèqìng tone system is consistently described with eight categories (lacking [32]), characterization of modality for each category differs across sources, and the nature

of the non-modal tones differs across speakers based on the instrumental work presented by Fēng WĀNG (2015b). On the other hand, the conservative Ěrhǎi Bái tone system has eight categories (lacking [66]) while some communities and/or speakers around the Ěrhǎi Lake have seven or six tone categories.

Despite some of the aforementioned inconsistencies across sources, it is clear that phonological representation of the tone categories needs to distinguish pitch, register, breathiness, and duration based on the generalizations in (66). As with my analyses of the consonant and vowel contrasts of Bái, my proposed analysis of the contrastive tone categories in Bái uses articulator-based features. The features are gestures made by the glottis and larynx. I list the relevant features used in the specification of pitch and register contrasts in (67). I address the duration properties of Bái tone categories in 6.3.2.

Fig. (67) Sub-oral Articulator Gestures in Bái Tone Production



The tone contrasts in Bái are generated by specifications of the three articulator-based features in (67) on the [V] and [X] slots of the syllable rime. I address the top two features in regard to phonological representation of tone levels before addressing the nature of [spread]. Parsimonious theories of tone features assume that there are four possible contrastive levels of tone (Yip 1980, Sān DUĀNMÙ 2016). These contrastive levels of tone take two dimensions – pitch and register. Pitch is specified by [H] and register is specified by [stiff].

Pitch is the consequence of cricothyroid movement specified by the feature [GLOTTIS]—[H]. Positive specification of this feature [GLOTTIS]—[+H] represents

thin stretching of the vocal cords by the cricothyroid muscles and this stretching generally reflects production of high pitch (Edmondson & Esling 2006:161). Negative specification for this feature [GLOTTIS]—[-H], conversely, reflects production of low pitch. Register is distinguished by modal voicing or breathy quality (Yip 1980, Zhìmíng BĀO 1999, Sān DUĀNMÙ 1996, Sān DUĀNMÙ 2016). The breathy quality is specified by the feature [GLOTTIS]—[±stiff] for which a positive specification represents stiffness of the vocal cords (thereby producing a breathy quality) and a negative specification represents slacking of the vocal cords (thereby producing a regular or modal voice quality). The feature [GLOTTIS]—[±spread], on the other hand, reflects spreading of the vocal cords, which occurs during aspiration or glottal frication. This feature must be included because some tone categories are contrasted by glottal frication in some varieties of Bái. Positive specification of this feature produces glottal frication whereas negative specification or underspecification reflects an absence of this frication. Most tone categories are specified for [GLOTTIS]—[±H] and [GLOTTIS]—[±stiff] while only particular categories are specified for [GLOTTIS]—[±spread]. I explore the required specifications in the next section through an AIP description of the common Jiànchuān-Hèqìng tone system.

6.3.2 Common Jiànchuān-Hèqìng Tone System

The previous section introduces all of the required articulator-based features to represent tonal contrasts in Bái. The specifications of those three articulator-based features are bound to feature bundles linearized beginning with the nuclear vowel. This is based on arguments in the literature that although the pitch (F_0) of a syllable is suprasegmental and can be observed on voiced consonants, phonologically contrastive

tone is only specified on the rime portion of a syllable (Kratochvil 1970, Hyman 1985, Sān DUĀNMÙ 1996). The feature bundle for the short tone, although separate from the bundle for the nuclear vowel, is ordered with the same subscript as the nuclear vowel. Contour tones, however, require two feature bundles. The first specified feature bundle is ordered with the same subscript as the nuclear vowel while the second specified feature bundle reflecting rise or fall is ordered with a subscript of 1 higher than the first bundle. Lengthened level tones are specified with two bundles: the first bundle includes the relevant specifications of the features from (67) and the second bundle expresses lengthening of those features. This ordering provides for representation of contrastive duration for tones and vowels as implied by short rimes [V] and long rimes [V X] in syllable structure. I present a table of the tone features across underlying feature bundles for the common Jiànchuān-Hèqìng tone system in (68). The features are only specified as necessary by the principle of contrast dictating that if two given sounds (tone categories in this case) are distinct, then they must be specified distinctively by the features representing the gestures which distinguish those two sounds.

Fig. (68) Jiànchuān-Hèqìng Tone Features

Tone Category	Features	Bundles	
[66]		x_1	x_2
	[GLOTTIS]—[H]	+	:
	[GLOTTIS]—[stiff]	+	:
[55]		x_1	x_2
	[GLOTTIS]—[H]	+	:
	[GLOTTIS]—[stiff]	-	:
[44]		x_1	x_2
	[GLOTTIS]—[H]	-	:
	[GLOTTIS]—[stiff]	+	:
[42]		x_1	x_2
	[GLOTTIS]—[H]	+	-
[35]		x_1	x_2
	[GLOTTIS]—[H]	-	+
[33]		x_1	x_2
	[GLOTTIS]—[H]	-	:
	[GLOTTIS]—[stiff]	-	:
[31]		x_1	x_2
	[GLOTTIS]—[H]	-	:
	[GLOTTIS]—[stiff]	-	:
	[GLOTTIS]—[spread]		+
[21]		x_1	
	[GLOTTIS]—[spread]	+	

The tone features are arranged in AIP format in (68). Seven of the eight contrastive tone categories are specified as long with two underlying feature bundles. All of the possible combinations of [stiff] and [spread] are contrastive for the long level tones [66], [55], [44], [33]. The Chao tone numbering system suggests that [33] and [31] should be contrastive for pitch with the former being a (mid) low level tone and the latter being a mid-to-low fall. However, instrumental studies suggest that these two tones are not distinguished by pitch (Fēng WĀNG 2015) and that the second half of a syllable with a [31] tone is “whispered without voice” (Edmondson et al. 2005). I abandon the impressionistic description offered by the Chao numbering system in favor of the

generalizations offered by instrumental analysis. Therefore, I assume that tones [31] and [33] are contrasted from one another by spreading of the glottis on the second portion of the syllable (the second feature bundle) for [31]. One may wonder why I choose not to designate a specification for [GLOTTIS]—[spread] for the first underlying feature bundle on tone [31]. I return to this inquiry briefly, but first address the other contour tones. If we assume the analysis of tone [31] as I specify in (68), there are only two contour tones in Jiànchuān Bái – a rising tone [35] and a falling tone [42] – as the impressionistic transcription implied by the Chao tone numbering system for tone [21] simply represents short duration in my understanding of the system. The rising tone is described variably as modal or non-modal while the falling tone is described as non-modal and, more specifically, glottalized. The absence of other contrastive contour tones permits us to specify these tone categories exclusively by change in pitch ([GLOTTIS]—[H]) without any necessary specification for register ([GLOTTIS]—[stiff]). The consequence of this specification explains the variability in modality for tone [35] and the inconsistent production of glottalization or phonetic glottal stop for tone [42] as described in Allen (2004).

Returning to the underspecification of [GLOTTIS]—[spread] in the first bundle of tone [31] in (68), my justification is as follows. First, a negative specification for this feature reflects the typical or unmarked vowel, so specification is redundant for modal voicing of vowels. Second, there is a restriction against co-occurrence of aspirated onsets and breathy vowels in Bái. For instance, the tone [21], which is only specified by breathiness ([GLOTTIS]—[+spread]), never co-occurs with an aspirated onset. The breathiness of the short tone presents an interesting case in which the breathiness is

produced throughout the production of the nuclear vowel. I present underlying and surface representation AIP tables reflecting the impossible and unattested syllable *[pha̤^{21}] in (69).

Fig. (69) Impossibility of Short Breathy Tone with Aspirated Onsets

	*/p^{h}a^{21}/		
	x_1	x_2	x_2
[LIPS]—[stop]	+		
[BODY]—[high]		-	
[BODY]—[back]		+	
[GLOTTIS]—[spread]	+		+

→

*[p^{h}a̤^{21}]	
x_{ons}	x_{nuc}
+	
	-
	+
+	+

I suggest the absence of these kinds of syllables is due to a form of the OCP, or Obligatory Contour Principle (McCarthy 1986); which, in this case, avoids adjacent specification of an articulator-based feature. Prior to the description of the impossible syllable [p^{h}a̤] (69), I have only presented the reader with AIP tables for possible syllables in this language. Although articulator-based features have the same specifications in adjacent positions in the surface representations in previous AIP tables, these features are all spread from different underlying feature bundles to fixed positions dictated by syllable structure. It appears that Bái actively blocks adjacent underlying feature bundles with the same specification for a given articulator-based feature. Because any combination of onset, vowel, and tone is affiliated to a monosyllabic morpheme, the restriction of adjacent underlying feature bundles can be considered to be the consequence of a morpheme structure constraint at the underlying level. While opposing specifications for a given articulator-based feature between two underlying bundles of features indicates that those two bundles must be linearized in relation to one another, the same specification of a given feature between two underlying bundles prevents those bundles

from being adjacent. Returning to the underspecification in the case of tone [31], the configuration of the tone [31] category as specified in (68) permits this tone to co-occur with aspirated onsets. These syllable types are attested, common and contrastive with unaspirated onsets (ex. [$t^{h}ɯ^{31}$] 'often' and [$tɯ^{31}$] 'bean') in Jiànchuān and other varieties of Bái. The next section describes the tone system of Ěrhǎi Bái. While much of the phonological structure of those tones is the same as the system described in this section, there are some noteworthy differences between these systems.

6.4 Variation in the Ěrhǎi Bái Tone System

Unlike the common Jiànchuān-Hèqìng system introduced in the previous section, the total number of contrastive tone categories differ from speaker to speaker and locality to locality in proximity to the Ěrhǎi Lake. These varieties are generally described with eight contrastive tone categories (XÚ & ZHÀO 1984, DUÀN 2008a) but there are some works that specify seven tones (LǏ Zhèngqīng 2014, Fēng WĀNG 2006) or six tones (ZHÀO Yànzhēn 2012) as well. I have observed this variation across the system and present my account of the Ěrhǎi Bái tone system in this section as follows. Sub-section 6.4.1 introduces an AIP description of the conservative system along with acoustic measurements. Sub-section 6.4.2 discusses three other attested systems around the Ěrhǎi Lake based on data from 18 Ěrhǎi Bái speakers. Sub-section 6.4.3 presents the results of a tone identification task conducted with Zhàozhuāng variety speakers – speakers with the most reduced Ěrhǎi Bái tone system. Sub-section 6.4.4 concludes discussion of the Ěrhǎi Bái tone system.

6.4.1 Conservative Ěrhǎi Bái

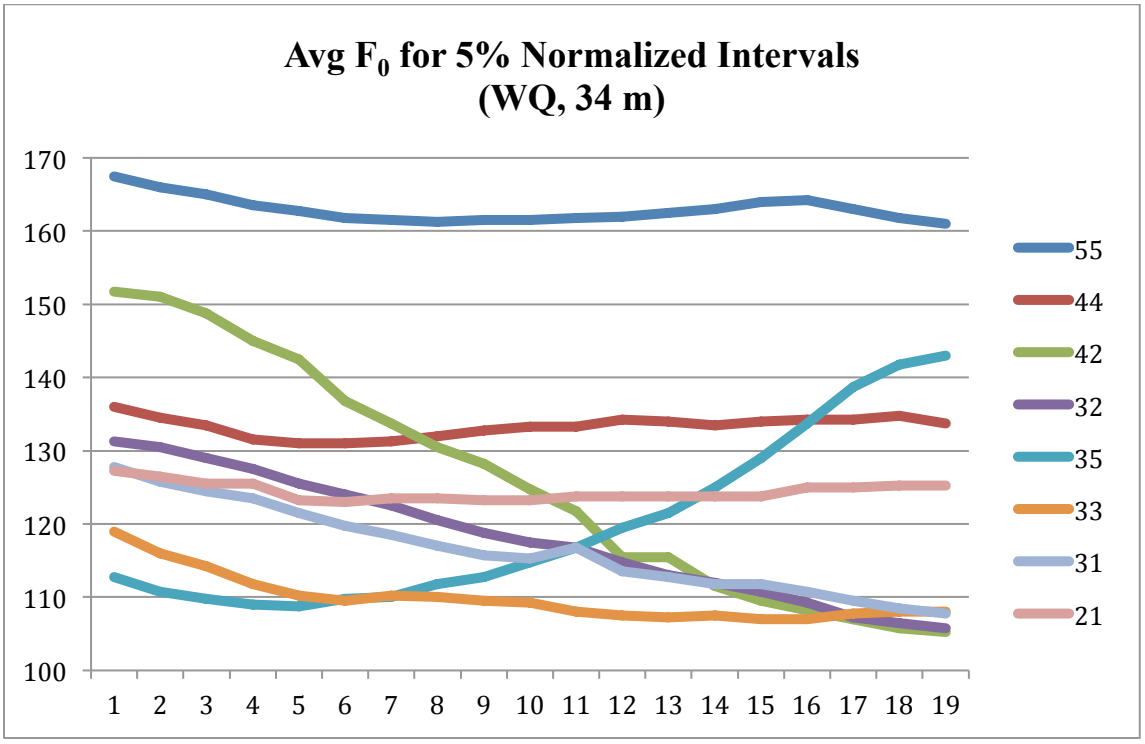
Since most researchers working on Bái are interested in etymological relationships between Bái and other Sino-Tibetan languages, fieldworkers will ideally try to find consultants who speak a variant of the language which maintains as many conservative tonal (and other) contrasts as possible. Most references state that the representative variety of "Southern Bái" in Dàlǐ (or Xǐzhōu, more specifically) has an eight-tone inventory: [55], [44], [42], [35], [33], [32], [31], and [21]. My articulator-based feature account of these tone categories is presented in (70).

Fig. (70) Feature Specifications for Conservative Ěrhǎi Bái

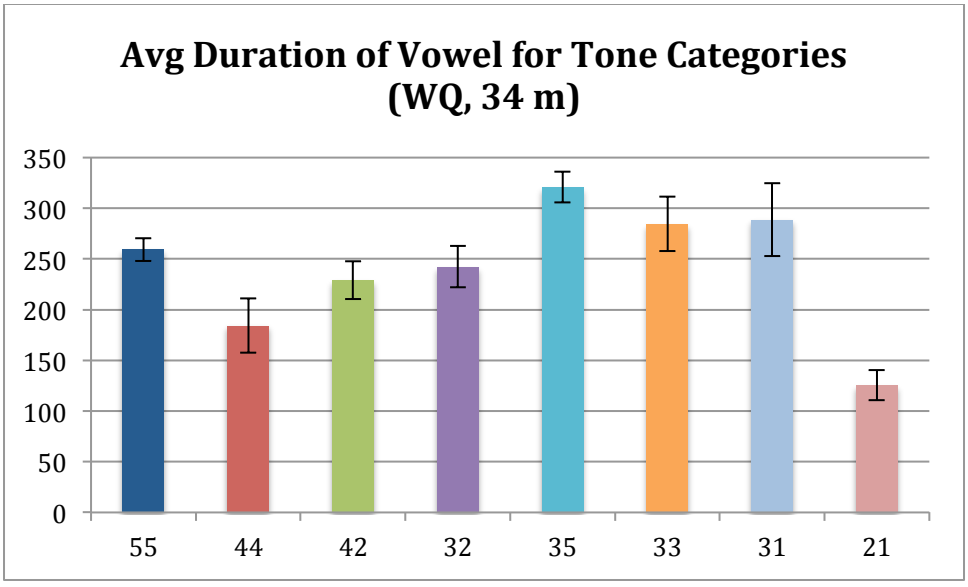
Tone Category	Features	Bundles	
[55]		x_1	x_2
	[GLOTTIS]—[H]	+	:
[44]		x_1	x_2
	[GLOTTIS]—[H]	-	:
	[GLOTTIS]—[stiff]	+	:
[42]		x_1	x_2
	[GLOTTIS]—[H]	+	-
	[GLOTTIS]—[stiff]	+	:
[32]		x_1	x_2
	[GLOTTIS]—[H]	+	-
	[GLOTTIS]—[stiff]	-	:
[35]		x_1	x_2
	[GLOTTIS]—[H]	-	+
[33]		x_1	x_2
	[GLOTTIS]—[H]	-	:
	[GLOTTIS]—[stiff]	-	:
[31]		x_1	x_2
	[GLOTTIS]—[H]	-	:
	[GLOTTIS]—[stiff]	-	:
	[GLOTTIS]—[spread]		+
[21]		x_1	
	[GLOTTIS]—[spread]	+	

Many of the feature specifications for the tone categories in (70) are the same as the specifications in (68). The differences between the feature specifications in (69) and (70) can be summarized as follows. Since tone category [55] in Ěrhǎi Bái does not contrast with the higher [66] tone as in the Jiànchuān-Hèqìng tone system, this high tone only needs to be specified for perceived pitch ([GLOTTIS]—[H]) and must be underspecified for register ([GLOTTIS]—[stiff]). On the other hand the conservative Ěrhǎi tone system contrasts two falling tones [42] and [32]. I argue that these tones are distinguished from one another with opposing specifications for [stiff]. I present acoustic measurements for syllables with segmental specification [pa] minimally contrasted for each of the tone categories specified in (70) produced by a 34 year-old male speaker from Wānqiáo. Each type was produced five times; I extracted the complete duration of the vowel and F_0 measurements at 5% intervals of the vowel of each token. These average F_0 measurements normalized for duration are presented in (71). The average durations (in ms) of the vowel for each tone category are presented in (72).

Fig. (71) Change in F_0 over Normalized Duration



(72) Average Vowel Duration for Each Contrastive Category



There are two points of interest to note regarding these measurements for tone [21]. First, the average F_0 values for the normalized change over time for tone [21] are higher than the other low and even some of the mid tone categories, as plotted for the

chart in (71). Second, the average duration for tone [21] is considerably shorter than the other tone categories. These observations regarding tone [21] are not surprising given the absence of specified values for [GLOTTIS]—[H] and [GLOTTIS]—[stiff] and a single bundle allocated for length for this tone category. Such specification suggests that this tone is not distinguished by height nor register but simply breathiness. The measurements for the other tone categories reflect generalizations predicted by the tone feature specifications. Aside from these measurements, I make note that many tokens of [31] not included in the measurements in (71) and (72) have breath pulses toward the end of the vowel production. The stimuli I designed for listeners to identify for the tone identification task introduced in 6.4.3 were recorded by this speaker; some of the monosyllabic lexical items in these stimuli are tokens used in the presented measurements. Discussion in the next sub-section presents a brief overview of the attested variation in contrastive tone categories across Ěrhǎi Bái speakers.

6.4.2 Three Reduced Ěrhǎi Bái Tone Systems

As I have noted in my review of the literature, some references for Ěrhǎi Bái describe a tone system reduced from the conservative system described in 6.4.1. Based on this literature and my own survey of native speakers across the area, I propose there are three reduced tone systems. These systems have the same feature specifications for tones [55], [44], [35], and [21] as the conservative system in (70). I categorize these three systems as ‘Type A’, ‘Type B’, and ‘Type C’ in (73), offering feature specifications deviant from (16) for tones [42], [32], [33], and [31].

Fig. (73) Specifications of Tone Categories [42], [32], [33], and [31]

	Type A	Type B	Type C
[42]	<table><tr><td></td><td>x_1</td><td>x_2</td></tr><tr><td>[H]</td><td>+</td><td>-</td></tr><tr><td>[stiff]</td><td>+</td><td>:</td></tr></table>	<table><tr><td></td><td>x_1</td><td>x_2</td></tr><tr><td>[H]</td><td>+</td><td>-</td></tr></table>	<table><tr><td></td><td>x_1</td><td>x_2</td></tr><tr><td>[H]</td><td>+</td><td>-</td></tr></table>
[32]	<table><tr><td></td><td>x_1</td><td>x_2</td></tr><tr><td>[H]</td><td>+</td><td>-</td></tr><tr><td>[stiff]</td><td>-</td><td>:</td></tr></table>		
[33]	<table><tr><td></td><td>x_1</td><td>x_2</td></tr><tr><td>[H]</td><td>-</td><td>:</td></tr><tr><td>[stiff]</td><td>-</td><td>:</td></tr></table>	<table><tr><td></td><td>x_1</td><td>x_2</td></tr><tr><td>[H]</td><td>-</td><td>:</td></tr><tr><td>[stiff]</td><td>-</td><td>:</td></tr></table>	<table><tr><td></td><td>x_1</td><td>x_2</td></tr><tr><td>[H]</td><td>-</td><td>:</td></tr><tr><td>[stiff]</td><td>-</td><td>:</td></tr></table>
[31]		<table><tr><td></td><td>x_1</td><td>x_2</td></tr><tr><td>[H]</td><td>-</td><td>:</td></tr><tr><td>[stiff]</td><td>-</td><td>:</td></tr><tr><td>[spread]</td><td></td><td>+</td></tr></table>	

Reduced tone system type A is assumed in LǏ Zhèngqīng (2014), a detailed glossary of the author's own native dialect in Xǐzhōu. This type of reduced tone system maintains the register contrast for the two falling tones (as specified by [GLOTTIS]—[stiff]) and has lost the specified [GLOTTIS]—[+spread] on the second bundle. Many speakers of Ěrhǎi Bái have lost the contrast between [33] and [31]. The merger of these two categories sounds variably like a low level or slight fall. The type B reduced system maintains the contrast between [33] and [31] but has lost tone [32]. This loss eliminates the need to specify register for tone category [42]. The final reduced tone system, type C, has lost [32] and has merged [33] and [31]. The absence of these contrasts eliminates the need to specify register on the feature bundles for category [42] and the need to specify [GLOTTIS]—[+spread] on the second bundle for the merged [33]-[31] tone. I have elicited a range of lexical items contrasting various lexical items distinct in tones (complete set of tone contrasts for [pa] and [tɕi]) and vowels (minimal or near-minimal contrasts after unaspirated stops) from 18 speakers of Ěrhǎi Bái. My impressionistic

characterizations of their speech based on the specified tone systems described in this chapter are tabulated in (74).

The impressionistic characterization of the tone systems of the 18 speakers described in (74) is tabulated as follows. The leftmost column provides an identification number for a given consultant. The second, third, and fourth columns from the left indicate the consultant's place of origin, gender, and age. The third column from the right indicates which of the four specified tone systems the consultant produced for the complete set of tones for [pa] and [tɕi]. The second column from the right characterizes the difference between [31] and [33]. The rightmost column specifies whether the words 'to wash' and 'small' are produced with different nuclear rimes as [sei^{33}] and [sɛ:^{31}] respectively, are homophonous, or are distinguished by tone. I discuss the patterns in this table for the remainder of this sub-section.

Fig. (74) Impressionistic Characterizations of Tone System Variation

ID	Location	Gender	Age	Tone System	[31]-[33]?	[sei^{33}]-[sɛ:^{31}]?
1	Wānqiáo	Male	34	Conservative	Level [33], Breathy [31]	Differ in tone
2	Wānqiáo	Female	30	Reduced A	Both Level	Homophonous
3	Wānqiáo	Male	40	Reduced A	Both Fall	Homophonous
4	Wānqiáo	Female	40	Reduced B	Level [33], Fall [31]	Differ in tone
5	Zhàozhuāng	Male	42	Reduced C	Both Fall	Homophonous
6	Zhàozhuāng	Female	41	Reduced C	Both Level	Homophonous
7	Zhàozhuāng	Male	42	Reduced C	Both Fall	Homophonous
8	Zhàozhuāng	Female	43	Reduced C	Both Fall	Homophonous
9	Shuāngláng	Male	45	Conservative	Level [31], Breathy [31]	Differ in tone
10	Shuāngláng	Female	35	Conservative	Level [33], Fall [31]	[sei^{33}]-[sɛ:^{31}]
11	Shuāngláng	Female	23	Conservative	Level [33], Fall [31]	Tone
12	Hǎidōng	Female	37	Reduced C	Both Fall	Homophonous
13	Fèngyí	Male	55	Reduced C	Both Level	Homophonous
14	Fèngyí	Female	41	Reduced B	Level [33], Fall [31]	Differ in tone
15	Fèngyí	Male	55	Reduced C	Both Fall	Homophonous
16	Zhōuchéng	Male	59	Conservative	Level [33], Breathy [31]	Differ in tone
17	Xǐzhōu	Male	34	Conservative	Level [33], Breathy [31]	[sei^{33}]-[sɛ:^{31}]
18	Wāsè	Female	53	Reduced A	Both Fall	Homophonous

Note that some speakers with the conservative set of tonal contrasts lack any obvious production of breathiness as their tone [31] productions sound like a fall (as indicated by 'Fall [31]'). Despite this absence of breathiness, the feature specification for breathiness ([GLOTTIS]—[+spread] on the second feature bundle) cannot be changed because the pitch cannot be specified any lower on the second feature bundle. This is not problematic, however, as many speakers who have merged [31] and [33] produce the merged tone as a long fall instead of a low level (in my perceived impressionistic judgment). This suggests that low-level specification in Bái variably reflects a slight fall or low-level pitch trajectory.

In chapter 5, I mention that although there are nine rimes in Ěrhǎi Bái varieties, some speakers who produce their rime 3 toward the back of their vowel space also have different realizations of the vowels for the words 'to wash' [sei^{33}] and 'small' [sɛ:^{31}] (the

vowels of these items are transcribed as rime 2 [e] in most descriptions, but are distinct in Dell 1981). Because it appears that the alternation between these nuclear vowels can be dictated by tone category, it is not clear if these rimes are contrastive, due to a lack of reliable and easily identifiable minimal pairs. However, I report this variation because it seems to only be found in speakers residing along the northwestern portion of the Ěrhǎi Lake who distinguish tones [31] and [33]. Furthermore, it is noteworthy that Dell (1981) is the only reference (of which I am aware) that transcribes the rimes of the two lexical items as distinct. While this distinction may not be contrastive synchronically, it is possible that this distinction was once contrastive given the large amount otherwise of unused area in the lower front portion of the schematic vowel space.

The absence of tone [32] in reduced tone systems is interesting as this tone category appears to not have undergone regular sound change in varieties that lack this tone. This tone can correspond to several different tone categories in varieties of Ěrhǎi Bái with reduced tone systems. For instance, tone [32] from the conservative system corresponds with tones [33], [44], and [42] in the Zhàozhuāng variety; examples of these correspondences are provided in (75).

Fig. (75) Correspondences of Conservative [32] Tone in Zhàozhuāng Bái

Tone [32] in Zhàozhuāng Dialect		
Conservative	Zhàozhuāng	English
[pa:^{32}]	[pa:^{44}]	‘panther’
[xa:^{32}]	[xa:^{33}]	‘Chinese’
[me:^{32}]	[mei^{42}]	‘coal’
[mɯ:^{32}]	[mɯ:^{44}]	‘dream’
[tɔ:^{32}]	[tɔ:^{33}]	‘big’

Aside from these irregular correspondences, this tone category is somewhat unusual in that it is considerably less common than the other tone categories in the

lexicon in the conservative varieties. Out of the 491 monosyllabic entries in XÚ & ZHÀO (1984) from a 1002 basic vocabulary glossary, only 12 entries are specified for this tone (roughly 2.4% of this subset of entries); the other categories range from 53 to 92 entries each (11.8-18% of total items). I do not offer any speculation regarding the loss of this tone, but in the next sub-section I present and discuss the results of a tone identification task conducted with speakers with reduced tone systems.

6.4.3 Tone Identification Task

While it is clear that speakers of Ěrhǎi Bái with reduced tone systems do not produce the entire inventory of conservative tones from (70), it is not clear whether or not these speakers can identify the tones that they do not distinguish in production. Certain implications regarding this innovative loss of contrast can be implied if speakers can identify these tones reliably. For instance, it may be possible that this loss is a fairly recent innovation or that these speakers regularly communicate with speakers who make the conservative distinctions. On the other hand, direct observation of how these speakers respond to conservative stimuli can help us understand which gestural and/or acoustic properties of the conservative categories are salient to speakers with reduced tone systems. I conducted a tone identification task to explore these questions further. Eight participants from Zhàozhuāng (reduced tone system type C) were tested on their ability to distinguish the conservative set of tones (as produced by the male speaker from Wānqiáo introduced in 6.4.1).

The task was designed as follows. The Qualtrics interface was used to create forty multiple choice questions with four possible answers each. Each question consisted of an auditory stimulus with a monosyllabic lexical item of interest ‘X’ appearing in the carrier

sentence [X, tɯː^{21} tseː^{55} mɯː^{55} sʷɑ^{44}ː] ‘X, (do you) know how to say (it)?’. Each question had four possible responses glossed in Chinese for speakers to select. In total there were two unique tokens for each of twenty stimuli types. The selectable choices for the twenty stimuli types are indicated in (76), these choices appeared in randomly generated left-to-right order. Speakers listened and responded to each stimulus five times in randomized order.

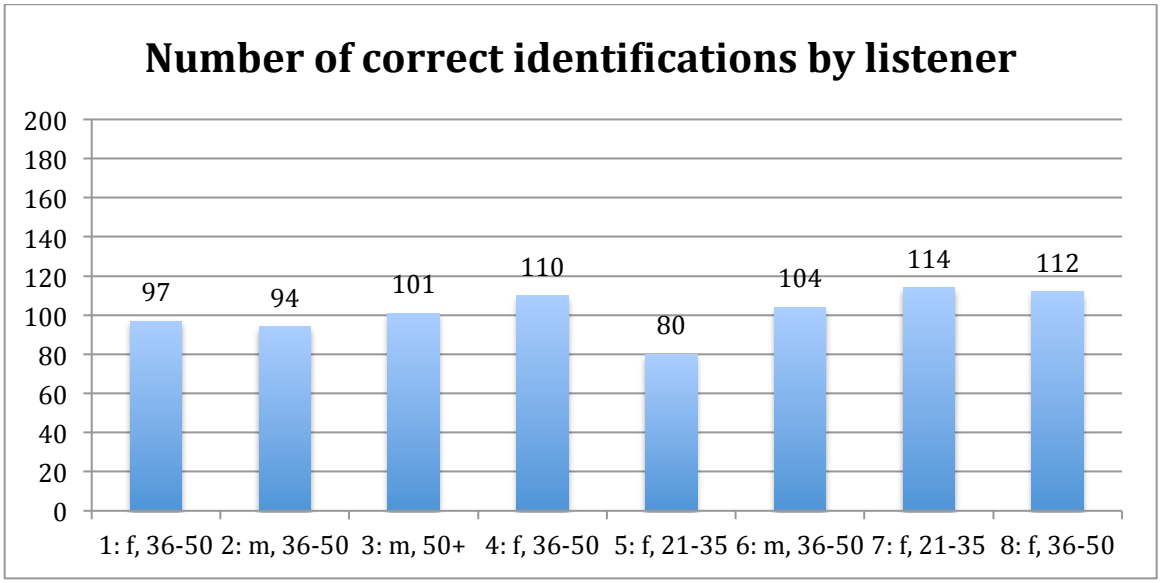
Fig. (76) Selectable Choices for Twenty Stimuli Types

Category	Stimulus Type	Selectable Choices
[tɕi]-set	[tɕi^{21}] ‘to sing’	[21], [31], [32], [33]
[tɕi]-set	[tɕiː^{31}] ‘field’	[31], [21], [32], [33]
[tɕi]-set	[tɕiː^{32}] ‘arrow’	[32], [21], [42], [44]
[tɕi]-set	[tɕiː^{33}] ‘to pull’	[33], [32], [31], [21]
[tɕi]-set	[tɕiː^{42}] ‘nephew’	[42], [31], [32], [44]
[tɕi]-set	[tɕiː^{44}] ‘queen ant’	[44], [31], [32], [42]
[pɑ]-set	[pɑ^{21}] ‘to move’	[21], [31], [32], [33]
[pɑ]-set	[pɑː^{31}] ‘to stir’	[31], [21], [32], [33]
[pɑ]-set	[pɑː^{32}] ‘panther, puma’	[32], [21], [42], [44]
[pɑ]-set	[pɑː^{33}] ‘foam’	[33], [32], [31], [21]
[pɑ]-set	[pɑː^{42}] ‘milk’	[42], [31], [32], [44]
[pɑ]-set	[pɑː^{44}] ‘to fall down’	[44], [31], [32], [42]
[se]-set	[seː^{31}] ‘small’	[31], [32], [33], [44]
[se]-set	[seː^{32}] ‘to lay (an egg)’	[31], [35], [33], [44]
[se]-set	[seː^{33}] ‘to wash’	[31], [35], [33], [44]
[tɯ]-set	[tɯː^{31}] ‘bean’	[33], [31], [32], [21]
[tɯ]-set	[tɯː^{32}] ‘to wear’	[33], [31], [32], [21]
[tɯ]-set	[tɯː^{33}] ‘to wait’	[33], [31], [32], [21]
filler-1	[mɑː^{42}] ‘busy’	‘busy’, ‘free’, ‘clear’, ‘them’
filler-2	[kɑo^{44}] ‘older brother’	‘older brother’, ‘younger brother’, ‘younger sister’, ‘older sister’

The selectable choices were determined as follows. For the syllable sets with larger numbers of available minimally contrastive tones ([pɑ] and [tɕi]), listeners were offered four different choices for lexical glosses based on impressionistic similarity implied by the Chao tone number system. For the syllable type [se], listeners could select

from the three relevant tones of interest and tone [35]. For the syllable type [tɯ], listeners could select from the three relevant tones of interest and tone [21]. The two filler types listeners were offered choices which do not have similar segmental realizations. The overall accuracy in tone identification for each speaker is presented in the bar graph in (77).

Fig. (77) Overall Accuracy in Tone Identification by Listener



Overall, listeners were able to accurately identify roughly half of the stimuli correctly. The fillers and tone categories [21], [42], [44] (except for [pɑ:^{44}]) were identified accurately by most listeners at a rate greater than chance. The rate of accurate identification did not differ between stimuli of the same type. These tendencies are reflected in the table of accurate responses in (78).

Fig. (78) Accurate Identification of Stimulus by Speaker

		1: f, 36-50	2: m, 36-50	3: m, 50+	4: f, 36-50	5: f, 21-35	6: m, 36-50	7: f, 21-35	8: f, 36-50
	pa21.1	40%	80%	80%	100%	80%	60%	100%	80%
	pa21.2	80%	80%	100%	100%	100%	80%	100%	60%
pa set	pa31.1	100%	80%	0%	80%	0%	40%	0%	80%
	pa31.2	100%	60%	40%	60%	0%	20%	0%	80%
	pa32.1	0%	0%	20%	40%	0%	0%	0%	80%
	pa32.2	0%	0%	20%	0%	0%	40%	0%	80%
	pa33.1	0%	0%	60%	40%	0%	60%	60%	0%
	pa33.2	0%	0%	20%	80%	0%	0%	60%	0%
	pa42.1	100%	100%	100%	100%	100%	100%	100%	60%
	pa42.2	100%	100%	100%	100%	100%	100%	100%	60%
	pa44.1	0%	0%	0%	20%	0%	20%	40%	0%
	pa44.2	0%	0%	0%	0%	0%	20%	20%	0%
	tɕi21.1	0%	20%	80%	100%	80%	20%	100%	80%
	tɕi21.2	0%	40%	80%	100%	80%	40%	100%	60%
tɕi set	tɕi31.1	100%	80%	40%	0%	40%	40%	0%	80%
	tɕi31.2	100%	40%	60%	40%	40%	40%	0%	80%
	tɕi32.1	0%	0%	40%	0%	0%	100%	0%	0%
	tɕi32.2	0%	0%	0%	0%	0%	100%	0%	0%
	tɕi33.1	40%	40%	0%	20%	0%	0%	80%	80%
	tɕi33.2	0%	60%	0%	20%	0%	20%	60%	60%
	tɕi42.1	100%	100%	100%	100%	100%	100%	100%	100%
	tɕi42.2	100%	100%	100%	100%	100%	100%	100%	100%
	tɕi44.1	80%	100%	100%	100%	20%	100%	100%	100%
	tɕi44.2	80%	100%	60%	100%	20%	100%	100%	80%
tɯ set	tɯ31.1	100%	40%	60%	40%	60%	60%	60%	80%
	tɯ31.2	100%	60%	60%	60%	40%	60%	80%	100%
	tɯ32.1	0%	0%	0%	0%	0%	0%	40%	0%
	tɯ32.2	0%	0%	0%	0%	0%	0%	80%	0%
	tɯ33.1	0%	0%	40%	40%	0%	40%	60%	0%
	tɯ33.2	20%	40%	40%	60%	20%	20%	40%	40%
se set	se31.1	100%	40%	80%	80%	100%	80%	60%	100%
	se31.2	100%	40%	80%	40%	100%	80%	20%	80%
	se32.1	0%	0%	0%	0%	0%	0%	0%	0%
	se32.2	0%	0%	0%	0%	0%	0%	0%	0%
	se33.1	0%	80%	40%	0%	20%	40%	80%	20%
	se33.2	0%	0%	20%	80%	0%	20%	40%	20%
	kɑo44.1	100%	100%	100%	100%	100%	100%	100%	100%
	kɑo44.2	100%	100%	100%	100%	100%	100%	100%	100%
	mɑ42.1	100%	100%	100%	100%	100%	100%	100%	100%
	mɑ42.2	100%	100%	100%	100%	100%	80%	100%	100%

Aside from the aforementioned generalizations about tokens for a given type regarding accurate identification of the fillers and tone categories [44], [42], and [21], relevant observations about the rate of accurate identification by speaker can be summarized as follows. Although listeners generally could not accurately identify all three tones [33], [32], and [31] at a rate greater than chance, nearly every speaker was

able to accurately identify at least one of these three tone categories at a rate greater than chance for a given set; this is emphasized with borders and highlighting around the relevant cells in (22). Overall, listeners identified tone [31] accurately and misidentified tones [33] and [32]. Conversely, listener 7 identified [33] accurately at a level greater than chance for most sets, but generally misidentified [31] except for the [tɯ]-set which she was able to distinguish each of the tone contrasts at a rate greater than chance. The accurate identification of either [31] or [33] but not both categories suggests that these categories are merged in perception and speakers consistently access one of these items when presented with lexical items which are produced distinctively in the conservative system. Nearly all misidentifications for stimuli of these two categories selected the other tone (i.e. category [31] was misidentified as category [33] and vice-versa). This is reflected in the complete set of responses in Appendix D. The misidentification of [32] is more interesting; a summary of the selected responses for these tokens is presented in (79).

Fig. (79) Selected Responses for Tone [32] Tokens

	[32]	[21]	[42]	[35]	[44]	[31]	[33]
[tɕi]-set	12 (20%)	16 (15%)	37 (46%)	N/A	15 (19%)	N/A	N/A
[pɑ]-set	14 (18%)	12 (15%)	46 (57%)	N/A	8 (10%)	N/A	N/A
[se]-set	0	N/A	N/A	0	N/A	59 (74%)	21 (26%)
[tɯ]-set	6 (8%)	0	N/A	N/A	N/A	45 (56%)	29 (36%)

When listeners could choose from one of the four categories – [42], [32], [21], or [44] – tone category [42] was more commonly selected than [32]. The other tone categories were selected somewhat often as well. When tone categories [31] or [33] were available options speakers selected either option, with [31] being more commonly selected than [33]. Unfortunately at the time of preparation I did not expect that tone [32]

would be misidentified as the [42], [33], and [31] categories and did not offer sets contrasting these three most commonly misidentified tones. Despite this design flaw, the results of this listening task suggest that Zhàozhuāng speakers cannot identify category [32] accurately and misidentify this category based on falling change in pitch. This is not surprising as the falling tone [42] for Zhàozhuāng speakers is underspecified for register. Furthermore, although the merged [33]-[31] tone category is simply specified as a long low tone (two time units specified as [GLOTTIS]—[-H], [GLOTTIS]—[-stiff]), if we think of achieving tone as a gesture, then a falling movement can reflect a speaker's intention to reach a low pitch target throughout the production of the syllable.[26]

6.4.4 Summary of the Ěrhǎi Bái Tone System

This section presents a composite account of the variation in number and nature of tone categories across speakers of Ěrhǎi Bái. The merger of tone categories [31] and [33] is a regular sound change which has completed for many speakers of Ěrhǎi Bái, even in the speech of speakers who reside in communities which have other speakers who can produce the distinctions generated by the conservative tone system. On the other hand, the loss of tone [32] is irregular. This tone corresponds to several different tones in excerpts of Bái language data which do not specify [32] as contrastive. Furthermore, speakers misidentify this tone with other falling categories. This absence of evidence for regular loss of this tone could suggest that this contrastive production is actually an innovation amongst certain speakers and communities; however, given the limited available instances of this tone in the relevant Bái language references, I leave this inquiry open to further research.

[26] See Gussenhoven (2007:266) for a similar explanation in the realization of low-pitched targets in several languages.

6.5 Summary

This chapter presents an overview of the content which is contrastively specified in the rime of a syllable. Although the tone and vowel contrasts are specified on different sets of feature bundles, the surface production of these contrasts is not independent. For instance, specified [GLOTTIS]—[+spread] for tone category [21] gives the nuclear vowel a breathy quality. Furthermore, the production of [ɛ] or [e] in the Xǐzhōu variety might be allophonic and dictated by tone category.

While it is clear that there is an intricate connection between vowel and tone in Bái, some aspects of these systems remain obscure. For instance, although the analysis presented in this chapter assumes that features for tone categories dictate syllable weight, it is not entirely unquestionable that vowels should be specified as long vowels in underlying representation and hence trigger the level tone features to be spread from nucleus to coda. Although monophthongs are not contrastive with diphthongs in Bái, there is some evidence that coda features affect the well-formedness of possible phonological representation. For instance, syllables with the gestures of a palatal glide ([BODY]—[+high], [BODY]—[-back]) in both onset and coda positions (such as *[jej]) are avoided. Consider the potential three-way contrast among syllables [tʲe:]-[tʲei]-[tʲɛ:] as represented in (80) for instance.

Fig. (80) Avoidance of Repeated Oral Gestures in Onset and Coda Position

	a. [tʲe:] ‘mat’			b. *[tʲei]			c. [tʲɛ:] ‘dot		
	x_{ons}	x_{nuc}	x_{cod}	x_{ons}	x_{nuc}	x_{cod}	x_{ons}	x_{nuc}	x_{cod}
[TIP]—[stop]	+			+			+		
[BODY]—[high]	+	-	:	+	-	+	+	-	:
[BODY]—[back]	+	-	:	+	-	+	+	-	:
[ROOT]—[advanced]		+	:		+			-	:

Some varieties contrast (80a) ‘mat’ with (80c) ‘dot’ and other varieties pronounce both of these lexical items as (80c), but no variety produces a form such as (80b). The speakers who do not make this contrast consistently produce rime 2 as diphthong [ei] (Ěrhǎi Vowel System Type B). Despite the avoidance of syllables like (80b), however, these speakers do not contrast [e] from [ei], and hence contrastive specification of these two rimes is unnecessary in underlying representation. On the other hand, the appeal of specifying level tones as long can be summarized as follows. Level tones are not appreciably shorter than the falling and rising tones (which require specification for two timing units) in Bái; lengthened specification in underlying representation reflects this similarity in produced duration. Furthermore, specified tones are fixed to monosyllabic morphemes in Bái. Productive tone sandhi is not described in the majority of Bái language references which means that tone features do not spread across word or phrase boundaries. Lengthened specification of level tones hence accounts for the fact that contour tones are similar in duration with level tones and dissimilar in duration with the short breathy tone. This specification simulatenously permits the free variation of nuclear monophthongs and their diphthongized variants in underlying representation (for example, the segmental component of the morpheme ‘older brother’ can be represented as [kɔ], [kɔː], or [kɑo] in underlying representation). This latter aspect permits individual speakers to produce one or the other while maintaining a consistent representation for the composite phonological system.

Chapter 7. Spreading and Epenthesis in Bái Phonology

The previous two chapters offer an account of attested underlying specifications for contrastive onsets and rimes. In chapter 4, I state that the fixed $C^{G}VX$ syllable structure for Bái can provide better coverage of the attested to possible predicted syllables than prior syllable structure formats, approximately 77.7% of the available syllable vectors represent attested syllables (131:170 [CV] + 86:109 [$C^{G}V$] = 217/279). This count does not include syllables which I propose are derived from onset-to-rime feature spreading. In this chapter I present an analysis of phenomena which spread features between these sub-syllabic constituents to account for attested syllables which are contrastive (and non-contrastive) with one another. My proposal of the relevant phenomena is as follows. The palatals [tɕ, tɕ^{h}, ɕ, ɕ^{h}, ɳ̟, ʑ̟] and alveopalatals [tʃ, tʃ^{h}, ʃ, ʃ^{h}, ɲ, ʒ] are derived from rime-to-onset spreading or coarticulation of consonant and glide features in the onset. The fricative vowels, commonly transcribed as <ɿ> and <ʮ> in descriptions of Bái, are epenthetic segments taking their phonological qualities from features of the onset. I address these phenomena as follows. Section 7.1 describes the distributions of the palatals and alveopalatals with AIP analyses of these derived onsets. Section 7.2 describes the epenthesis patterns in Bái and presents an AIP analysis of these epenthesis processes. Discussion concludes in section 7.3.

7.1 Deriving Palatals and Alveopalatals

If the palatals and alveopalatals are considered to be derived from another class of consonants in contexts with a high front pre-nuclear glide, and generalizations about

fixed [$C^{G}VX$] syllable structure for Bái as presented in chapter 4 are accurate, then these consonant classes do not contrast with the velars or the dental continuants in most varieties of Bái. However, I argue that the palatals are derived from the dental continuants for three primary reasons. First, some varieties of Bái (such as Dàshí Bái described in Fēng WĀNG 2006) have palatalized dental sibilants [ts^{j}, ts^{hj}, s^{j}] corresponding to the palatals in most other varieties of Bái. Second, the corresponding segments for the dentals [ts, ts^{h}, s, z, n] have the same manners as the palatals [tɕ, $tɕ^{h}$, ɕ, ʑ, ȵ]; the corresponding manners for the velars [k, k^{h}, x, ɣ, ŋ] are stops instead of affricates. Third, some speakers of Bái have innovated such that the velars and the palatals are contrastive as I have detailed for the Zhàozhuāng variety in chapters 4 and 6. I introduce the processes of vocoid spreading and coarticulation which derive the innovations attested in particular varieties in sub-section 7.1.1. Sub-section 7.1.2 presents an AIP analysis of palatalization for the Bái data. Sub-section 7.1.3 summarizes the relevance of this phenomenon.

7.1.1 Vocoid Spreading and Coarticulation

In my view, the palatals and alveopalatals in Bái are derived from the combination of features representative of high vowels and dental sibilants in the onset. These combinations are derived in two ways – vocoid spreading and coarticulation. Vocoid spreading refers to the process by which features from the nuclear vowel in the rime must spread into the glide position of the onset. Coarticulation, on the other hand, is the process by which a glide segment appears in an onset due to required ordering of vocoid features before a nuclear vowel. Examples of these processes are compared for the relevant syllable types with unaffected syllables in (81).

Fig. (81) Comparison of Three Syllable Types

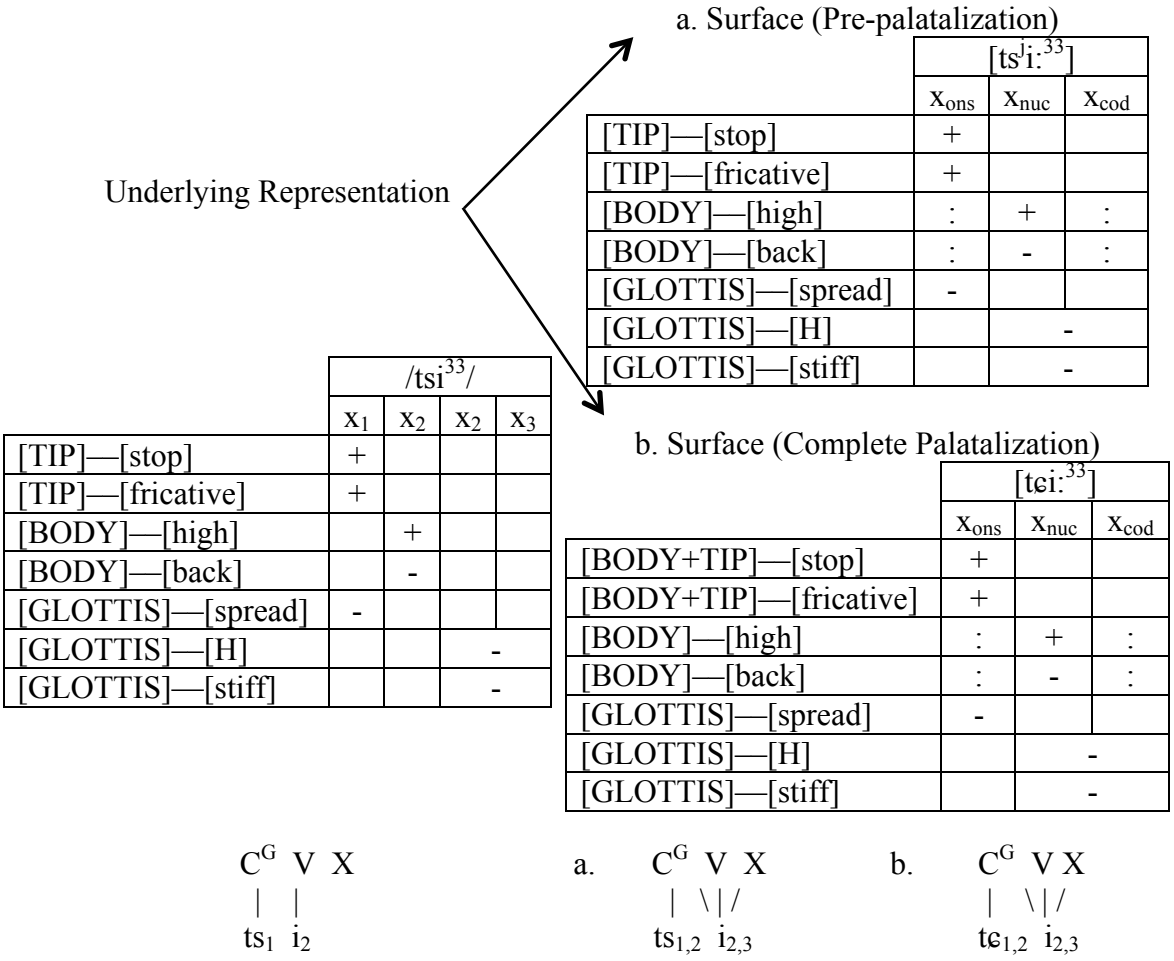
	Initial-Final Transcription	Underlying Representation	Surface Representation	Phonological Process
(a)	<pa> 'to hit'	/p_1 a_2/	[p_1 a_2]	N/A
(b)	<pia> 'eight'	/p_1 i_1 a_2/	[$p^j{}_1$ a_2]	Coarticulation
(c)	<ka> 'cold'	/k_1 a_2/	[k_1 a_2]	N/A
(d)	<kua> 'strange'	/k_1 u_1 a_2/	[$k^w{}_1$ a_2]	Coarticulation
(e)	<tsa> 'how?'	/ts_1 a_2/	[ts_1 a_2]	N/A
(f)	<tɕa> 'debt'	/ts_1 i_1 a_2/	[$tɕ_1$ a_2]	Coarticulaiton
(h)	<tɕi> 'pull'	/ts_1 i_2/	[$tɕ_{1+2}$ i_2]	Spreading
(g)	<tɕy> 'drunk'	/ts_1 y_2/	[$tɕ^w{}_{1+2}$ y_2]	Spreading

The eight example syllables in (81) compare the mappings between underlying and surface representations for three syllable configurations – $CV_{[-high]}$, $C^GV_{[-high]}$, and $CV_{[+high]}$. These examples were specifically selected to illustrate the consequences of affiliation of pre-nuclear glides (and their corresponding vocoid features) to the onset. The first column indexes the examples alphabetically (a-g). The second column presents syllables as they are typically transcribed in the Initial-Final descriptions. The third column presents the underlying representations of the relevant lexical items. The fourth column presents the surface representations of the relevant lexical items. The palatalized onsets, labialized onsets, and palatals are derived by coarticulation of consonant and vocoid segments preceding non-high vowels as expressed in (81b) (81d), and (81f) respectively. The palatals can also be derived from vocoid features spreading from the rime into the onset as in (81h) and (81g). Since a positive value for [round] is specified for [y], this feature also spreads from rime to onset. The palatals (and labialized onsets) are generated from affiliation of vocoid features to the onset either from rime-to-onset spreading or direct ordering to avoid conflicting feature specification. I introduce an AIP analysis of vocoid spreading and coarticulation in the next sub-section.

7.1.2 AIP Analysis of Vocoid Spreading and Coarticulation in Bái

Throughout this dissertation I have advocated for an allophonic relationship between the palatals and dental continuants. Allophonic palatalization is an assimilatory process triggered by adjacent vocoid segments (Krämer & Urek 2016). The lack of regular and active alternations obscures the triggering of this allophonic relationship in Bái. Fortunately the range of varieties considered offers various stages of this change. Nearly each variety of Bái has completed this sound change, although the Dàshí variety still shows incomplete palatalization whereby the vocoid features have spread to the onset, but the place of articulation of the consonant has not changed from dental to palatal. These two stages of palatalization are tabulated in (82) for vocoid spreading derived from nuclear [i].

Fig. (82) Palatalization by Vocoid Spreading

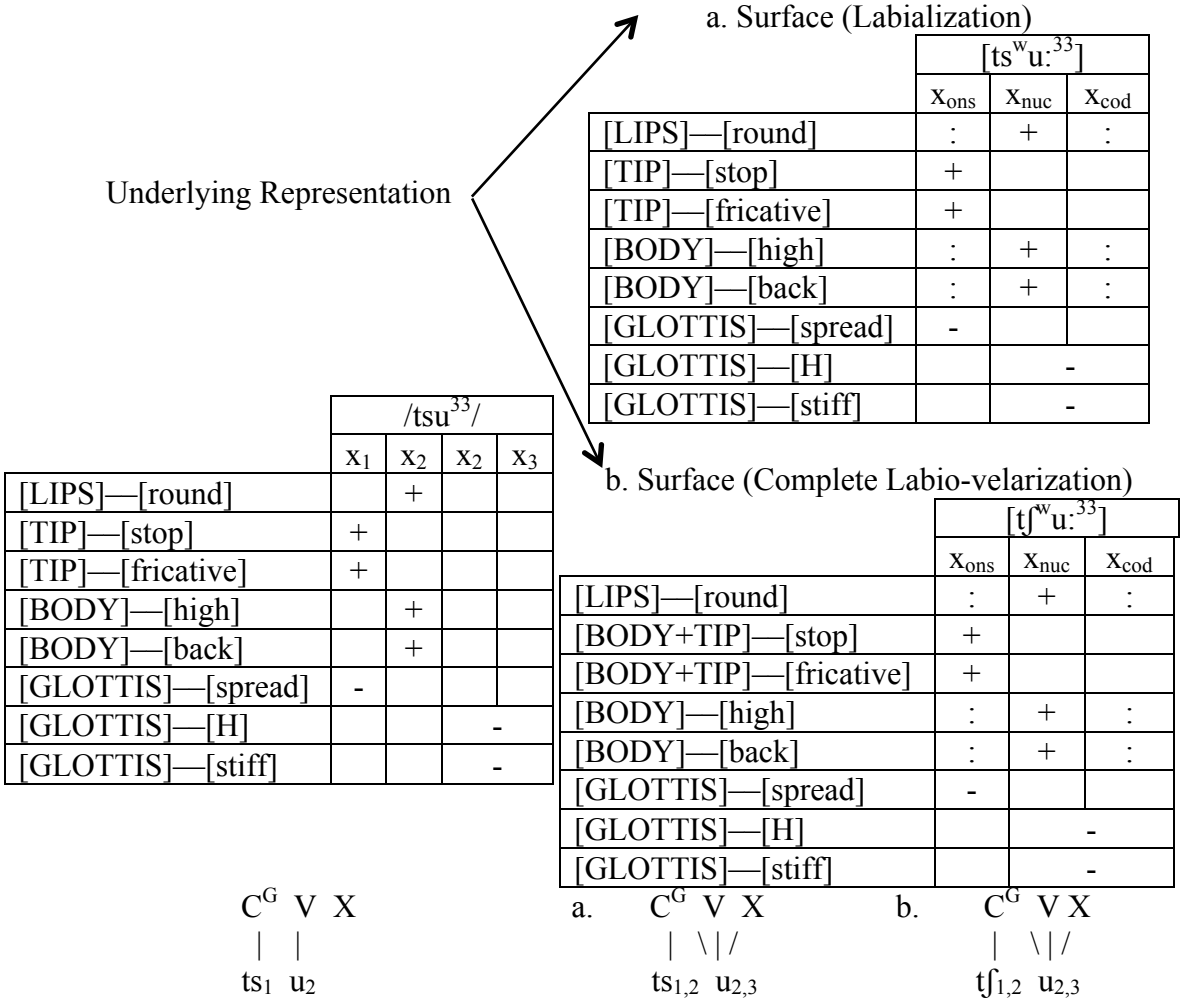


a. Spread vocoid features
b. Spread features triggered place change (TS > Tɕ)

The AIP tables in (82) show two stages of palatalization in Bái for the monosyllabic morpheme [tsʲi]~[tɕi] 'to pull'. Stage (82a) represents a state observed in the Dàshí variety in which the vocoid features spread from rime-to-onset but do not trigger change in onset place. In contrast, stage (82b) represents the state observed in nearly all other varieties in which these features have triggered the change in onset place; that is, the [+stop] and [+fricative] features are specified for both the [BODY] and [TIP] articulators. The obstruent constrictions for the transformed palatals include not only the

original articulator – the tongue tip – but also the articulator of the spread vocoid features – the tongue body. I return to the relevance of this change in the next few examples as other important features spread from rime-to-onset. Despite the lack of active alternations, these two forms suggest that palatalization in Bái is indeed an assimilatory process as there is no need for two distinct underlying representations for the palatals and the dental sibilants. Discussion turns to labio-velarization before [u] as visualized in (83) which is innovative in some of the Ěrhǎi Bái varieties (particularly the Zhàozhuāng, Xǐzhōu, Qīlǐqiáo, and other varieties around the southwest coast of the Ěrhǎi Lake).

Fig. (83) Innovative Labio-velarization Before [u]

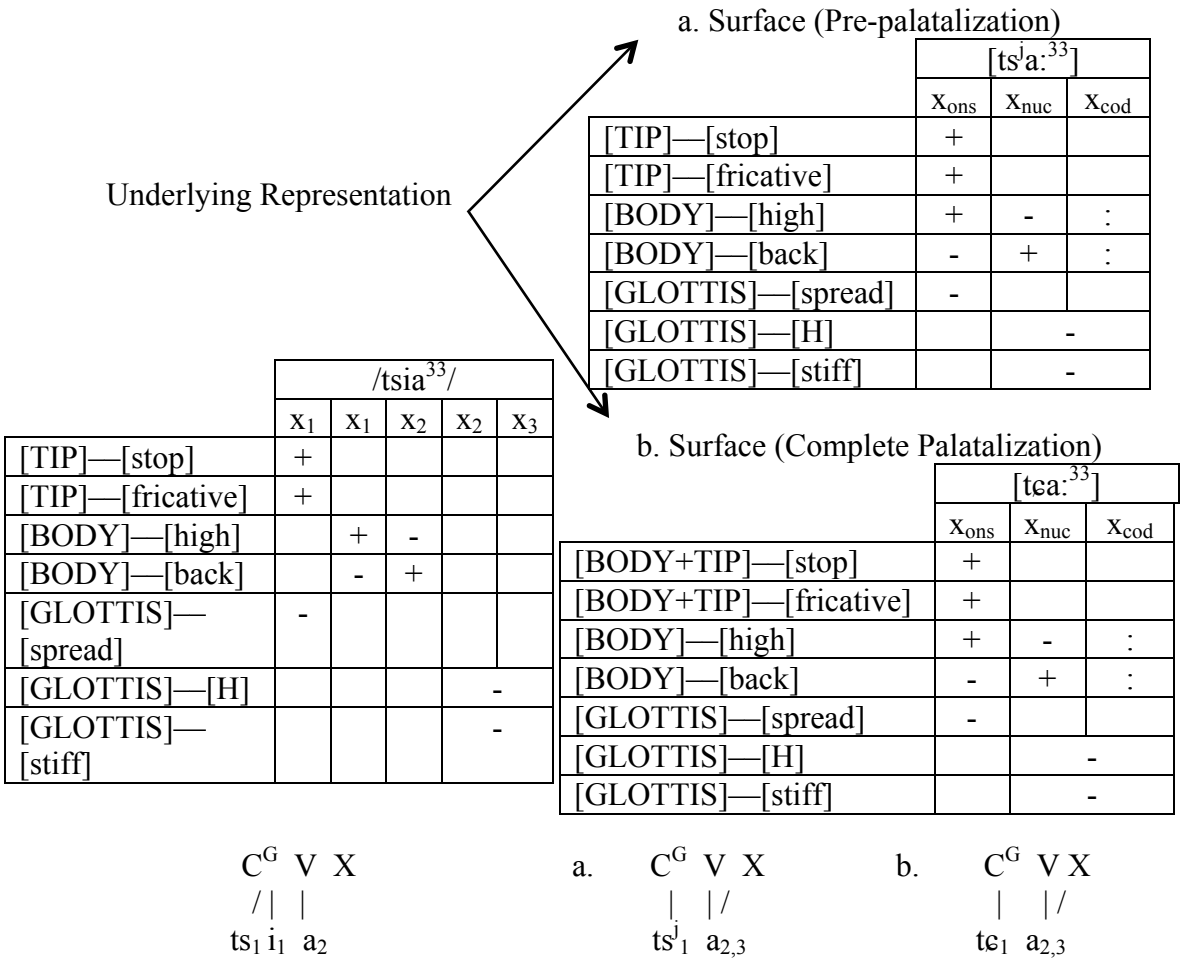


a. Spread vocoid features
b. Spread features triggered place change (TS > TʃS)

The AIP tables in (83) show two stages of labio-velarization in Bái for the word /tsu^{33}/ ‘early’. The process of labio-velarization is similar to the pattern observed in (2) for palatalization in that the features affiliated to the vocoids (including the rounding of the lips) spread to onset position in both stage (83a) and (83b). However, the place of the labiov-elarized onset in (83b) differs due to backness of the tongue body (alveopalatal [ʃ] as opposed to palatal [ɕ]). The two kinds of vocoid spreading introduced in (82) and (83) suggest that palatalization is strictly assimilatory and non-contrastive in Bái. The features

affiliated to vocoid feature bundles spread to the onset in all cases, but only change place of constriction as an innovation. Perhaps this innovation enhances perception and production of vocoid features ([high], [back], [round]) since the preceeding obstruent articulation includes both the tongue body and the tongue tip, rather than just the tongue tip. Discussion continues with coarticulatory innovations in onset position with a palatalization in (84).

Fig. (84) Coarticulatory Palatalization



a. Spread vocoid features
b. Spread features triggered place change

The AIP tables in (84) reflect the two stages of palatalization in Bái for coarticulatory palatalization in the onset. The rationale and observed patterns are the same as (82) and (83) with the primary difference being that the vocoid gestures precede vowels of higher sonority. Assuming the fixed $C^{G}VX$ syllable structure, any pre-nuclear glide and consonant coarticulate in onset position, but combinations of dental continuants and these glides result in non-contrastive palatalization for the varieties which have innovative palatalization from either pattern (82b) or (82b) and (83b). Similarly, this coarticulation facilitates the perception of the vocoid features, but also facilitates the transition between the changing gestures of the tongue body across the production of the syllable. Discussion continues with the innovative patterns of the velars in the Zhàozhuāng variety.

While I have continued to advocate for the allophonic relationship between the dental continuants and the palatals, the palatals are generally non-contrastive with the velars except in certain innovative varieties. These innovations are related to the raising of vowels in the context of velars as evidenced by correspondences across varieties. In Zhàozhuāng Bái, for instance, the palatals contrast with the velars before [i]. That is, the monosyllabic words [ki:^{35}] ‘chicken’ and [tɕi:^{35}] ‘many’ are minimal pairs in the Zhàozhuāng variety whereas the former word is pronounced as [ke:^{35}] in non-innovative varieties. The AIP tables in (85) show the underlying-to-surface mapping for [k^{j}i^{35}] ‘chicken’ in Zhàozhuāng Bái.

Fig. (85) Vocoid Palatalization of Velars in Zhàozhuāng Bái

	/ki^{35}/			
	x_1	x_2	x_2	x_3
[BODY]—[stop]	+			
[BODY]—[high]		+		
[BODY]—[back]		-		
[GLOTTIS]—[spread]	-			
[GLOTTIS]—[H]			-	+

→

	[k^{j}i:^{35}]		
	x_{ons}	x_{nuc}	x_{cod}
[BODY]—[stop]	+		
[BODY]—[high]	:	+	:
[BODY]—[back]	:	-	:
[GLOTTIS]—[spread]	-		
[GLOTTIS]—[H]		-	+

The palatals must be distinct from the velars in Zhàozhuāng Bái as the spreading of the vocoid features from rime-to-onset in (85) suggests that palatalized velars are contrastive with the palatals. Furthermore, an articulator-based account of feature representations suggests that the necessary change in place of articulation required for palatalization requires fewer steps for dental continuants (change place) than for velars (change place and manner). In brief, both the tongue body and tongue tip articulators appear in the onset when dental continuants are palatalized via vocoid spreading whereas only features specified for the tongue body appear in the underlying and surface representations of palatalized velars.

7.1.3 Summary of Relevant Processes in Bái

This section has presented a few examples of innovative onsets in Bái. In particular, I have shown that the dental continuants have undergone palatalization before high front vowels in most varieties and have undergone labio-velarization in specific varieties of Ěrhǎi Bái. I have argued that these processes are the result of affiliation of vocoid features to the onset before an underlying dental continuant. The three innovative processes can be characterized as follows. Palatalization is conditioned by the presence of

the [BODY]—[-back] feature in the onset (i.e. [s] > [ɕ]), labialization is conditioned by the presence of the [LIPS]—[+round] feature in the onset (i.e. [sw] > [s^w]), and velarization is conditioned by the presence of the [BODY]—[+back] feature in the onset (i.e. [s] > [ʃ]). In sum, vocoid [j] conditions palatalization, vocoid [w] conditions labio-velarization, and vocoid [ɥ] conditions labio-palatalization. Although these innovations are diachronic changes since there are no active alternations between the relevant classes, I have suggested that the change in place which occurs during these innovations is motivated by articulatory and perceptual principles. This is further supported by another innovative kind of palatalization I refer to as "complete" dental palatalization.

This innovative "complete" dental palatalization is attested in some varieties of Ěrhǎi Bái. In some communities along the northwestern region of the Ěrhǎi Lake, such as Zhōuchéng and Táoyuán, the dental stops have merged into the palatals before [i] ([T] > [Tɕ] / [#_i]). This change has resulted in a loss in the contrast between syllables such as [tɕi:^{33}] 'elder sister' and [ti:^{33}] 'father' which are both realized as [tɕi] in these innovative varieties. This example is particularly informative of the central role of the articulators in the representation of phonological contrast as it is relatively difficult to maintain a contrast between stops and affricates in the context of high front vowels as the built-up air pressure for the [+stop] constriction is released into a relatively constricted passage (Ohala 1983:204). Palatalization reflects a sound change derived from features specified for consonants and vocalic segments in underlying representation. The next section introduces epenthetic phenomena which generate contrast in the absence of particular underlying material.

7.2 Rime Epenthesis

In this section I argue that there are three kinds of epenthetic rimes in Bái: the default epenthetic vowel, fricative vowels, and "spread round" vowels. The default epenthetic vowel in Bái is [ɯ]. This vowel is attested after every consonant and its specification or underspecification is required in the underlying representation of a syllable depending on certain factors. The conditioning triggers for the insertion of this vowel are typical of default epenthesis and I address this epenthesis after thorough treatment of the other types of epenthesis. Fricative vowels are derived by spreading the feature [+fricative] from an underlying onset into a rime which is underspecified for segmental content. "Spread round" vowels are similarly derived by spreading the feature [+round] from an underlying onset into an underspecified rime. Discussion in this section is organized as follows. The distribution of fricative vowels and spread round vowels is described in 7.2.1. The diachronic origin of spread round vowels is presented in 7.2.2. Default epenthesis is described in 7.2.3. AIP analysis of these epenthetic segments is provided in 7.2.4.

7.2.1 Distribution of Fricative Vowels in Bái

This sub-section is devoted to the exploration of the two kinds of epenthetic vowels attested in Bái phonology which are cross-linguistically uncommon – fricative vowels and "spread-round" vowels. These categories are not necessarily mutually-exclusive as some epenthetic vowels are both fricative and "spread-round". In brief, these epenthetic vowels are the consequence of spreading specified [+fricative] and/or [+round] features from a feature bundle in the onset of a syllable onto a rime devoid of

any segmental features in underlying representation. Discussion begins with fricative vowels.

There are numerous terms for 'fricative vowels' in the literature – 'fricativized vowels', 'apical vowels', 'obstruent vowels', and others. I prefer the term 'fricative vowels' because these segments are derived from spreading the [+fricative] feature from onset-to-rime in my analysis. Prior work transcribes two fricative vowels <ɿ> and <ʅ> in Bái, but I argue that there are three different fricative vowels in Bái: [z̩], [z̩^{w}], [ʏ̩]. Although my analysis has a larger number of surface variants than prior analyses, my analysis offers better phonological economy as these four sounds are non-contrastive with one another and are derived from their preceding onset consonants. The distribution of the relevant sounds is provided in (86); tones are omitted in the presented exemplar syllables.

Fig. (86) Fricative Vowels

	Initial-Final Transcription	Underlying Representation	Surface Representation	Phonological Process
(a)	<tɕi> 'to pull'	/ts$_1$ i$_2$/	[tɕ$_{1+2}$ i$_2$]	Vocoid Spreading
(b)	<tsɿ> 'street'	/ts$_1$/	[ts$_1$ z̩$_2$]	Fricative Spreading
(c)	<v> 'wife'	/v$_1$/	[v$_1$ ʏ̩$_2$]	Fricative Spreading
(d)	<fv> 'six'	/f$_1$/	[f$_1$ ʏ̩$_2$]	Fricative Spreading
(e)	<tsv> 'insect'	/ts$_1$ w$_1$/	[ts$^{w}_1$ z̩$^{w}_2$]	Fricative Spreading

The data in (86) are organized in the same manner as the data in (81). While most prior work treats the palatals and dental continuants as distinct from one another in order to treat syllables in (86a) and (86b) as contrastive, my analysis assumes that the underlying representations share the same dental continuant feature bundle differing in presence of a vocoid nuclear vowel (86a) or absence of this vowel (86b). I propose that fricative vowels are not specified in underlying representation. That is, the underlying

representations for syllables with fricative vowels only consist of sibilant and tonal features. The absence of an underlying vowel but specification of tonal features triggers the spreading of the [+fricative] feature from onset-to-rime. Since features are articulator-based in the theory of distinctive features assumed in this dissertation, the articulator which includes the feature [+fricative] determines the place of the fricative in the nucleus. Furthermore, since affricates are the result of a simultaneous specification of [+fricative] and [+stop] in the single timing-slot available to the onset, the fricative nuclei of the syllables with affricate onsets are derived from spreading the [+fricative] feature into the rime, but since [+stop] cannot be a continuous action this feature cannot spread. Additionally, since every syllable requires a tone in Bái, the fricative in the rime must be voiced.

Considering all the statements in the previous paragraph, the generalizations regarding fricative vowels can be summarized as follows. Fricative vowel [z̩] appears after dental sibilant onsets [ts, ts^{h}, s, z] as in (86b). Fricative vowel [ɣ] appears after labiodental fricative onsets [f, v] as in (86c-d). The fricative vowel from example (86e) – [z̩^{w}] – is perhaps the most unusual of the four fricative vowels in this language. Although every Bái description of which I am aware transcribes this vowel as <v> after dental sibilants, Dell (1981) notes that this sound is produced differently from the [ɣ] after labiodentals and ZHÀO Yànzhēn (2012) provides a generalization along the lines of the rule: [ɣ] → [ɥ] / C$_{[Dental]}$_#.[27] This vowel is derived in a manner similar to example (86b) with the exception that the feature bundle includes [+round] in addition to the other dental sibilant features. Accordingly the underlying representations of syllables (not

[27] The sound transcribed as <ɥ> is the rounded variant of the apical vowel <ɿ> in the Chinese practice of phonetic transcription.

including tones) with these vowels are: /s^{w}/ → [s^{w}ʐ^{w}], /ts^{w}/ → [ts^{w}ʐ^{w}], /ts^{hw}/ → [ts^{hw}ʐ^{w}], and /z^{w}/ → [z^{w}ʐ^{w}]. Although rounding can spread from rime-to-onset via vocoid spreading in Bái (as proposed in the previous sub-section 7.1.1), such spreading would require underlying specification of [u] or [y]. However, these underlying specifications are blocked by those which generate the palatalized surface forms /su/ → [ʃu] and/or [sy] → [ɕy].

As mentioned in the previous paragraph, the rounded fricative vowel [ʐ^{w}] is generally transcribed as <v> after dental sibilant onsets. My discussion of (86) also hypothesizes that transcribed <v> also represents fricative vowel [ɣ] after labiodental onsets. However, transcribed <v> is not limited to these two fricative vowels. Transcribed <v> is also attested in syllables with stop onsets such as <tv>, <t^{h}v>, <kv>, and <k^{h}v> and syllables with sonorant onsets such as <lv> and <nv>. Although this sound is similar to [ʐ^{w}], this sound cannot be derived by fricative spreading for these syllables as the onsets of these syllables lack the specified [+fricative] in the feature bundle. Instead, in my analysis the nuclear vowel transcribed as <v> after stops, laterals, and nasals is simply a round vowel underspecified for height and backness. I address this segment after the non-sibilant segments in the next sub-section with regard to its diachronic origins but do not offer a synchronic analysis until my discussion of default vowel epenthesis in 7.2.3.

7.2.2 Diachronic Origin for Spread Round Vowels

If we compare lexical items across sources, the Kāngfú variety spoken in Hèqìng prefecture as described in ZHÀO Jīncān (2011) deviates from the typical patterns of rimes transcribed as <v> and <y> in an enlightening manner. There is no nuclear segment

transcribed as <v> in that variety; every rime that is transcribed as <v> in the other varieties is pronounced as [o] in Kāngfú. On the other hand, the syllables with surface rime [y] correspond to the usual distribution. The table in (87) compares the underlying-to-surface mappings for the common pattern with the Kāngfú variety; tones are omitted in the presented exemplar syllables.

Fig. (87) Sounds Typically Transcribed as <v> and <y> in Bái Descriptions

	Transcribed Example	Common Pattern	Kāngfú Variety
Labiodentals	<fv> 'six' <v> 'wife	/f/ → [fɣ] /v/ →[vɣ]	/fo/ → [fo] /vo/ → [vo]
Dentals	<tv> 'jab'	/t^w/ → [tÿ]	/to/ → [t^wo]
Dental Sibilants	<tsv> 'insect'	/ts^w/ → [$ts^w$$z^w$]	/tso/ → [ts^wo]
Palatals	<tɕy> 'drunk'	/tsy/ → [tɕy]	
Velars	<kv> 'ghost'	/k^w/ → [kÿ]	/ko/ → [k^wo]

The table in (87) is organized as follows. The leftmost column lists the onsets by place and manner. Examples which are consistently transcribed with the combination of the onset class in the leftmost column and <v>~<y> are presented in their typical transcription format in the column second to the left. The most typical underlying-to-surface mapping for each example is presented in the column second to the right. The rightmost column lists the mappings found in the Kāngfú variety. The syllables that are the same across most varieties of Bái and the Kāngfú variety are those with rime [y] which either occurs after palatal onsets or with no underlying onset (rime [y] syllables with no underlying onset are transcribed as <y>~<ʑy>~<jy> depending on the source). On the other hand, I transcribe the nuclear segments typically transcribed as <v> after non-sibilant onsets are as [ÿ] for three reasons. First, this sound is not appreciably different from the other segments which are transcribed as <v> in other varieties. Second, this segment is triggered by the same environment (underspecified material which would

otherwise appear in the nucleus) and derived by spreading the feature [+round]. Third, the absence of the feature [+fricative] suggests that this segment is vocalic. I consider the surface realization of this segment in this context to be the consequence of [round] spreading over the default epenthesis vowel in 7.2.5, but focus on the origin of these segments in this sub-section rather than their synchronic derivation for presentational ease.

The comparative reconstruction of Proto-Bái from Fēng WĀNG (2006) suggests that the rime [o] from the Kāngfú data represents a conservative stage of Bái phonology. On pages 78-79 of that source two relevant changes are discussed. The first change [u] > [u/ɣ] is hypothesized to trigger the second change [o] > [ɣ]. In that work the Dàshí variety retains [o], following the same pattern as Kāngfú (both varieties are spoken in Hèqìng prefecture). In the synchronic phonology of the Kāngfú variety, the feature [+round] spreads from rime [o] into the feature bundle of the preceding onset. This rounding is non-contrastive before this rime and is generally not transcribed in ZHÀO Jīncān (2011); however, I have observed epenthetic rounding (which I transcribe as [^{w}] in (7) and as [w] without a specified preceding consonant) before [o] in my own elicitation from the native-speaker author of that work. The generalization regarding the sound change from [o] > {[ʐ^{w}], [ɣ], [ÿ]} can be understood as follows. In conservative varieties of Bái, the vowel [o] triggers synchronic epenthetic rounding (/o/ → [wo]). The nuclear vowel [o] is deleted as an innovation stranding the specified [+round] feature ([wo] > [w]). If there was a consonant preceding this vowel, then the innovated underlying bundle of consonant features includes [+round]. Let us consider the example syllable <tsv> ‘insect’ from (87), for instance. In Kāngfú, this syllable is pronounced as [ts^{w}o]. The

innovative [o] deletion changed the underlying representation of this monosyllabic morpheme to /ts^{w}/. The surface realization of this underlying representation is [ts^{w}z̩^{w}] which is derived by spreading both the [+fricative] and the [+round] features bound to the tongue tip articulator into the underspecified empty rime. On the other hand, one may be wondering why there are no combinations of a transcribed <v> nucleus with bilabials and velar fricatives. The absence of this segment with bilabials and velar fricatives is interesting. Since the voiced velar fricative does not co-occur with [o] in the Kāngfú variety (representative of a conservative stage of the language) there is no possible diachronic origin for a potential correspondence in other varieites. On the other hand, I speculate that the co-occurrence of the bilabials and voiceless velar fricative with [o] in Kāngfú is limited to modern Chinese loanwords (ex. [zʊ̃ː^{55} xoː^{42}] 'any' from Chinese *rènhé*) which may have been borrowed after the innovation in other varieties but I cannot offer a definitive statement regarding the absence of the syllable types combining bilabials and velar fricatives with a transcribed <v> nucleus otherwise.

My proposal regarding the derivation of the fricative vowels is the opposite of palatalization in terms of directionality of feature spreading. In section 7.1, the analysis of the considered data suggests that palatalization is either derived from rime-to-onset spreading or coarticulated to avoid opposing specifications of [high]. In sub-section 7.2.1, the analysis of the considered data suggests that fricative vowels are derived by spreading the feature [+fricative] from the onset into the rime. Through comparison of the diachronic data, I have suggested that the feature [+round] can be spread both ways. This feature spreads from rime-to-onset as part of a vocoid feature bundle (ex. /su/ → [ʃ^{w}u]) and spreads onset-to-rime as part of a sibilant consonant bundle (ex. /s^{w}/ → [s^{w}ÿ]). The

range of sources considered reflects various synchronic stages of these processes. The Dàshí variety described in Fēng WĀNG (2006) reflects an intermediate stage of palatalization in which all lexical items with palatal onsets in other varieties have palatalized dental sibilant onsets. On the other hand, the rime-to-onset spreading of [+round] as observed for the vowel [o] in Kāngfú provides us with the origin of the stranded [+round] feature hitherto deriving round fricative vowels. Interestingly, it is not entirely obvious if the labiodentals spread the feature [fricative] or both features [round] and [fricative]. I discuss the implications of this ambiguity in 7.2.5. The patterns of fricative vowels can be summarized as follows. First, the nucleus transcribed as <ɿ> is derived from the spreading of the [fricative] feature from onset to rime. Second, the nucleus transcribed as <v> is derived from the onset to rime spreading of [round] and/or [fricative] in the case of its application after dental sibilants. Note the absence of a spread velar fricative nucleus *[ɣ̩]. From a purely synchronic point of view, the absence of syllables with fricative onsets and derived spread fricative nuclei suggests that this may not be a productive process. While these fricative nuclei are the consequence of diachronic changes, I propose that the absence of spread fricatives with the velar onsets is attributed to the fact that oral articulators are affected differently by epenthesis. Default epenthesis, introduced in the next section, is a process made by the tongue body whereas fricative spreading is only possible for features specified for the tongue tip and lips.

7.2.3 Default Epenthesis

Epenthetic rimes are triggered by a void of specified features whereas nuclear vowels are typically specified in underlying representation. I have suggested that fricative nuclei are derived by spreading the feature [+fricative] from onset to rime. I have also

suggested that rounding specified in the onset and can spread into the rime. The default epenthetic vowel differs from those spread nuclei in that it is epenthesized, and not spread, in the absence of a fricative feature from the onset. This raises the question whether or not the vowel [ɯ] needs to be specified in underlying representation. On one hand, underspecification of this segment offers better economy in underlying representation and explains why vocoid features of [ɯ] ([BODY]—[+high],[-back]) do not spread into any preceding onset consonants. On the other hand, there are syllables such as [pʲɯ] and [lʲɯ] which require specification of nuclear [ɯ] in order for pre-nuclear glide [j] to coarticulate with the onset consonant preceding this nuclear vowel. That is, if nuclear vowel [ɯ] is underspecified then such syllables should surface as [pi] or [li] because the bundle of features for [j]~[i] must appear in the nucleus for assignment of tone features. Furthermore, this vowel needs to be specified after sibilants as underspecification of a nuclear segment otherwise triggers fricative spreading; that is, the attested lexical items [sɯ^{44}] 'hand' and [sɿ^{44}] 'poem' could not be contrastive if [ɯ] is underspecified in contexts of dental sibilants.

Although the vowel [ɯ] is transcribed as a high back vowel and is specified as such in terms of features in chapter 6, the phonetic measurements introduced in chapter 6 suggest that this vowel is somewhat centralized for most speakers and generally produced lower than the other high vowels. These lowered characterizations are typical of default vowels as described in de Lacy (2002:153).

While default epenthesis is necessarily not applied after the dental sibilants and labiodentals, it can be triggered by the absence of a nuclear vowel after any other consonant. This includes the residual rounded variants of consonants derived from the

loss of [o] which is described as a diachronic change in 7.2.3. When the default vowel is epenthesized after these segments, the rounding also spreads from onset to rime. This explanation is how I account for the syllables transcribed with <v> after non-sibilants (ex. transcribed <kv> 'ghost' represents the mapping /k^{w}/ → [kÿ]). I offer a summary of the epenthesized rimes in the next sub-section.

7.2.4 Summary of Epenthesized Rimes

The table in (88) presents a summary of the underlying-to-surface mappings of different epenthetic vowels introduced in this section. These phenomena are analyzed in AIP in the next section. The layout of this table can be summarized as follows. The left column lists the relevant place and manner consonant class features. The second column from the left presents an example of the underlying form for one of these classes. The second column from the right lists the surface form of the underlying representation from the middle column. The rightmost column specifies the type of epenthesis.

Fig. (88) Underlying to Surface Mappings for Singleton Consonants

Class	Underlying	Surface	Process
Bilabial Stops	/p/	[pɯ]	Default Epenthesis
Labiodental Fricatives	/f/ or /f^{w}/	[fɣ]	Fricative Spreading and/or Round Spreading?
Dental Stops	/t/	[tɯ]	Default Epenthesis
Rounded Dental Stops	/t^{w}/	[tÿ]	Round Spreading and Default Epenthesis
Dental Sonorants	/l/	[lɯ]	Default Epenthesis
Rounded Dental Sonorants	/l^{w}/	[lÿ]	Round Spreading and Default Epenthesis
Dental Sibilants	/ts/	[tsʐ]	Fricative Spreading
Rounded Dental Sibilants	/ts^{w}/	[ts^{w}ʐ^{w}]	Fricative Spreading and Round Spreading
Velar Stops	/k/	[kɯ]	Default Epenthesis
Rounded Velar Stops	/k^{w}/	[kÿ]	Round Spreading and Default Epenthesis
Velar Fricatives	/x/	[xɯ]	Default Epenthesis

Most of these underlying-to-surface mappings have been discussed at length throughout this sub-section, but I offer discussion of two oddities in the epenthesized rime patterns as tabulated in (88).

First, the true underlying form of the combinations of labiodentals and their epenthetic nucleus [ɣ] is unclear. While it is clear that the syllables which have this nucleus correspond to the syllables which have rime-to-onset [+round] spreading from specified nuclear [o] in the conservative Kāngfú variety and correspond regularly other such syllables, the pronunciation of the nucleus in these syllables (ex. <fv>; [fɣ] 'six') is different than the nucleus of other syllables transcribed with rime <v> (ex. <kv>; [kÿ] 'ghost'). My own observations of these syllables and the descriptions of these sounds from Dell (1981) and ZHÀO Yànzhēn (2012) substantiate this difference. I explore this in detail in 7.2.5 in AIP tabular representation for example (92).

Second, while unrounded epenthesized rimes are derived from either fricative spreading or default epenthesis, rounded epenthesized rimes are necessarily derived from round spreading and one of the other processes. This is not problematic because there are no conflicting contrastive surface syllables (i.e there is no contrast between syllables such as [ts^{w}ʐ^{w}] and *[ts^{w}ÿ]). On the other hand, given the absence of alternating processes which offer insight regarding the triggering of these spreading processes, it is safest to assume that both processes apply. All three of these kinds of processes are presented in AIP format in the next sub-section.

7.2.5 AIP Description of Rime Epenthesis Processes

The previous section suggests that palatalization in Bái is the result of either rime-to-onset vocoid spreading or coarticulation of obstruent and vocoid features in the onset.

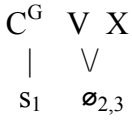
In this sub-section I suggest that rime epenthesis is the consequence of empty specification of segmental material in underlying representation. Discussion begins with the fricative vowels derived from dental sibilants. My analysis of the fricative spreading is nearly identical to the analysis for similar syllables in Standard Chinese offered by Sān DUĀNMÙ (2007:83) as visualized in AIP tables in (89) for the syllable [sz̩^{44}] ‘poem’.

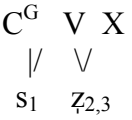
Fig. (89) Fricative Vowels Derived from Dental Sibilants

$$\varnothing \rightarrow \text{z̩} \;/\; C_{[\text{Dental Sibilant}]}\_\#^{44}$$

	/s^{44}/		
	x_1	x_2	x_3
[TIP]—[fricative]	+		
[GLOTTIS]—[spread]	-		
[GLOTTIS]—[H]		-	
[GLOTTIS]—[stiff]		+	

	[sz̩:^{44}]		
	x_{ons}	x_{nuc}	x_{cod}
[TIP]—[fricative]	+	:	
[GLOTTIS]—[spread]	-		
[GLOTTIS]—[H]		-	
[GLOTTIS]—[stiff]		+	





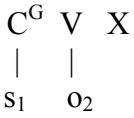
The AIP tables in (89) suggest that the epenthesis is triggered by the need of the syllable to produce a long tone which is impossible to superimpose over a short duration of a voiceless fricative. The epenthetic segment is the voiced variant of this consonant and fills the syllable structure positions required by the specified tone gestures. The epenthesis of the other fricative vowels in Bái is less straightforward and requires further discussion. As mentioned in 7.2.2, the vowels transcribed as <v> in descriptions of Bái varieties are derived from an earlier stage of the language where they are produced as [o]. AIP tables for the observed rounding of the lips as spread from rime-to-onset in the synchronic phonology for the conservative Kāngfú variety are presented in (90) for the syllable [s^{w}o:] ‘mountain’.

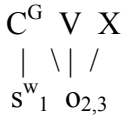
Fig. (90) Rounding Epenthesis in Kāngfú

ø → w / C_o:

	/so^{44}/		
	x_1	x_2	x_3
[LIPS]—[round]		+	
[TIP]—[fricative]	+		
[BODY]—[high]		-	
[BODY]—[back]		+	
[ROOT]—[advanced]		+	
[GLOTTIS]—[spread]	-		
[GLOTTIS]—[H]		+	
[GLOTTIS]—[stiff]		-	

	[s^{w}o:^{44}]		
	x_{ons}	x_{nuc}	x_{cod}
[LIPS]—[round]	:	+	:
[TIP]—[fricative]	+		
[BODY]—[high]		-	:
[BODY]—[back]		+	:
[ROOT]—[advanced]		+	:
[GLOTTIS]—[spread]	-		
[GLOTTIS]—[H]		+	
[GLOTTIS]—[stiff]		-	





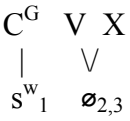
Most varieties of Bái transcribe this lexical item as <sv>. I understand this vowel to be the rounded variant of the fricative vowel derived in (89) – [ʐ̩^{w}]. I propose that innovative production of [ʐ̩^{w}] in place of conservative [o] reflects deletion of the rime but preservation of the epenthesized rounding. This rounding is stranded with the specification of [LIPS]—[+round] in addition to the other specified consonant features in the underlying feature bundle as illustrated in (91).

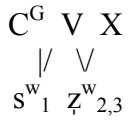
Fig. (91) Rounded Fricative Vowel Spreading

$$\varnothing \rightarrow z\!\!\!^{w} / C_{[\text{Dental Sibilant}]^{w}}\_\#$$

	/s^{w44}/		
	x_1	x_2	x_3
[LIPS]—[round]	+		
[TIP]—[fricative]	+		
[GLOTTIS]—[spread]	-		
[GLOTTIS]—[H]		-	
[GLOTTIS]—[stiff]		+	

	[s^{w}z^{w}:^{44}]		
	x_{ons}	x_{nuc}	x_{cod}
[LIPS]—[round]	+	:	
[TIP]—[fricative]	+	:	
[GLOTTIS]—[spread]	-	+	
[GLOTTIS]—[H]		-	
[GLOTTIS]—[stiff]		+	





The trigger and process behind the spreading are the same as in (9), differing exclusively in so far that the fricative vowel [z^{w}] is derived by spreading both [+round] and [+fricative] from onset-to-rime. Although the pattern observed in (91) is intuitive under the principles of feature spreading between underlying-to-surface mappings, the patterns for the labials and velars are slightly more complicated. Discussion continues with the labials.

Just like the dental sibilants, the syllables generally transcribed with rime <v> after labiodental fricatives are derived from a conservative stage with nuclear [o:].[28] For instance, the lexical item ‘six’ is pronounced as [fɣ:^{44}] in most varieties but is pronounced as [fo:^{44}] in the Kāngfú variety. However, unlike the dental sibilants there is no contrast in rounding for fricative vowels spread from labiodental fricatives. In absence of such a contrast, it may seem reasonable to propose that the underlying-to-surface mapping for the segmental configurations of these syllables is simply /f/→[fɣ:] or /v/→[vɣ:]. However, reduplication patterns suggest that rounding specified from an underlying form

[28] I assume that these forms are “conservative” and “innovative” based on the change described in Fēng WĀNG (2006:78-79) introduced in 7.2.2.

is copied in the reduplicants of these types of syllables (ex. the reduplicant of [fɣ:] is [lÿ:] not [luː] which is the reduplicant for [sɻ:]). This whole story is further complicated by the fact that surface forms with more than one feature specified for the [LIPS] articulator are vastly underrepresented; the only indisputable exception to this generalization is a very small number of non-native items in the lexicon with onsets consisting of labial consonants and glides before nuclear vowels. I include AIP tables visualizing the underlying-to-surface mapping for both the specified [+round] and underspecified [round] variant of labiodental fricative spreading in (92).

Fig. (92) Labiodental Fricative Vowel Spreading

$$ø \rightarrow ɣ \,/\, C_{[\text{Labiodental Fricative}]}{}^{w}\_\#$$

	a. /f$^{w\ 44}$/ ~ b. /f^{44}/		
	x_1	x_2	x_3
[LIPS]—[round]	(+)		
[LIPS]—[fricative]	+		
[GLOTTIS]—[spread]	-		
[GLOTTIS]—[H]		-	
[GLOTTIS]—[stiff]		+	

a.

C^{G} V X
| ∨
$f^{w}{}_{1}$ $ø_{2,3}$

	a. [fɣ:^{44}] ~ b.[f^{w}ɣ^{w}:^{44}]		
	x_{ons}	x_{nuc}	x_{cod}
[LIPS]—[round]	(+)	(:)	
[LIPS]—[fricative]	+	:	
[GLOTTIS]—[spread]	-	+	
[GLOTTIS]—[H]		-	
[GLOTTIS]—[stiff]		+	

a.

C V X
|/ ∨
f_{1} $ɣ_{2,3}$

b.

C V X
|/ ∨
$f^{w}{}_{1}$ $ɣ^{w}{}_{2,3}$

The mappings between underlying and surface represenations for the rounded variant (92a) and unrounded variant (92b) differ exclusively in the positive specification for [round] in the onset and first time bundle and its spreading into the rime; this is expressed by parenthesis. Historical relationships and word-level phenomena support mapping (92a) whereas impressionistic description of the segment supports mapping (92b). Since such distinctions in underlying contrast do not result in surface contrast I assume that either option is possible.

Discussion now turns to the epenthesis of the default vowel. Although the tongue body is used in default vowel epenthesis, its actual position is not entirely clear. For instance, I advocate throughout the discussion that the vowel transcribed as <ɯ> in descriptions is the default vowel for Bái, but have also addressed that this vowel is somewhat more central than high and back as is indicated by typical features for this phonetic cover symbol. Since default epenthetic segments do not need to be specified in feature-based representations relative to other segments, I propose that these default segments can be specified by the unary [BODY] articulator for place without any feature dictating gestural instruction (this is represented as a unary [BODY] feature in the AIP tables). I present the underlying to surface mapping for the epenthesis of this vowel in the word [tɯ:^{31}] 'bean' through the AIP tables in (93).

Fig. (93) Default Vowel Epenthesis

$$\varnothing \rightarrow \text{ɯ} \;/\; C_{[stop]}\_\#$$

	/t ^{31}/		
	x_1	x_2	x_3
[TIP]—[stop]	+		
[GLOTTIS]—[spread]	-		+
[GLOTTIS]—[H]		-	
[GLOTTIS]—[stiff]		-	

	[tɯ:^{31}]		
	x_{ons}	x_{nuc}	x_{cod}
[TIP]—[stop]	+		
[BODY]		+	
[GLOTTIS]—[spread]	-		+
[GLOTTIS]—[H]		-	
[GLOTTIS]—[stiff]		-	

Like the other pheneomena examined in this section, I assume that this process is motivated by the need to fill the nucleus. In absence of any specified gestures, the unary tongue body can be epenthesized to make this syllable pronouncable and contrastive with other syllables. Discussion concludes with the nature of the spread round epenthetic

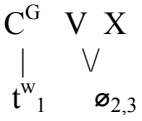
vowel. This variant can epenthesize from singleton consonants in underlying representation as demonstrated in (94) for the word [tÿ^{35}] ‘east’ (generally transcribed as <tv>). The only difference between this epenthesized form and the form in (93) is the presence of specified [+round] in the onset.

Fig. (94) Epenthesis of the Rounded Variant of the Default Epenthetic Vowel

$$ø \rightarrow ÿ \ / \ C_{[Stop]}{}^{w}\_\#$$

	/t^{w} ^{35}/		
	x_1	x_2	x_3
[LIPS]—[round]	+		
[TIP]—[stop]	+		
[GLOTTIS]—[spread]	-		
[GLOTTIS]—[H]		-	+

	[tÿ:^{35}]		
	x_{ons}	x_{nuc}	x_{cod}
[LIPS]—[round]	+	:	
[TIP]—[stop]	+		
[BODY]		+	
[GLOTTIS]—[spread]	-		
[GLOTTIS]—[H]		-	+



The AIP analysis in this section has shown that while underspecification results in more complex surface variants of epenthetic rimes than underlying specification of such segments, the process by which these segments are derived is consistent and regular. Specifically, the features specified in the onset that can spread do in fact spread to occupy the rime position as necessary because of the lexically specified tone. This permits the grammar to generate all rounded and unrounded epenthetic nuclear segments without requiring an explanation as to why certain segments which appear in the nucleus (such as [z̩]) can occur with certain onsets and cannot occur with others. This also provides a mechanism by which these syllables can be contrastive in both underlying and surface representation with other monosyllabic morphemes.

7.3 Summary

This chapter has offered a survey of palatalization, onset-to-rime spreading, and epenthesis in Bái. These processes are proposed to serve the same purpose – to account for variation in surface phonological representations with a minimal amount of specification in underlying representation. These processes opposing in directionality are motivated by the same principle – economy in phonological representation to optimize accountability of attested syllables in the space of possible syllables.

While the observed patterns of palatalization are fairly typical amongst languages of the world, the epenthetic segments which are the result of spread fricative and/or round features from onset-to-rime are somewhat uncommon or atypical. Interestingly, both processes are demonstrated to be the consequence of diachronic change. The range of sources considered in the dissertation offers reliable synchronic correspondences to account for palatalization as the result of vocoid spreading and the presence of epenthetic round segments as the result of round spreading. Analysis of phonological contrast at the variety-specific level for each stage of these two spreading processes suggests that these contrasts are generated in a manner which appeals to the aforementioned principle of phonotactic explanation through underspecification. Since palatalized and non-palatalized dental continuants are non-contrastive in Bái, this suggests that the motivation behind the change of constriction at the oral articulators is independent of phonological contrast. However, identification of the pattern reduces the need to specify palatals as distinct segments in underlying representation. On the other hand, both the spread round epenthetic segments and the conservative Kāngfú [o] productions optimize accountability of attested syllables in the space of possible syllables. The epenthetic segments reduce the

amount of underlying specification and the conservative [o] variant is a productive nuclear vowel in the Kāngfú variety. In brief, neither strategy leaves unprincipled gaps in the representation of contrast.

Chapter 8. Conclusion

This dissertation has taken a long journey from the original interpretation of transcribed Bái syllables in primary sources. Prior work is shown to prioritize the ability to describe observed contrastive syllables in Bái with limited consideration for defining the range of possible syllables and impossible syllables in this language. In chapter 4 for instance, I show that segmental combinations of attested syllables described in prior linguistic research on Bái utilize approximately 48-71% of the space of predicted possible syllables in the Zhàozhuāng variety based on assumptions regarding phonemic analysis and syllable structure in those works. On the other hand, my account of phonological contrast for this language is able to make predictions about impossible and unattested phonological forms and improve coverage of attested forms within the space of possible forms considerably. I accomplish this goal by decomposing contrastive units into articulator-based features with a minimal amount of defined ordering and specification in underlying representation. This representation is then mapped into a fixed $C^{G}VX$ syllable structure in surface representation. In doing so, attested syllables with specified underlying representations of the limited subset of available segments can cover approximately 79% of the predicted available syllable types. Furthermore, underspecification of nuclear segments can explain why certain consonants can co-occur with fricative nuclei such as [fɣ̩^{44}] ‘six’ and [sz̩^{44}] ‘poem’ and other consonants such as *[pɣ] or *[kz̩] cannot co-occur with these nuclei.

Despite the improved coverage of attested types in the space of predicted possible segmental combinations of syllable types, there are still many segmental combinations which are unattested. Furthermore, if predicted possible syllable types are to include the availability of contrastive nasalization and all tonal contrasts, then the number of gaps between attested and possible syllables for any given variety is considerably higher and inexplicable based on synchronic factors alone. However, these unprincipled gaps are the result of the arbitrariness between the mapping of lexical items to phonological representation. While the strings of phonological contrasts specified for given lexical items are arbitrary, the grammar of a language imposes limits on possible and impossible contrasts in phonological representation.

APPENDICIES

APPENDIX A

Language Conventions

Throughout the body of the text in this dissertation I assume the following typographical and language usage conventions:

1. Chinese proper names and conventional linguistic terminology are transliterated in Pīnyīn with tone diacritics with the English translation (if appropriate) in quotation marks. The first time a Chinese language term appears in the text I include the Chinese characters for that term after the Pīnyīn gloss. I use only the Pīnyīn gloss after first mention.
    a. Ex. Dàlǐ Báizú Zìzhìzhōu 大理白族自治州 [Dàlǐ Bái Autonomous Prefecture]
    b. Ex. *shēngmǔ* 声母 'initial'
2. When Chinese language sources are mentioned in the text, I follow convention #1. Treatment after the first reference differs depending on authorship. If the source has one author I use his or her full name (surname, space, given name) in Pīnyīn with the last name in all capital letters followed by the year of publication. If the source has two or more authors, I use only the capitalized surnames in later references. If the source is a reference text I use an abbreviation made up of the first letter each first Pīnyīn transliterated syllable. The examples below list first references and later references with a colon in between.
    a. Ex. LǏ Zhèngqīng 李正清 (2014): LǏ Zhèngqīng (2014)
    b. Ex. XÚ Lín 徐林 & ZHÀO Yǎnsūn 赵衍荪 (1984): XÚ & ZHÀO (1984)

c. Ex. *Xiàndài Hànyǔ Cídiǎn* 现代汉语词典 [Modern Chinese Dictionary] (2005): XDHYCD

3. As in #2, single authored Chinese language works are referenced by full name in the Chinese order – surname followed by given name – in Pīnyīn transliteration. This is particularly important for the Bái linguistic literature as there are two prominent Bái specialists whose different names would be identical without diacritics, namely WĀNG Fēng 汪锋 and WÁNG Fēng 王锋. Works published in English by scholars with Chinese names are transcribed in Pīnyīn with tone marks in the order with the given name first followed by the surname in all capital letters – Ex. Sān DUĀNMÙ (2007).
4. Transcriptions of the Bai romanization and orthographic usages of the International Phonetic Alphabet are glossed within less-than and greater-than brackets '< >'.
5. Underlying representations are glossed within slashes '/ /'.
6. Surface representations are glossed within end brackets '[ ]'

APPENDIX B

Maps of the Bái-speaking Area

Fig. (95) Primary Bái-speaking Region in the People's Republic of China

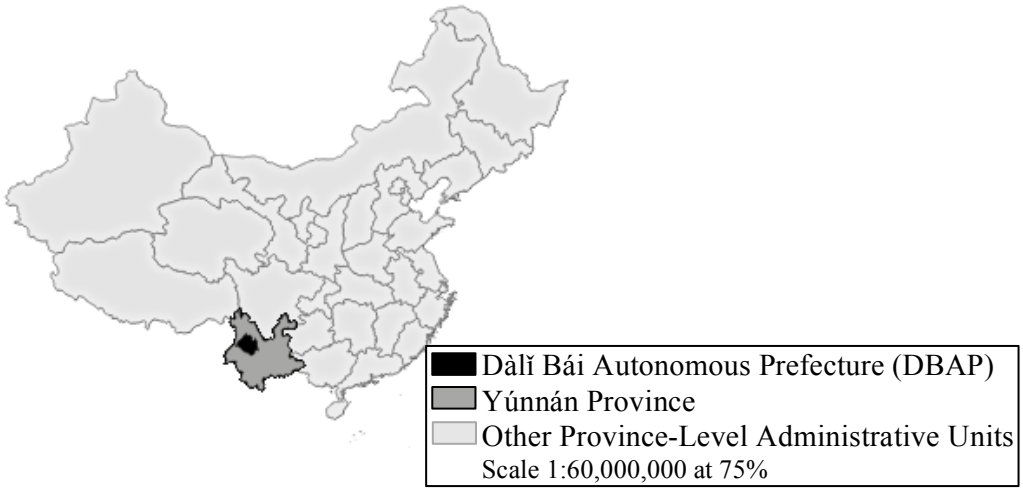
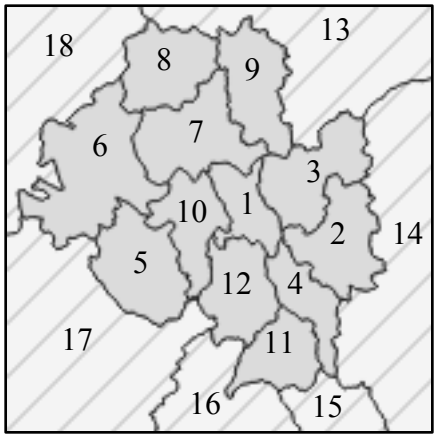
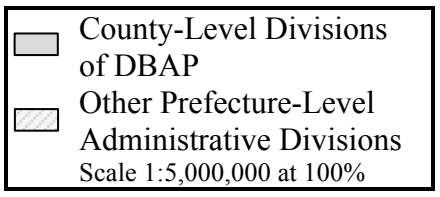


Fig. (96) County-Level Divisions of DBAP and Surrounding Administrative Units

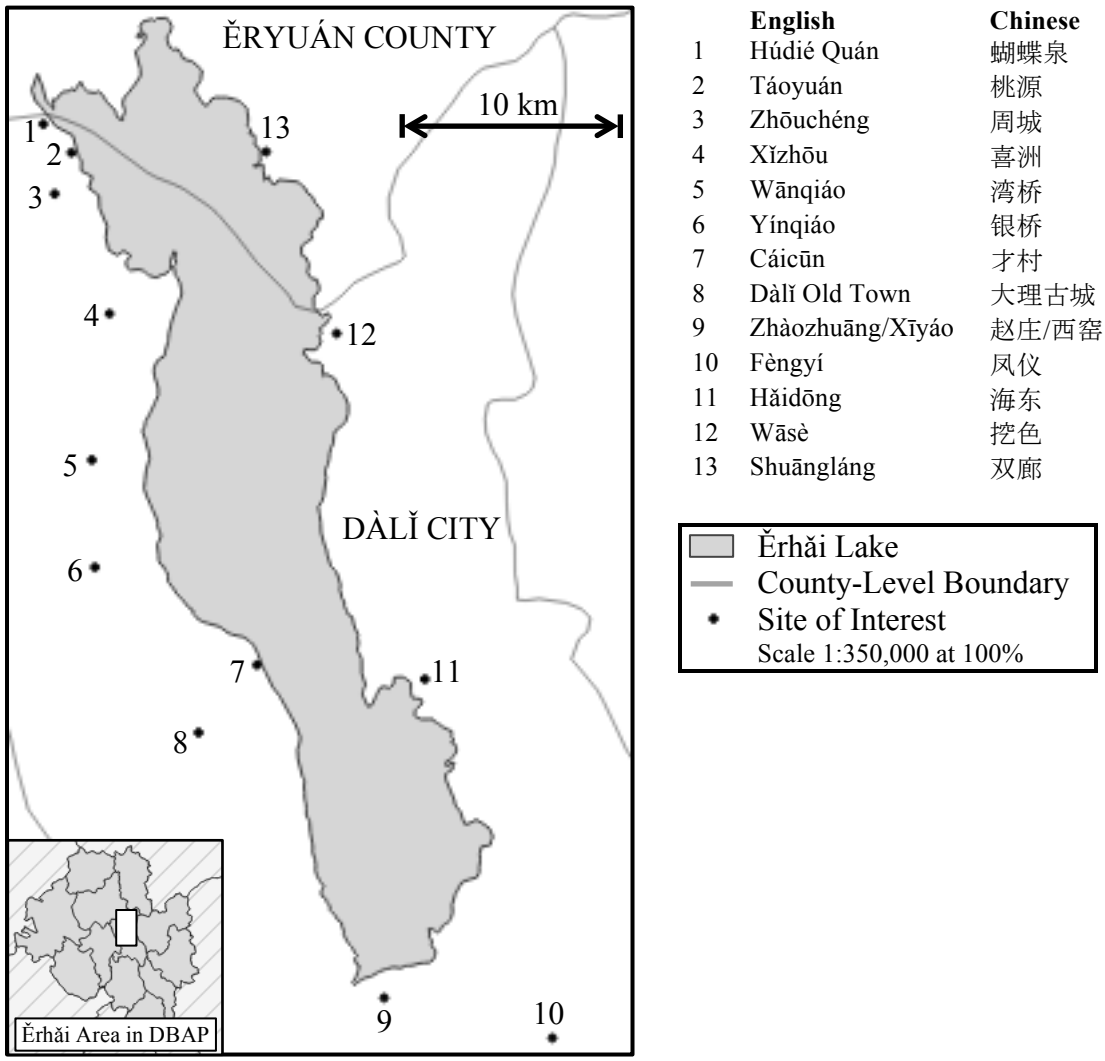




	English	Chinese
1	Dàlǐ City	大理市
2	Xiángyún County	祥云县
3	Bīnchuān County	宾川县
4	Mídù County	弥渡县
5	Yǒngpíng County	永平县
6	Yúnlóng County	云龙县
7	Ěryuán County	洱源县
8	Jiànchuān County	剑川县
9	Hèqìng County	鹤庆县
10	Yàngbì Yí AC	漾濞彝族自治县
11	Nánjiàn Yí AC	南涧彝族自治县
12	Wēishān Yí and Huí AC	巍山彝族回族自治县
13	Lìjiāng City	丽江市
14	Chǔxióng Yí AP	楚雄彝族自治县
15	Pǔ'ěr City	普洱市
16	Líncāng City	临沧市
17	Bǎoshān City	保山市
18	Nùjiāng Lìsù AP	怒江傈僳族自治县

AP = Autonomous Prefecture, AC = Autonomous County

Fig. (97) Sites of Interest Around the Ěrhǎi Lake



	English	Chinese
1	Húdié Quán	蝴蝶泉
2	Táoyuán	桃源
3	Zhōuchéng	周城
4	Xǐzhōu	喜洲
5	Wānqiáo	湾桥
6	Yínqiáo	银桥
7	Cáicūn	才村
8	Dàlǐ Old Town	大理古城
9	Zhàozhuāng/Xīyáo	赵庄/西窑
10	Fèngyí	凤仪
11	Hǎidōng	海东
12	Wāsè	挖色
13	Shuāngláng	双廊

All maps were prepared in QGIS with OpenStreetMap plugin and GIS Shape files offered by the University of Michigan China Data Center.

APPENDIX C

Zhàozhuāng Bái Syllable Inventory

This syllable table is arranged according to the following norms:

- The header includes five categories: UR (Underlying Representation), SR (Surface Representation), Book Gloss (as transcribed in ZHÀO Yànzhēn 2012), English (meaning), Chinese (meaning).
- Syllables are ordered by the subscripts under each category for the following constituents. First by consonant [p_1, p^h_2, m_3, f_4, v_5, t_6, t^h_7, n_8, l_9, ts_{10}, ts^h_{11}, s_{12}, z_{13}, k_{14}, k^h_{15}, x_{16}, $ɣ_{17}$, $null_{18}$], then by glide [$null_1$, j_2, w_3, $ɥ_4$], then by vowel [i_1, e_2, $ɛ_3$, a_4, $ɔ_5$, o_6, u_7, $ɯ_8$, y_9, $null_{10}$].
- The mappings between underlying and surface representations do not include tone, therefore the vowels are not lengthend in surface representation.
- Productive and marginal syllables are included in the inventory below.
- Loanwords from Modern Chinese are indicated by 'Chin.' followed by an italicized Pīnyīn transcription with the English meaning in quotations (ex. Chin. *dì* 'ordinal' (FW)).
- Grammatical abbreviations include 'FW' for 'function word', 'MW' for 'measure word', and 'n, v' when both the noun and verb usages are possible.
- All types were checked by the native speaker author of ZHÀO Yànzhēn 2012.

UR	SR	Book Gloss	English	Chinese
/pi/	[pi]	pi35	'salt'	盐
/pe/	[pe]	pe33	'dinner'	晚饭
/pɛ/	[pɛ]	pɛ33	'sick, illness'	病
/pa/	[pa]	pa55	'them, other people'	他们
/pɔ/	[pɔ]	pɔ33	'he/she/it'	他
/po/	[po]	po44 tsɻ44	'ring'	箍子(绣花用)
/pu/	[pu]	pu42	'weak, thin, frail'	薄
/p/	[pɯ]	pɯ44	'north'	北
/p^{j}ɛ/	[p^{j}ɛ]	piɛ44	'to ask'	问
/p^{j}a/	[p^{j}a]	pia44	'eight'	八
/p^{j}ɔ/	[p^{j}ɔ]	piɔ33	'to not be'	不（是）
/p^{j}ɯ/	[p^{j}ɯ]	piɯ44	'ice'	冰
/p^{w}o/	[p^{w}o]	puo44 luo44	Chin. *bō* 'pineapple'	菠萝
/p^{h}i/	[p^{h}i]	phi33	'piece' (MW)	（一）块（糍粑）
/p^{h}e/	[p^{h}e]	phe55	'to rip'	撕破
/p^{h}ɛ/	[p^{h}ɛ]	phɛ55	'moist, damp'	湿

/pʰa/	[pʰa]	pha55	'to rake'	耙（田）
/pʰɔ/	[pʰɔ]	phɔ42	'deep fry'	炸（油饼）
/pʰo/	[pʰo]	pho42	'shack'	棚子
/pʰu/	[pʰu]	phu44	'cucumber'	黄瓜
/pʰ/	[pʰɯ]	phɯ33	'lid, cover'	盖子
/pʰʲɛ/	[pʰʲɛ]	phiɛ55	'slice' (MW)	片
/pʰʲa/	[pʰʲa]	phia44	'lung'	肺
/pʰʲɔ/	[pʰʲɔ]	phiɔ33	'cloth'	布
/pʰʲo/	[pʰʲo]	phio44	‘team' (MW)	（一）队（人马）
/pʰʲɯ/	[pʰʲɯ]	phiɯ55	'page' (MW)	（一）页（书）
/mi/	[mi]	mi33	'to think'	想
/me/	[me]	me33	'lower'	低（头）
/mɛ/	[mɛ]	mɛ21	'to call'	（马）叫
/ma/	[ma]	ma33	'full, sufficent'	满
/mɔ/	[mɔ]	mɔ33	'mother'	母亲
/mu/	[mu]	mu33	'not have'	没有
/m/	[mɯ]	mɯ44	'dream'	梦
/mʲɛ/	[mʲɛ]	miɛ44	'life'	生命
/mʲɔ/	[mʲɔ]	miɔ35	'to spay'	阉（鸡）
/mʲo/	[mʲo]	mio44	'straight'	直
/fe/	[fe]	fe35 sɻ35	'kite’	风筝
/fɛ/	[fɛ]	fɛ44	Chin. *fā* as in ‘fever’ or ‘burn'	发烧
/fa/	[fa]	fa44	square'	方
/fo/	[fo]	fo55 xua42	phoenix'	凤凰
/fɯ/	[fɯ]	fɯ44 tɕhu44	'small onion'	小葱
/f/	[fɣ]	fv44	'six'	六
/ve/	[ve]	ve55	Chin. *wèi* ‘8th of the 12 Earthly Branches’	未(地支八)
/va/	[va]	va35 tsɻ44	'sock'	袜子
/vɯ/	[vɯ]	vɯ55 ti42	'question'	问题
/v/	[vɣ]	vv42	'stomach'	胃
/ti/	[ti]	ti55	Chin. *dì* ‘ordinal' (FW)	第（－，二，三）
/te/	[te]	te42	'pig'	猪
/tɛ/	[tɛ]	tɛ44	'to hit'	打（人）
/ta/	[ta]	ta44	'to throw up'	呕吐
/tɔ/	[tɔ]	tɔ33	'big'	大
/to/	[to]	to33	'on top'	上方（地势、河流）
/tu/	[tu]	tu35	'poison'	毒
/t/	[tɯ]	tɯ33	'bean'	豆
/tʲɛ/	[tʲɛ]	tiɛ44	'some'	一些
/tʲo/	[tʲo]	tio44	'to fish'	钓（鱼）
/tʲɯ/	[tʲɯ]	tiɯ44	‘to schedule’	预定
/tʷe/	[tʷe]	tui33	'far'	远
/tʷo/	[tʷo]	tuo44	'to cut, chop'	剁（肉）

/tʷ/	[tÿ]	tv35	'east'	东
/tʰi/	[tʰi]	thi55	'to raise, lift'	提（篮子）
/tʰe/	[tʰe]	the44	'younger brother'	弟弟
/tʰɛ/	[tʰɛ]	thɛ55	‘matter, affair' (MW)	（一）件（事）
/tʰa/	[tʰa]	tha33	'coal'	（木）炭
/tʰɔ/	[tʰɔ]	thɔ55 lɔ55	'rabbit'	兔
/tʰo/	[tʰo]	tho44	'set'	套（衣服）
/tʰu/	[tʰu]	thu44	'road'	路
/tʰ/	[tʰɯ]	thɯ55	'to go down'	下（楼）
/tʰʲɛ/	[tʰʲɛ]	thiɛ42	'to fill, stuff'	填（坑）
/tʰʲɔ/	[tʰʲɔ]	thiɔ55	'to jump'	（用脚）跳
/tʰʲo/	[tʰʲo]	thio44 ɕu44	'flea'	跳蚤
/tʰʲɯ/	[tʰʲɯ]	thiɯ42	'to stop'	停止
/tʰʷe/	[tʰʷe]	thui55	'fade, retreat'	（向后）退
/tʰʷa/	[tʰʷa]	thua44	'mould, statue'	（泥）塑
/tʰʷo/	[tʰʷo]	thuo44	'to delay'	拖延（时间）
/tʰʷ/	[tʰÿ]	thv33	'bucket'	水桶
/ni/	[ɳi]	ɳi21 kiɛ35	'person'	人
/ne/	[ne]	ne44	'hold, bring'	拿
/na/	[na]	na55	'you (pl)'	你们
/nɔ/	[nɔ]	nɔ33	'you (sg)'	你
/no/	[no]	no21	'bag'	（一）袋（烟）
/n/	[nɯ]	nɯ33	'this'	这
/nʲa/	[ɳa]	ɳa55	'we (inclusive)'	咱们
/nʲo/	[ɳo]	ɳo44	'demand'	索取
/nʲɯ/	[ɳɯ]	ɳɯ21	'soft'	软
/nʷ/	[nÿ]	nv33	'to use'	用（使用）
/nᵠ/	[ɳÿ]	ɳv33	'daughter'	女儿
/li/	[li]	li44	'filter’ (n, v)	过滤
/le/	[le]	le33	'infect, catch a disease'	传染
/lɛ/	[lɛ]	lɛ35	'to tie'	勒
/la/	[la]	la33	'lazy'	懒
/lɔ/	[lɔ]	lɔ21	'tiger'	虎
/lu/	[lu]	lu35	'enough, sufficent'	足够
/l/	[lɯ]	lɯ44	'to be'	是
/lʲɛ/	[lʲɛ]	liɛ55 tsɻ44	'chain'	链子
/lʲa/	[lʲa]	lia44	'bright'	明亮
/lʲo/	[lʲo]	lio44	'to throw'	扔
/lʲɯ/	[lʲɯ]	liɯ42	'zero'	零
/lʷe/	[lʷe]	lui35	'to take off (clothes)'	脱（衣）
/lʷa/	[lʷa]	lua42	'to drop/fall'	落下（东西）
/lʷo/	[lʷo]	luo42 sɻ44	'snail'	螺狮
/lʷ/	[lÿ]	lv44	'green'	绿

/tsi/	[tɕi]	tɕi33	'to pull'	拉
/tse/	[tse]	tse42	'toungue'	舌头
/tsɛ/	[tsɛ]	tsɛ44	‘right (side)'	右
/tsa/	[tsa]	tsa44	'debt'	债
/tsɔ/	[tsɔ]	tsɔ55	'to make, create'	制造
/tso/	[tso]	tso21	'bed'	床
/tsu/	[tʃu]	tɕu33	'early'	早
/tsɯ/	[tsɯ]	tsɯ33	'tree'	树
/tsy/	[tɕy]	tɕy21	‘to forward, pass on’	递
/ts/	[tsʐ]	tsɻ33	'alcohol'	酒
/ts^{j}ɛ/	[tɕɛ]	tɕɛ33	'well (water)'	井
/ts^{j}a/	[tɕa]	tɕa42	'friend'	朋友
/ts^{j}ɔ/	[tɕɔ]	tɕɔ44 ɔ55	'proud, arrogant'	骄傲
/ts^{j}o/	[tɕo]	tɕo44	'sauce'	酱
/ts^{j}ɯ/	[tɕɯ]	tɕɯ33	'nine'	九
/ts^{w}a/	[tʃ^{w}a]	tɕua33 tsɻ44	'claw'	爪子
/ts^{w}o/	[tʃ^{w}o]	tɕuo44	'stove'	灶
/ts^{w}/	[tsÿ]	tsv33	'seed'	种子
/ts^{ɥ}ɛ/	[tɕ^{ɥ}ɛ]	tɕuɛ33	'to allow'	允许
/ts^{h}i/	[tɕ^{h}i]	tɕhi44	'seven'	七
/ts^{h}e/	[ts^{h}e]	tshe44	'to guess'	猜（谜语）
/ts^{h}ɛ/	[ts^{h}ɛ]	tshɛ44	'sleep, to lie down'	睡
/ts^{h}a/	[ts^{h}a]	tsha55	'to sing'	唱（歌儿）
/ts^{h}ɔ/	[ts^{h}ɔ]	tshɔ33 tsɻ33	'paper'	纸
/ts^{h}o/	[ts^{h}o]	tsho42 tsɻ44	'silk fabric'	绸子
/ts^{h}u/	[tʃ^{h}u]	tɕhu44	'grass'	草
/ts^{h}ɯ/	[ts^{h}ɯ]	tshɯ33	'vegetable'	菜
/ts^{h}y/	[tɕ^{h}y]	tɕhy44	'to temper (by water)’	淬
/ts^{h}/	[ts^{h}ʐ]	tshɻ44	'to extend, stretch'	伸（手）
/ts^{hj}ɛ/	[tɕ^{h}ɛ]	tɕhɛ44	'to kick'	踢
/ts^{hj}a/	[tɕ^{h}a]	tɕha44	‘to paste, stick’	贴
/ts^{hj}ɔ/	[tɕ^{h}ɔ]	tɕhɔ55	'to pry open'	撬
/ts^{hj}o/	[tɕ^{h}o]	tɕho44	'wing'	翅
/ts^{hj}ɯ/	[tɕ^{h}ɯ]	tɕhɯ55	'money'	钱
/ts^{hw}a/	[tʃ^{ʰw}a]	tɕhua44	'to cut'	切（菜）
/ts^{hw}o/	[tʃ^{ʰw}o]	tɕhuo55	'wrong'	错
/ts^{hw}/	[ts^{h}ÿ]	tshv55	'gun'	枪
/ts^{hɥ}ɛ/	[tɕ^{hɥ}ɛ]	tɕhuɛ42 tsɻ44	'skirt'	裙子
/si/	[ɕi]	ɕi33	'to die'	死
/se/	[se]	se33	'small'	小
/sɛ/	[sɛ]	sɛ44	'saw' (n, v)	锯
/sa/	[sa]	sa55	'three'	三
/sɔ/	[sɔ]	sɔ33	‘smile’ (n, v)	笑

/so/	[so]	so44	'rope, string'	绳子
/su/	[ʃu]	ɕu55	'to burn'	燃烧
/sɯ/	[sɯ]	sɯ44	'hand'	手
/sy/	[ɕ^{ɥ}y]	ɕy33	'water'	水
/s/	[sʐ̩]	sɻ44	'poem'	诗
/s^{j}ɛ/	[ɕɛ]	ɕɛ44	'to be surnamed'	姓
/s^{j}a/	[ɕa]	ɕa44	'to kill'	杀（鸡）
/s^{j}ɔ/	[ɕɔ]	ɕɔ35	'flute'	箫
/s^{j}o/	[ɕo]	ɕo33	'few'	少
/s^{j}ɯ/	[ɕɯ]	ɕɯ55	‘to believe’	相信
/s^{w}a/	[ʃ^{ʷ}a]	ɕua33	'garlic'	蒜
/s^{w}o/	[ʃ^{ʷ}o]	ɕuo33	'lock' (n, v)	锁
/s^{w}/	[sÿ]	sv44	'mountain'	山
/s^{ɥ}ɛ/	[ɕ^{ɥ}ɛ]	ɕuɛ44 tsɻ44	'boots'	靴子
/ze/	[ze]	ze33	'to dye'	染（布）
/zo/	[zo]	zo44	'to wind, tie together'	绕（道）
/zɯ/	[zɯ]	zɯ33 ki44	'to know, recognize'	知道
/z^{w}/	[zÿ]	zv35 the44	'elder brother'	兄弟（姐妹）
/ki/	[ki]	ki35	'chicken'	鸡
/kɛ/	[k^{j}ɛ]	kiɛ21	'meat'	肉
/ka/	[ka]	ka21	'to freeze'	（手）冻了
/kɔ/	[kɔ]	kɔ21	'body of water'	海
/ko/	[ko]	ko44	'foot/feet'	脚
/ku/	[ku]	ku33	'old'	老
/k/	[kɯ]	kɯ33	'thick'	厚
/k^{w}e/	[k^{w}e]	kui44	'button'	扣子
/k^{w}ɛ/	[k^{w}ɛ]	kuɛ44	'strange'	奇怪
/k^{w}a/	[k^{w}a]	kua35	'pants'	裤子
/k^{w}o/	[k^{w}o]	kuo44	'to pass'	过了（两年）
/k^{w}/	[kÿ]	kv33	'ghost'	鬼
/k^{h}i/	[k^{h}i]	khi55	'open, start'	（花）开（了）
/k^{h}a/	[k^{h}a]	kha44	'to be thirsty'	渴
/k^{h}ɔ/	[k^{h}ɔ]	khɔ55	'to lean'	靠（墙）
/k^{h}o/	[k^{h}o]	kho44	'to cry'	哭
/k^{h}u/	[k^{h}u]	khu44	'bitter'	苦
/k^{h}/	[k^{h}ɯ]	khɯ33	'inside'	里（边）
/k^{hw}e/	[k^{hw}e]	khui55	'piece'	块
/k^{h}ɛ/	[k^{hj}ɛ]	khiɛ44	'guest'	客人
/k^{hw}ɛ/	[k^{hw}ɛ]	khuɛ55	'slanting'	斜
/k^{hw}a/	[k^{hw}a]	khua44	'dog'	狗
/k^{hw}/	[k^{h}ÿ]	khv44	'snake'	蛇
/ŋi/	[ŋi]	ŋi21	'shoes'	鞋
/ŋɛ/	[ŋ^{j}ɛ]	ŋiɛ21	'to go'	去

/ŋa/	[ŋa]	ŋa44	'to bite'	（被狗）咬
/ŋɔ/	[ŋɔ]	ŋɔ33	'I, me'	我
/ŋo/	[ŋo]	ŋo44	'hungry'	饿
/ŋ/	[ŋɯ]	ŋɯ21	'cow'	牛
/ŋ^{w}/	[ŋÿ]	ŋv33	'five'	五
/xi/	[xi]	xi44	'bad, weak'	坏
/xe/	[xe]	xe55	‘day, heaven'	天
/xɛ/	[xɛ]	xɛ55	‘vegetable, food'	菜
/xa/	[xa]	xa33	'Han (Chinese)'	汉
/xɔ/	[xɔ]	xɔ33	'to sun dry'	晒（太阳）
/xo/	[xo]	xo55 xui33	'regret'	后悔
/xu/	[xu]	xu33	'good'	好
/x/	[xɯ]	xɯ33	'strong'	强
/x^{w}e/	[x^{w}e]	xui33	'fire'	火
/x^{w}a/	[x^{w}a]	xua44	'to draw'	画
/x^{w}o/	[x^{w}o]	xuo35	'flower'	花
/ɣ/	[ɣɯ]	ɣɯ44	‘to eat’	吃
/i/	[ji]	ʑi21	'to find'	寻找
/e/	[e]	e44	'to love'	爱（她）
/ɛ/	[ɛ]	ɛ33	'underneath'	（山）下
/a/	[a]	a33	'to see'	看（书）
/ɔ/	[ɔ]	ɔ21	'shrimp'	虾
/o/	[o]	o21	'goose'	鹅
/u/	[wu]	u55	'fog'	雾（雾气）
/ɯ/	[ɯ]	ɯ44	'to yell, curse'	骂
/y/	[ɥy]	ʑy55	'jade'	玉石
/jɛ/	[jɛ]	ʑɛ42	'mat'	席子
/ja/	[ja]	ʑa33	'to raise'	养（鸡）
/jo/	[jo]	ʑo21	'lamb'	羊
/jɯ/	[jɯ]	ʑɯ42 xa42	'bank'	银行
/we/	[we]	ui42	'buddha'	佛
/wɛ/	[wɛ]	uɛ42	'to write'	写
/wa/	[wa]	ua44	'moon'	月
/wo/	[wo]	uo35	‘nest’	窝
/ɥɛ/	[ɥɛ]	ʑuɛ35	Chin. *yuè* ‘more’	越来越

APPENDIX D

Complete Set of Selected Responses in Tone Identification Task

Type	Set	Instance	1	2	3	4	5	6	7	8
tɕi^{21}	1	1	tɕi^{31}	tɕi^{33}	tɕi^{32}	tɕi^{21}	tɕi^{31}	tɕi^{21}	tɕi^{21}	tɕi^{21}
tɕi^{21}	1	2	tɕi^{31}	tɕi^{31}	tɕi^{21}	tɕi^{21}	tɕi^{31}	tɕi^{33}	tɕi^{21}	tɕi^{33}
tɕi^{21}	1	3	tɕi^{31}	tɕi^{33}	tɕi^{21}	tɕi^{21}	tɕi^{21}	tɕi^{21}	tɕi^{21}	tɕi^{31}
tɕi^{21}	1	4	tɕi^{31}	tɕi^{31}	tɕi^{32}	tɕi^{21}	tɕi^{21}	tɕi^{33}	tɕi^{21}	tɕi^{21}
tɕi^{21}	1	5	tɕi^{31}	tɕi^{21}	tɕi^{21}	tɕi^{21}	tɕi^{21}	tɕi^{33}	tɕi^{21}	tɕi^{31}
tɕi^{21}	2	1	tɕi^{31}	tɕi^{33}	tɕi^{21}	tɕi^{21}	tɕi^{21}	tɕi^{32}	tɕi^{21}	tɕi^{21}
tɕi^{21}	2	2	tɕi^{31}	tɕi^{31}	tɕi^{21}	tɕi^{21}	tɕi^{21}	tɕi^{33}	tɕi^{21}	tɕi^{21}
tɕi^{21}	2	3	tɕi^{31}	tɕi^{21}	tɕi^{21}	tɕi^{21}	tɕi^{21}	tɕi^{21}	tɕi^{21}	tɕi^{21}
tɕi^{21}	2	4	tɕi^{31}	tɕi^{21}	tɕi^{21}	tɕi^{21}	tɕi^{21}	tɕi^{32}	tɕi^{21}	tɕi^{21}
tɕi^{21}	2	5	tɕi^{31}	tɕi^{33}	tɕi^{21}	tɕi^{21}	tɕi^{21}	tɕi^{32}	tɕi^{21}	tɕi^{21}
tɕi^{31}	1	1	tɕi^{31}	tɕi^{33}	tɕi^{31}	tɕi^{31}	tɕi^{31}	tɕi^{21}	tɕi^{21}	tɕi^{33}
tɕi^{31}	1	2	tɕi^{31}	tɕi^{31}	tɕi^{31}	tɕi^{21}	tɕi^{31}	tɕi^{31}	tɕi^{21}	tɕi^{33}
tɕi^{31}	1	3	tɕi^{31}	tɕi^{31}	tɕi^{32}	tɕi^{21}	tɕi^{21}	tɕi^{21}	tɕi^{21}	tɕi^{31}
tɕi^{31}	1	4	tɕi^{31}	tɕi^{31}	tɕi^{31}	tɕi^{21}	tɕi^{31}	tɕi^{21}	tɕi^{21}	tɕi^{31}
tɕi^{31}	1	5	tɕi^{31}	tɕi^{31}	tɕi^{31}	tɕi^{33}	tɕi^{21}	tɕi^{21}	tɕi^{21}	tɕi^{31}
tɕi^{31}	2	1	tɕi^{31}	tɕi^{31}	tɕi^{32}	tɕi^{21}	tɕi^{21}	tɕi^{21}	tɕi^{21}	tɕi^{31}
tɕi^{31}	2	2	tɕi^{31}	tɕi^{33}	tɕi^{31}	tɕi^{31}	tɕi^{31}	tɕi^{31}	tɕi^{21}	tɕi^{31}
tɕi^{31}	2	3	tɕi^{31}	tɕi^{33}	tɕi^{21}	tɕi^{21}	tɕi^{21}	tɕi^{33}	tɕi^{21}	tɕi^{31}
tɕi^{31}	2	4	tɕi^{31}	tɕi^{33}	tɕi^{21}	tɕi^{21}	tɕi^{21}	tɕi^{31}	tɕi^{21}	tɕi^{31}
tɕi^{31}	2	5	tɕi^{31}	tɕi^{31}	tɕi^{21}	tɕi^{21}	tɕi^{21}	tɕi^{31}	tɕi^{21}	tɕi^{31}
tɕi^{32}	1	1	tɕi^{42}	tɕi^{42}	tɕi^{32}	tɕi^{42}	tɕi^{42}	tɕi^{32}	tɕi^{42}	tɕi^{21}
tɕi^{32}	1	2	tɕi^{42}	tɕi^{44}	tɕi^{42}	tɕi^{21}	tɕi^{42}	tɕi^{32}	tɕi^{42}	tɕi^{42}
tɕi^{32}	1	3	tɕi^{42}	tɕi^{21}	tɕi^{44}	tɕi^{42}	tɕi^{21}	tɕi^{32}	tɕi^{42}	tɕi^{44}
tɕi^{32}	1	4	tɕi^{44}	tɕi^{21}	tɕi^{21}	tɕi^{42}	tɕi^{21}	tɕi^{32}	tɕi^{42}	tɕi^{44}
tɕi^{32}	1	5	tɕi^{42}	tɕi^{21}	tɕi^{32}	tɕi^{42}	tɕi^{42}	tɕi^{32}	tɕi^{42}	tɕi^{44}
tɕi^{32}	2	1	tɕi^{42}	tɕi^{44}	tɕi^{42}	tɕi^{42}	tɕi^{42}	tɕi^{32}	tɕi^{21}	tɕi^{44}
tɕi^{32}	2	2	tɕi^{42}	tɕi^{21}	tɕi^{21}	tɕi^{42}	tɕi^{42}	tɕi^{32}	tɕi^{42}	tɕi^{44}
tɕi^{32}	2	3	tɕi^{42}	tɕi^{21}	tɕi^{42}	tɕi^{44}	tɕi^{21}	tɕi^{32}	tɕi^{42}	tɕi^{44}
tɕi^{32}	2	4	tɕi^{44}	tɕi^{42}	tɕi^{42}	tɕi^{42}	tɕi^{21}	tɕi^{32}	tɕi^{42}	tɕi^{44}
tɕi^{32}	2	5	tɕi^{44}	tɕi^{42}	tɕi^{21}	tɕi^{42}	tɕi^{42}	tɕi^{32}	tɕi^{21}	tɕi^{44}
tɕi^{33}	1	1	tɕi^{31}	tɕi^{31}	tɕi^{31}	tɕi^{31}	tɕi^{31}	tɕi^{31}	tɕi^{31}	tɕi^{21}
tɕi^{33}	1	2	tɕi^{31}	tɕi^{31}	tɕi^{31}	tɕi^{31}	tɕi^{31}	tɕi^{33}	tɕi^{21}	tɕi^{33}

tɕi^{33}	1	3	tɕi^{31}	tɕi^{33}	tɕi^{32}	tɕi^{31}	tɕi^{31}	tɕi^{31}	tɕi^{33}	tɕi^{33}
tɕi^{33}	1	4	tɕi^{31}	tɕi^{33}	tɕi^{31}	tɕi^{31}	tɕi^{31}	tɕi^{32}	tɕi^{33}	tɕi^{33}
tɕi^{33}	1	5	tɕi^{31}	tɕi^{31}	tɕi^{31}	tɕi^{31}	tɕi^{31}	tɕi^{32}	tɕi^{33}	tɕi^{33}
tɕi^{33}	2	1	tɕi^{31}	tɕi^{31}	tɕi^{32}	tɕi^{31}	tɕi^{31}	tɕi^{32}	tɕi^{33}	tɕi^{31}
tɕi^{33}	2	2	tɕi^{33}	tɕi^{31}	tɕi^{31}	tɕi^{33}	tɕi^{31}	tɕi^{32}	tɕi^{33}	tɕi^{33}
tɕi^{33}	2	3	tɕi^{31}	tɕi^{33}	tɕi^{32}	tɕi^{31}	tɕi^{31}	tɕi^{32}	tɕi^{33}	tɕi^{31}
tɕi^{33}	2	4	tɕi^{33}	tɕi^{33}	tɕi^{31}	tɕi^{31}	tɕi^{31}	tɕi^{32}	tɕi^{33}	tɕi^{33}
tɕi^{33}	2	5	tɕi^{31}	tɕi^{33}	tɕi^{32}	tɕi^{33}	tɕi^{31}	tɕi^{32}	tɕi^{31}	tɕi^{33}
tɕi^{42}	1	1	tɕi^{42}	tɕi^{42}	tɕi^{42}	tɕi^{42}	tɕi^{42}	tɕi^{42}	tɕi^{42}	tɕi^{42}
tɕi^{42}	1	2	tɕi^{42}	tɕi^{42}	tɕi^{42}	tɕi^{42}	tɕi^{42}	tɕi^{42}	tɕi^{42}	tɕi^{42}
tɕi^{42}	1	3	tɕi^{42}	tɕi^{42}	tɕi^{42}	tɕi^{42}	tɕi^{42}	tɕi^{42}	tɕi^{42}	tɕi^{42}
tɕi^{42}	1	4	tɕi^{42}	tɕi^{42}	tɕi^{42}	tɕi^{42}	tɕi^{42}	tɕi^{42}	tɕi^{42}	tɕi^{42}
tɕi^{42}	1	5	tɕi^{42}	tɕi^{42}	tɕi^{42}	tɕi^{42}	tɕi^{42}	tɕi^{42}	tɕi^{42}	tɕi^{42}
tɕi^{42}	2	1	tɕi^{42}	tɕi^{42}	tɕi^{42}	tɕi^{42}	tɕi^{42}	tɕi^{42}	tɕi^{42}	tɕi^{42}
tɕi^{42}	2	2	tɕi^{42}	tɕi^{42}	tɕi^{42}	tɕi^{42}	tɕi^{42}	tɕi^{42}	tɕi^{42}	tɕi^{42}
tɕi^{42}	2	3	tɕi^{42}	tɕi^{42}	tɕi^{42}	tɕi^{42}	tɕi^{42}	tɕi^{42}	tɕi^{42}	tɕi^{42}
tɕi^{42}	2	4	tɕi^{42}	tɕi^{42}	tɕi^{42}	tɕi^{42}	tɕi^{42}	tɕi^{42}	tɕi^{42}	tɕi^{42}
tɕi^{42}	2	5	tɕi^{42}	tɕi^{42}	tɕi^{42}	tɕi^{42}	tɕi^{42}	tɕi^{42}	tɕi^{42}	tɕi^{42}
tɕi^{44}	1	1	tɕi^{31}	tɕi^{44}	tɕi^{32}	tɕi^{44}	tɕi^{42}	tɕi^{44}	tɕi^{44}	tɕi^{42}
tɕi^{44}	1	2	tɕi^{42}	tɕi^{44}	tɕi^{44}	tɕi^{44}	tɕi^{42}	tɕi^{44}	tɕi^{44}	tɕi^{44}
tɕi^{44}	1	3	tɕi^{44}	tɕi^{44}	tɕi^{32}	tɕi^{44}	tɕi^{31}	tɕi^{44}	tɕi^{44}	tɕi^{44}
tɕi^{44}	1	4	tɕi^{44}	tɕi^{44}	tɕi^{44}	tɕi^{44}	tɕi^{42}	tɕi^{44}	tɕi^{44}	tɕi^{44}
tɕi^{44}	1	5	tɕi^{44}	tɕi^{44}	tɕi^{44}	tɕi^{44}	tɕi^{44}	tɕi^{44}	tɕi^{44}	tɕi^{44}
tɕi^{44}	2	1	tɕi^{44}	tɕi^{44}	tɕi^{44}	tɕi^{44}	tɕi^{44}	tɕi^{44}	tɕi^{44}	tɕi^{44}
tɕi^{44}	2	2	tɕi^{44}	tɕi^{44}	tɕi^{44}	tɕi^{44}	tɕi^{42}	tɕi^{44}	tɕi^{44}	tɕi^{44}
tɕi^{44}	2	3	tɕi^{44}	tɕi^{44}	tɕi^{44}	tɕi^{44}	tɕi^{42}	tɕi^{44}	tɕi^{44}	tɕi^{44}
tɕi^{44}	2	4	tɕi^{44}	tɕi^{44}	tɕi^{44}	tɕi^{44}	tɕi^{31}	tɕi^{44}	tɕi^{44}	tɕi^{44}
tɕi^{44}	2	5	tɕi^{44}	tɕi^{44}	tɕi^{44}	tɕi^{44}	tɕi^{42}	tɕi^{44}	tɕi^{44}	tɕi^{44}
kao^{44}	1	1	kao^{44}	kao^{44}	kao^{44}	kao^{44}	kao^{44}	kao^{44}	kao^{44}	kao^{44}
kao^{44}	1	2	kao^{44}	kao^{44}	kao^{44}	kao^{44}	kao^{44}	kao^{44}	kao^{44}	kao^{44}
kao^{44}	1	3	kao^{44}	kao^{44}	kao^{44}	kao^{44}	kao^{44}	kao^{44}	kao^{44}	kao^{44}
kao^{44}	1	4	kao^{44}	kao^{44}	kao^{44}	kao^{44}	kao^{44}	kao^{44}	kao^{44}	kao^{44}
kao^{44}	1	5	kao^{44}	kao^{44}	kao^{44}	kao^{44}	kao^{44}	kao^{44}	kao^{44}	kao^{44}
kao^{44}	2	1	kao^{44}	kao^{44}	kao^{44}	kao^{44}	kao^{44}	kao^{44}	kao^{44}	kao^{44}
kao^{44}	2	2	kao^{44}	kao^{44}	kao^{44}	kao^{44}	kao^{44}	kao^{44}	kao^{44}	kao^{44}
kao^{44}	2	3	kao^{44}	kao^{44}	kao^{44}	kao^{44}	kao^{44}	kao^{44}	kao^{44}	kao^{44}
kao^{44}	2	4	kao^{44}	kao^{44}	kao^{44}	kao^{44}	kao^{44}	kao^{44}	kao^{44}	kao^{44}
kao^{44}	2	5	kao^{44}	kao^{44}	kao^{44}	kao^{44}	kao^{44}	kao^{44}	kao^{44}	kao^{44}
ma^{42}	1	1	ma^{42}	ma^{42}	ma^{42}	ma^{42}	ma^{42}	X	ma^{42}	ma^{42}
ma^{42}	1	2	ma^{42}	ma^{42}	ma^{42}	ma^{42}	ma^{42}	ma^{42}	ma^{42}	ma^{42}
ma^{42}	1	3	ma^{42}	ma^{42}	ma^{42}	ma^{42}	ma^{42}	ma^{42}	ma^{42}	ma^{42}

$m\alpha^{42}$	1	4	$m\alpha^{42}$	$m\alpha^{42}$	$m\alpha^{42}$	$m\alpha^{42}$	$m\alpha^{42}$	$m\alpha^{42}$	$m\alpha^{42}$	$m\alpha^{42}$
$m\alpha^{42}$	1	5	$m\alpha^{42}$	$m\alpha^{42}$	$m\alpha^{42}$	$m\alpha^{42}$	$m\alpha^{42}$	$m\alpha^{42}$	$m\alpha^{42}$	$m\alpha^{42}$
$m\alpha^{42}$	2	1	$m\alpha^{42}$	$m\alpha^{42}$	$m\alpha^{42}$	$m\alpha^{42}$	$m\alpha^{42}$	$m\alpha^{42}$	$m\alpha^{42}$	$m\alpha^{42}$
$m\alpha^{42}$	2	2	$m\alpha^{42}$	$m\alpha^{42}$	$m\alpha^{42}$	$m\alpha^{42}$	$m\alpha^{42}$	$m\alpha^{42}$	$m\alpha^{42}$	$m\alpha^{42}$
$m\alpha^{42}$	2	3	$m\alpha^{42}$	$m\alpha^{42}$	$m\alpha^{42}$	$m\alpha^{42}$	$m\alpha^{42}$	$m\alpha^{42}$	$m\alpha^{42}$	$m\alpha^{42}$
$m\alpha^{42}$	2	4	$m\alpha^{42}$	$m\alpha^{42}$	$m\alpha^{42}$	$m\alpha^{42}$	$m\alpha^{42}$	$m\alpha^{42}$	$m\alpha^{42}$	$m\alpha^{42}$
$m\alpha^{42}$	2	5	$m\alpha^{42}$	$m\alpha^{42}$	$m\alpha^{42}$	$m\alpha^{42}$	$m\alpha^{42}$	$m\alpha^{42}$	$m\alpha^{42}$	$m\alpha^{42}$
$p\alpha^{21}$	1	1	$p\alpha^{32}$	$p\alpha^{31}$	$p\alpha^{32}$	$p\alpha^{21}$	$p\alpha^{31}$	$p\alpha^{32}$	$p\alpha^{21}$	$p\alpha^{31}$
$p\alpha^{21}$	1	2	$p\alpha^{21}$	$p\alpha^{31}$	$p\alpha^{21}$	$p\alpha^{21}$	$p\alpha^{21}$	$p\alpha^{33}$	$p\alpha^{21}$	$p\alpha^{31}$
$p\alpha^{21}$	1	3	$p\alpha^{31}$	$p\alpha^{21}$	$p\alpha^{21}$	$p\alpha^{21}$	$p\alpha^{21}$	$p\alpha^{33}$	$p\alpha^{21}$	$p\alpha^{21}$
$p\alpha^{21}$	1	4	$p\alpha^{31}$	$p\alpha^{21}$	$p\alpha^{21}$	$p\alpha^{21}$	$p\alpha^{21}$	$p\alpha^{21}$	$p\alpha^{21}$	$p\alpha^{21}$
$p\alpha^{21}$	1	5	$p\alpha^{31}$	$p\alpha^{21}$	$p\alpha^{21}$	$p\alpha^{21}$	$p\alpha^{21}$	$p\alpha^{21}$	$p\alpha^{21}$	$p\alpha^{21}$
$p\alpha^{21}$	2	1	$p\alpha^{21}$	$p\alpha^{21}$	$p\alpha^{21}$	$p\alpha^{21}$	$p\alpha^{21}$	$p\alpha^{21}$	$p\alpha^{21}$	$p\alpha^{21}$
$p\alpha^{21}$	2	2	$p\alpha^{21}$	$p\alpha^{21}$	$p\alpha^{21}$	$p\alpha^{21}$	$p\alpha^{21}$	$p\alpha^{21}$	$p\alpha^{21}$	$p\alpha^{21}$
$p\alpha^{21}$	2	3	$p\alpha^{21}$	$p\alpha^{21}$	$p\alpha^{21}$	$p\alpha^{21}$	$p\alpha^{21}$	$p\alpha^{21}$	$p\alpha^{21}$	$p\alpha^{31}$
$p\alpha^{21}$	2	4	$p\alpha^{21}$	$p\alpha^{21}$	$p\alpha^{21}$	$p\alpha^{21}$	$p\alpha^{21}$	$p\alpha^{21}$	$p\alpha^{21}$	$p\alpha^{21}$
$p\alpha^{21}$	2	5	$p\alpha^{21}$	$p\alpha^{21}$	$p\alpha^{21}$	$p\alpha^{21}$	$p\alpha^{21}$	$p\alpha^{21}$	$p\alpha^{21}$	$p\alpha^{21}$
$p\alpha^{31}$	1	1	$p\alpha^{31}$	$p\alpha^{31}$	$p\alpha^{21}$	$p\alpha^{31}$	$p\alpha^{21}$	$p\alpha^{31}$	$p\alpha^{21}$	$p\alpha^{21}$
$p\alpha^{31}$	1	2	$p\alpha^{31}$	$p\alpha^{31}$	$p\alpha^{33}$	$p\alpha^{31}$	$p\alpha^{21}$	$p\alpha^{33}$	$p\alpha^{21}$	$p\alpha^{31}$
$p\alpha^{31}$	1	3	$p\alpha^{31}$	$p\alpha^{31}$	$p\alpha^{21}$	$p\alpha^{31}$	$p\alpha^{21}$	$p\alpha^{31}$	$p\alpha^{21}$	$p\alpha^{31}$
$p\alpha^{31}$	1	4	$p\alpha^{31}$	$p\alpha^{31}$	$p\alpha^{33}$	$p\alpha^{33}$	$p\alpha^{21}$	$p\alpha^{31}$	$p\alpha^{21}$	$p\alpha^{31}$
$p\alpha^{31}$	1	5	$p\alpha^{31}$	$p\alpha^{21}$	$p\alpha^{33}$	$p\alpha^{31}$	$p\alpha^{21}$	$p\alpha^{33}$	$p\alpha^{21}$	$p\alpha^{31}$
$p\alpha^{31}$	2	1	$p\alpha^{31}$	$p\alpha^{31}$	$p\alpha^{31}$	$p\alpha^{33}$	$p\alpha^{21}$	$p\alpha^{33}$	$p\alpha^{21}$	$p\alpha^{21}$
$p\alpha^{31}$	2	2	$p\alpha^{31}$	$p\alpha^{31}$	$p\alpha^{33}$	$p\alpha^{33}$	$p\alpha^{21}$	$p\alpha^{33}$	$p\alpha^{21}$	$p\alpha^{31}$
$p\alpha^{31}$	2	3	$p\alpha^{31}$	$p\alpha^{21}$	$p\alpha^{31}$	$p\alpha^{31}$	$p\alpha^{21}$	$p\alpha^{33}$	$p\alpha^{21}$	$p\alpha^{31}$
$p\alpha^{31}$	2	4	$p\alpha^{31}$	$p\alpha^{31}$	$p\alpha^{21}$	$p\alpha^{31}$	$p\alpha^{21}$	$p\alpha^{33}$	$p\alpha^{21}$	$p\alpha^{31}$
$p\alpha^{31}$	2	5	$p\alpha^{31}$	$p\alpha^{21}$	$p\alpha^{33}$	$p\alpha^{31}$	$p\alpha^{21}$	$p\alpha^{33}$	$p\alpha^{21}$	$p\alpha^{31}$
$p\alpha^{32}$	1	1	$p\alpha^{42}$	$p\alpha^{21}$	$p\alpha^{21}$	$p\alpha^{42}$	$p\alpha^{42}$	$p\alpha^{44}$	$p\alpha^{42}$	$p\alpha^{21}$
$p\alpha^{32}$	1	2	$p\alpha^{42}$	$p\alpha^{42}$	$p\alpha^{42}$	$p\alpha^{32}$	$p\alpha^{42}$	$p\alpha^{21}$	$p\alpha^{42}$	$p\alpha^{21}$
$p\alpha^{32}$	1	3	$p\alpha^{42}$	$p\alpha^{42}$	$p\alpha^{21}$	$p\alpha^{42}$	$p\alpha^{42}$	$p\alpha^{21}$	$p\alpha^{42}$	$p\alpha^{32}$
$p\alpha^{32}$	1	4	$p\alpha^{42}$	$p\alpha^{21}$	$p\alpha^{42}$	$p\alpha^{42}$	$p\alpha^{42}$	$p\alpha^{44}$	$p\alpha^{42}$	$p\alpha^{32}$
$p\alpha^{32}$	1	5	$p\alpha^{42}$	$p\alpha^{42}$	$p\alpha^{32}$	$p\alpha^{42}$	$p\alpha^{42}$	$p\alpha^{44}$	$p\alpha^{42}$	$p\alpha^{32}$
$p\alpha^{32}$	2	1	$p\alpha^{42}$	$p\alpha^{42}$	$p\alpha^{21}$	$p\alpha^{42}$	$p\alpha^{42}$	$p\alpha^{44}$	$p\alpha^{42}$	$p\alpha^{32}$
$p\alpha^{32}$	2	2	$p\alpha^{42}$	$p\alpha^{42}$	$p\alpha^{42}$	$p\alpha^{42}$	$p\alpha^{42}$	$p\alpha^{32}$	$p\alpha^{42}$	$p\alpha^{32}$
$p\alpha^{32}$	2	3	$p\alpha^{42}$	$p\alpha^{42}$	$p\alpha^{21}$	$p\alpha^{44}$	$p\alpha^{42}$	$p\alpha^{44}$	$p\alpha^{42}$	$p\alpha^{32}$
$p\alpha^{32}$	2	4	$p\alpha^{42}$	$p\alpha^{42}$	$p\alpha^{21}$	$p\alpha^{44}$	$p\alpha^{42}$	$p\alpha^{32}$	$p\alpha^{42}$	$p\alpha^{32}$
$p\alpha^{32}$	2	5	$p\alpha^{42}$	$p\alpha^{21}$	$p\alpha^{32}$	$p\alpha^{32}$	$p\alpha^{42}$	$p\alpha^{44}$	$p\alpha^{42}$	$p\alpha^{32}$
$p\alpha^{33}$	1	1	$p\alpha^{31}$	$p\alpha^{31}$	$p\alpha^{31}$	$p\alpha^{31}$	$p\alpha^{31}$	$p\alpha^{33}$	$p\alpha^{33}$	$p\alpha^{31}$
$p\alpha^{33}$	1	2	$p\alpha^{31}$	$p\alpha^{31}$	$p\alpha^{31}$	$p\alpha^{33}$	$p\alpha^{31}$	$p\alpha^{31}$	$p\alpha^{33}$	$p\alpha^{31}$
$p\alpha^{33}$	1	3	$p\alpha^{31}$	$p\alpha^{31}$	$p\alpha^{31}$	$p\alpha^{33}$	$p\alpha^{31}$	$p\alpha^{33}$	$p\alpha^{31}$	$p\alpha^{31}$
$p\alpha^{33}$	1	4	$p\alpha^{31}$	$p\alpha^{31}$	$p\alpha^{31}$	$p\alpha^{31}$	$p\alpha^{31}$	$p\alpha^{31}$	$p\alpha^{31}$	$p\alpha^{31}$

pa^{33}	1	5	pa^{31}	pa^{31}	pa^{33}	pa^{31}	pa^{31}	pa^{31}	pa^{31}	pa^{31}
pa^{33}	2	1	pa^{31}	pa^{31}	pa^{33}	pa^{33}	pa^{31}	pa^{32}	pa^{31}	pa^{31}
pa^{33}	2	2	pa^{31}	pa^{31}	pa^{33}	pa^{33}	pa^{31}	pa^{31}	pa^{33}	pa^{31}
pa^{33}	2	3	pa^{31}	pa^{32}	pa^{31}	pa^{33}	pa^{31}	pa^{31}	pa^{33}	pa^{31}
pa^{33}	2	4	pa^{31}	pa^{31}	pa^{33}	pa^{31}	pa^{31}	pa^{33}	pa^{33}	pa^{31}
pa^{33}	2	5	pa^{31}	pa^{31}	pa^{31}	pa^{33}	pa^{31}	pa^{31}	pa^{33}	pa^{31}
pa^{42}	1	1	pa^{42}	pa^{42}	pa^{42}	pa^{42}	pa^{42}	pa^{42}	pa^{42}	pa^{31}
pa^{42}	1	2	pa^{42}	pa^{42}	pa^{42}	pa^{42}	pa^{42}	pa^{42}	pa^{42}	pa^{31}
pa^{42}	1	3	pa^{42}	pa^{42}	pa^{42}	pa^{42}	pa^{42}	pa^{42}	pa^{42}	pa^{44}
pa^{42}	1	4	pa^{42}	pa^{42}	pa^{42}	pa^{42}	pa^{42}	pa^{42}	pa^{42}	pa^{31}
pa^{42}	1	5	pa^{42}	pa^{42}	pa^{42}	pa^{42}	pa^{42}	pa^{42}	pa^{42}	pa^{42}
pa^{42}	2	1	pa^{42}	pa^{42}	pa^{42}	pa^{42}	pa^{42}	pa^{42}	pa^{42}	pa^{42}
pa^{42}	2	2	pa^{42}	pa^{42}	pa^{42}	pa^{42}	pa^{42}	pa^{42}	pa^{42}	pa^{42}
pa^{42}	2	3	pa^{42}	pa^{42}	pa^{42}	pa^{42}	pa^{42}	pa^{42}	pa^{42}	pa^{42}
pa^{42}	2	4	pa^{42}	pa^{42}	pa^{42}	pa^{42}	pa^{42}	pa^{42}	pa^{42}	pa^{42}
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$tɯ^{31}$	1	2	$tɯ^{31}$	$tɯ^{31}$	$tɯ^{33}$	$tɯ^{31}$	$tɯ^{33}$	$tɯ^{31}$	$tɯ^{31}$	$tɯ^{31}$
$tɯ^{31}$	1	3	$tɯ^{31}$	$tɯ^{33}$	$tɯ^{33}$	$tɯ^{33}$	$tɯ^{31}$	$tɯ^{31}$	$tɯ^{31}$	$tɯ^{31}$
$tɯ^{31}$	1	4	$tɯ^{31}$	$tɯ^{33}$	$tɯ^{31}$	$tɯ^{31}$	$tɯ^{31}$	$tɯ^{33}$	$tɯ^{31}$	$tɯ^{31}$
$tɯ^{31}$	1	5	$tɯ^{31}$	$tɯ^{31}$	$tɯ^{31}$	$tɯ^{31}$	$tɯ^{31}$	$tɯ^{33}$	$tɯ^{31}$	$tɯ^{31}$
$tɯ^{31}$	2	1	$tɯ^{31}$	$tɯ^{31}$	$tɯ^{33}$	$tɯ^{31}$	$tɯ^{31}$	$tɯ^{31}$	$tɯ^{31}$	$tɯ^{31}$
$tɯ^{31}$	2	2	$tɯ^{31}$	$tɯ^{33}$	$tɯ^{33}$	$tɯ^{33}$	$tɯ^{33}$	$tɯ^{31}$	$tɯ^{33}$	$tɯ^{31}$
$tɯ^{31}$	2	3	$tɯ^{31}$	$tɯ^{31}$	$tɯ^{31}$	$tɯ^{33}$	$tɯ^{33}$	$tɯ^{33}$	$tɯ^{33}$	$tɯ^{31}$
$tɯ^{31}$	2	4	$tɯ^{31}$	$tɯ^{33}$	$tɯ^{31}$	$tɯ^{31}$	$tɯ^{33}$	$tɯ^{33}$	$tɯ^{33}$	$tɯ^{31}$
$tɯ^{31}$	2	5	$tɯ^{31}$	$tɯ^{33}$	$tɯ^{31}$	$tɯ^{33}$	$tɯ^{33}$	$tɯ^{31}$	$tɯ^{31}$	$tɯ^{31}$
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tɯ^{33}	2	5	tɯ^{31}	tɯ^{31}	tɯ^{33}	tɯ^{31}	tɯ^{31}	tɯ^{31}	tɯ^{33}	tɯ^{31}

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