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東亞漢字音之入聲韻變化：以優選理論探討

Phonological Changes of Entering Tone in Sino-Xenic Languages: An Optimality-Theoretic Approach

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English Abstract

Key words: Sino-Xenic Languages, Optimality Theory, Historical Phonology, Opacity, Syllable Structure

This thesis investigates the phonological change of entering tone in Sino-Xenic languages based on Optimality Theory. The research issues include (1) How is Optimality Theory applied to historical linguistics on the basis of Sino-Xenic languages? (2) How is Opacity in historical linguistics represented in Optimality Theory by means of Sino-Xenic languages? (3) How does internal syllable structure affect phonological change in Sino-Xenic languages? In this study, the data of entering tone are collected according to *Fāngyán Diàochá Zìbiǎo* (A wordlist for dialectal research). Specifically, the layers, which are pertinent to each other, from three Sino-Xenic languages, Literal Reading (Wéndú) in Southern Min and Kan-on in Sino-Japanese and Modern Sino-Korean, are compared. In addition, instead of the traditional method, Shè, this study concentrates on vowel changes by dividing vowels into [a]-vowel group, non-[a]-vowel group and Hékǒu.

First, to investigate the compatibility of historical phonology and modern phonological theories, this study adopts Faithfulness, Markedness, Dispersion-Optimality Theory (FMD-OT) (Sanders 2003), paying specific attention to vowel changes. The results show that Optimality Theory can account for the historical change of entering tone in Sino-Xenic languages and FMD-OT succinctly explains vowel changes in terms of dispersion constraints. Furthermore, this study amends Sanders' FMD-OT by proposing a new set of constraints for central vowel.

Second, this study also discusses opacity in historical phonology. To solve this problem, this study modifies and extends Candidate Chains (McCarthy 2007). It is proposed historical sound change is continual, each stage is evaluated parallelly, and new constraints are activated and reranked with previous constraints. This proposal is supported by *Gěngshè* (梗攝) in Southern Min, Division III of *Shēngshè* (深攝) and *Xiánshè* (咸攝) in Sino-Japanese and *Gěngshè* (梗攝) in Sino-Korean.

This study finally explores the influence of syllable structure on sound changes in Sino-Xenic languages. Two factors are suggested, Phonotactic Constraints and Licensing Constraints. When the moras belong to the same branch in syllable node, there is no interaction of the segments, such as Southern Min. On the contrary, when the moras locate in different branches, the segments interact, such as Sino-Japanese and Sino-Korean. What distinguishes Sino-Japanese from Sino-Korean is whether mora is prominent or not. On one hand, if the mora is prominent, the mora is maintained, for example, Sino-Japanese. On the other hand, if the mora is not prominent, the mora is likely to be deleted, i.e. Sino-Korean, when the interaction takes place.

中文摘要

關鍵字: 東亞漢字音、優選理論、歷史音韻、晦澀性、音節結構

本篇論文主旨在於以優選理論探討東亞漢字音的入聲韻變化。研究重點有三: (一) 東亞漢字音歷史音韻變化與現代音韻理論的相容性; (二) 東亞漢字音歷史音韻變化與音韻晦澀性 (Opacity); (三) 音節結構差異對東亞漢字音音韻變化的影響。研究資料乃以《方言調查字表》中所列的入聲韻爲依據。本研究採用三個層次相近的東亞漢字音 (臺灣閩南語之文讀音、日本漢字音之漢音與韓國漢字音)。而研究方法則以母音種類爲主，而非以傳統的攝，並分成 [a]母音、非[a]母音與合口。

首先，在歷史音韻與現代音韻理論的相容性方面，基於過去漢字音歷史音韻研究較少與現代音韻理論結合，因此本文以優選理論，特別以 Sanders (2003) 的擴散優選理論 (Faithfulness, Markedness, Dispersion-Optimality Theory) 爲主，來探討東亞漢字音入聲韻之歷史音韻變化。結果顯示在入聲韻中，[a]母音、非[a]母音與合口皆能與優選理論相容。而 Sanders (2003) 的擴散優選理論更能清楚地將母音變化以擴散限制 (Dispersion Constraints) 表現，不同的限制代表了不同的母音變化。同時本研究亦提出央元音限制以補足先前研究之不足。

本文更進一步探討歷史音韻變化與音韻晦澀性。本文認爲歷史音韻變化有一特色，即是連續性(Continuity)。但優選理論強調輸入項與輸出項的直接對應，使得優選理論無法解釋晦澀性。因此本文延伸 McCarthy (2007) 的連續候選項 (Candidate Chains) 並納入連續性 (Continuity) 概念，以解釋歷史音韻變化中出現的晦澀性。

最後本文亦探討音節結構差異對東亞漢字音音韻變化的影響，可從二方面來探討: 莫拉 (mora) 於音節內的位置 (Phonotactic Constraints) 與音段交流限制 (Licensing Constraints)。當音節內的莫拉位於同一音節分支時，位於下位的音段則不會有交流現象 (如: 臺灣閩南語)，但當莫拉分屬於不同分支時，則會產生交流現象。其中依據音節中的莫拉是否顯著，再加以分類。若是莫拉顯著者，則音段交流時，莫拉傾向被保留 (如: 日本漢字音)。若是莫拉不顯著者，則音段交流時，莫拉傾向不被保留 (如: 韓國漢字音)。

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Chapter 1 Introduction

1.0 Overview

This thesis investigates the phonological changes of entering tone (入聲韻 *Rù Shēng Yùn*) in Sino-Xenic languages, focusing on vowel changes and the influence syllable structure on sound changes. The framework is based on Optimality Theory, especially *Faithfulness, Markedness, and Dispersion in OT* (Sanders 2003) and Candidate Chains (McCarthy 2007). Abridging the gap between historical Chinese phonology and modern phonological theories is essential because previous works that deal with these two fields are seldom seen. One one hand, from *Qiēyùn* (切韻 601 A.D.), Chinese phonology has long history and many researchers have devoted themselves to different dialects to shape what Middle Chinese is. Historical Chinese phonology, however, are seldom explored by modern phonological theories. On the other hand, although modern phonological theories are not developed as early as Chinese phonology is, from SPE (Chomsky and Halle 1968) to Autosegmental phonology (Goldsmith 1990) and then to Optimality Theory (Prince and Smolensky 1993, 2004), phonological theories are bountiful and have transformed from leaner to non-leaner and now to tableau. With the rapid development of modern phonological theories, many issues have been re-visited and re-examined to propose new understandings. Yet, historical phonology hardly catches researchers' attention. Therefore it is theoretically inspiring and arouse a great of interests when historical phonology converses with modern phonological theories. Also, this study proposes a new set of constraints for central vowel to amend Sanders' FMD-OT, in which central vowel is not taken into account. In addition to vowel changes, this study modifies and extends Candidate Chains in order to solve opacity in historical phonology. Finally, how internal syllable structure affects sound changes is discussed.

1.1 Background Information of Sino-Xenic Languages

The following sections firstly define Sino-Xenic Languages and then describe the phonology and different layers of Chinese character readings in the three Sino-Xenic languages. Finally, previous comparative studies on Sino-Xenic languages are discussed.

1.1.1 Definition of Sino-Xenic Languages

Sino-Xenic languages indicate Chinese dialects in Taiwan and China and Sino-Xenic dialects in Japanese, Korean and Vietnamese. Generally speaking, Sino-Xenic languages refer to the pronunciation of Chinese characters in East Asian languages, existing not only in Chinese dialects but also in Japanese, Korean, and Vietnamese, which have been influenced by Chinese in history.[1] The introduction of Chinese characters to Japanese, Korean and Vietnamese has formed another system, termed as Sino-Japanese, Sino-Korean and Sino-Vietnamese, all of which are grouped as Sino-Xenic dialects. As proposed by Lee (1994), Middle Chinese are preserved in southern Chinese dialects, northern Chinese dialects and Sino-Xenic dialects. Lee further states that among the three systems, it is southern Chinese dialects, such as Southern Min, and Sino-Xenic dialects rather than northern Chinese dialects that keep characteristics of stop endings in Middle Chinese. As a result, this study will compare one southern Chinese dialect, Southern Min[2] and two Sino-Xenic dialects, Sino-Japanese and Sino-Korean, to unveil the phonological change of stop endings.

1.1.2 Phonology of Southern Min, Japanese and Korean

This section depicts the phonology of three target languages, Southern Min, Sino-Japanese and Sino-Korean, concentrating on vowel system, consonant system and syllable structure. For further investigation, it is crucial to realize the phonology of these three languages. First, according to Yang (1991) and Chang (2001), Southern Min has six basic vowels[3] and twenty consonants, shown in Table 1.1 and 1.2. In Table 1.1, the vowels in parentheses are nasalized vowels.

[1] The impacts of Chinese on Japanese and Korean are detailed in Section 1.2.3.
[2] Southern Min is chiefly spoken in Taiwan and Fujian Province of China. In this study, Southern Min specifically refers to Taiwan Southern Min rather than that in China.
[3] In some dialects, vowel [o] is transcribed as [ɤ].

Table 1.1: Vowel System of Southern Min

	Front	Central	Back
High	i (ĩ)		u
Mid-high	e (ẽ)		o
Mid			
Mid-Low			ɔ (ɔ̃)
Low		a (ã)	

In Table 1.2 the alveolar voiced stop [d] has one variation, which can also be pronounced as [l].

Table 1.2: Consonant System of Southern Min

			Bilabial	Alveolar	Palatal	Velar	Glottal
Stop		[+V]	b	d (l)		g	
	Unaspirated	[-V]	p	t		k	ʔ
	Aspirated	[-V]	p^h	t^h		k^h	
Fricative		[+V]		z			
		[-V]		s			h
Affricates	Unaspirated	[-V]		ts			
	Aspirated	[-V]		ts^h			
Nasal			m	n		ŋ	
Glide			w		j		

According to Tsujimura (1996) and Kubozono (2005), Japanese has five vowels and twenty-six consonants. Listed in Table 1.3 Japanese vowel system has one unmarked vowel, namely, the back unrounded high vowel, [ɯ].

Table 1.3: Vowel System of Japanese

	Front	Central	Back
High	i		ɯ
Mid-high	e		o
Mid			
Mid-low			
Low		a	

Although in Table 1.4 there are twenty-six consonant, the three vowels in parentheses remain controversial because the three consonants appear in rapid speech ([ʒ]) or coarticulation ([ň] and [ɲ]) (Tsujimura 1996).

Table 1.4: Consonant system of Japanese

		Bilabial	Alveolar	Alveo-palatal	Palatal	Velar	Uvular	Glottal
Stop	[+V]	b	d			g		
	[-V]	p	t			k		
Fricative	[+V]		z	(ʒ)	ç			h
	[-V]	ɸ	s	ʃ				
Affricates	[+V]		d^z	dʒ				
	[-V]		t^s	tʃ				
Liquid	[+V]		r					
Glide	[+V]				j	w		
Nasals	[+V]	m	n	(ň)	(ɲ)	ŋ	ɴ	

Following Sohn (1990) and Lee (1998), there are eight basic vowels in Korean[4], shown in Table 1.5 and nineteen consonants, exhibited in Table 1.6.

Table 1.5: Vowel System of Korean

	Front	Central	Back
High	i	ɨ	u
Mid-high	e		o
Mid		ə	
Mid-Low	ɛ		
Low		a	

Table 1.6: Consonant System of Korean

			Bilabial	Alveolar-dental	Palatal	Velar	Glottal
Stop	Lax	[+V] [-V]	p	T	c	k	
	Aspirated	[-V]	p^h	t^h	c^h	k^h	
	Tensed	[-V]	p’	t’	c’	k’	
Fricative	Aspirated	[-V]		s			h
	Tensed	[-V]		s’			
Nasal		[+V]	m	n		ŋ	
Liquid	Lateral or Flap	[+V]		l			

[4] Sohn (1990) also proposes [y] and [ø]; however these two vowels are mainly found in minor dialects. [y] results from [wi] and [ø] from [we]. In this study, the two vowels are not included in the discussion.

In consonant system of Korean, stop and fricative can be distinguished by [lax] and [tensed]. In addition, the lax stops are not distinguished by [voiced]. For example, bilabial stop can be transcribed as [p] or [b].

Apart from the vowel and consonant system, the rest part of this section briefly introduces syllable structure of Southern Min, Japanese and Korean. Although the canonical sequence of the three languages is CGVC for Southern Min, CV(N) for Japanese and CGVC for Korean, the internal structure plays a more significant role in phonological change. More detailed investigation and review of the syllable structure in Southern Min, Sino-Japanese and Sino-Korean is offered in Chapter 2.

1.1.3 Layers in Southern Min, Sino-Japanese and Sino-Korean

This section focuses on internal layers of Southern Min, Sino-Japanese and Sino-Korean. Since immigration from northern China to southern China in different dynasties, several phonological systems have been introduced to Southern Min (Yang 1991). Southern Min has two main layers[5], *Literal Reading* (文讀 *Wéndú*), *Colloquial Reading* (白讀 *Báidú*). *Literal Reading* (文讀 *Wéndú*), as its name suggests, is the layer for reading classics, while *Colloquial Reading* (白讀 *Báidú*) is the layer spoken in daily life (Chang 1993; Lin 2001; Lu 2003; Xu 1998, 2000; Yang 1982, 1991). Table 1.7 (tone is omitted) offers some examples of *Literal Reading* (文讀 *Wéndú*) and *Colloquial Reading* (白讀 *Báidú*).

Table 1.7: *Literal Reading* (文讀) and *Colloquial Reading* (白讀) of Southern Min

Chinese Characters	塔	粒	八	佛	泊	桌	北	木
Literal Reading (文讀 *Wendu*)	t^hap	lip	pat	hut hut	pok	tak	pok	bok
Colloquial Reading (白讀 *Báidú*)	t^haʔ	liap	pueʔ peʔ	put	poʔ	toʔ tok	pak	bak

[5] In Southern Min some characters have other pronunciations, which is relatively rare. It refers to the reading that is semantically related to the Chinese character but etymologically irrelevant. Take 不 (no) as an example, it is commonly recognized as [m], whereas its *Literal Reading* (文讀 *Wéndú*) and *Colloquial Reading* (白讀 *Báidú*) are [put] and [pue], respectively.

The most obvious discrepancy of *Literal Reading* (文讀 *Wéndú*) and *Colloquial Reading* (白讀 *Báidú*) is the stop ending. *Literal Reading* (文讀 *Wéndú*) does not include glottal stop, whereas *Colloquial Reading* (白讀 *Báidú*) has glottal stop.

In Southern Min, *Colloquial Reading* (白讀 *Báidú*) and *Literal Reading* (文讀 *Wéndú*) can be traced back to different periods of Middle Chinese and *Colloquial Reading* (白讀 *Báidú*) appears earlier than *Literal Reading* (文讀 *Wéndú*) (Chang 1996; Yang 1991).[6]

Unlike Southern Min, a dialect that descends from Middle Chinese and preserves its characteristics, Japanese and Korean borrow Chinese characters into their languages. In the early period, Chinese characters primarily function as phonetic symbols to record history, as 万葉仮名 (*Manyougana*) in Japanese and 鄕札 (*Hyanchal*) in Korean. Later, as China becomes more dominant and powerful, Japanese and Korea send scholars to China to learn Chinese. The frequent communication of China, Japan and Korea leads to systematic borrowing of Middle Chinese. Two primary layers, 漢音 (*Kan-on*) and 呉音 (*Go-on*) (Lee 2004; Numoto 1989; Takamatsu 1986; Todo 1980), are found in Japanese, illustrated in Table 1.8. Previous studies also indicate that *Go-on* (呉音) has been taken as the layer that precedes *Kan-on* (漢音) in history (Numoto1989; Takamatsu1986; Tsukishima 1992).

Table 1.8: *Kan-on* (漢音) and *Go-on* (呉音) of Sino-Japanese

Chinese Characters	合	入	別	卒	特	百	復
Kan-on (漢音)	コウ [ko:]	ジュウ [zjɯ:]	ヘツ [hetsɯ]	ソツ [sotsɯ]	トク [tokɯ]	ハク [hakɯ]	フク [hɯkɯ]
Go-on (呉音)	ゴウ [go]	ニュウ [njɯ:]	ベチ [beti]	ソチ [soti]	ドク [dokɯ]	ヒャク [hjakɯ]	ブク [bɯkɯ]

[6] Yang (1991) and Chang (1996) suggest that *Literal Reading* (文讀 *Wendu*) and *Colloquial Reading* (白讀 *Báidú*) are formed through generations and it is not easy to precisely point out their origins. However, it is certain that *Literal Reading* (文讀 *Wendu*) and *Colloquial Reading* (白讀 *Báidú*) represent different systems.

After 漢音 (*Kan-on*) and 呉音 (*Go-on*), the communication of China and Japan becomes less frequent. Borrowings continue, such as 新漢音 (*Shin-kan-on*), 宋音 (*Sou-on*) and 唐音 (*Tou-on*); however they do not establish layers as systematic as 漢音 (*Kan-on*) and 呉音 (*Go-on*).

Mentioning the layers of Sino-Korean, Korean has communicated with China as early as the first century BC (Sohn 1999). Although Sino-Korean has been affected by Chinese for a long time, unlike Southern Min and Sino-Japanese, there are no distinct layers in Modern Sino-Korean (Lee 2004; Oh 2005). Lack of regulated multiple layers in Sino-Korean does not imply that each Sino-Korean contains only one reading. In fact, some Chinese characters include two pronunciations, shown in Table1.9, Sino-Korean and Korean Reading of Chinese Characters. Short of adequate instance and systematic correspondence, examples in Table 1.9, however, do not form a specific layer.

Table 1.9: Characters with two Sino-Korean pronunciations

Chinese Characters	金	宅	扱	設	合	斛	夕	帖
Sino-Korean	금 [kɨm]	택 [t^hɛk]	흡 [hɨp]	삽 [sap]	합 [hap]	곡 [kok]	석 [sək]	첩 [c^həp]
Korean Reading of Chinese Characters	김 [kim]	댁 [tɛk]	급 [kɨp]	급 [kɨp]	홉 [hop]	괵 [kwek]	사 [sa]	체 [c^he]

In literature, studies on the layers in Sino-Xenic Languages are abundant in the past (Chang 1996; Hsu 1991; Liang 2000; Norman 1979; Wu 2001; Yang 1982 for Southern Min, Nutomo 1989; Takamatsu 1986 for Sino-Japanese, Kono 1979 for Sino-Korean). However, whether the layers are correlated cross-linguistically is not perspicuous. The next section will focus on the comparison of different languages.

1.1.4 Comparative Studies on Sino-Xenic Languages

This section offers the relationship of the layers across Southern Min, Sino-Japanese and Sino-Korean. Layers in Sino-Xenic languages are explored not only internally but also cross-linguistically. Although layers of the three Sino-Xenic languages cannot be leveled perfectly, based on the previous studies (Chang 1996; Eom 1991; Kim 1992; Lee 1994; Wu 1998), it can be implied that *Literal Reading* (文讀 *Wéndú*) of Southern Min,

Kan-on (漢音) of Sino-Japanese and Sino-Korean are pertinent to one another.[7] Lee (1999), Shinohara (1993, 1999) and Wang (1998), especially shedding light on Southern Min and Sino-Japanese, point out that *Colloquial Reading* (白讀 *Báidú*) of Southern Min is highly related to Wu Dialect (吳語), which is also connected with Japanese and known as *Go-on* (呉音). This indirect relationship leads to the similarity of *Colloquial Reading* (白讀 *Báidú*) of Southern Min and *Go-on* (呉音) of Sino-Japanese. On the other hand, Chang (1996) and Wu (1998) suggest that *Literal Reading* (文讀 *Wéndú*) and *Kan-on* (漢音) stem from the same origin, *Chang-An* (長安) in Tang Dynasty. The other cross-linguistic study consists in the correspondence of Southern Min and Sino-Korean. Kim (1992) concluded that *Literal Reading* (文讀 *Wéndú*) of Southern Min and Sino-Korean are partly related, resting in the correspondence of Initials (onsets) and Finals (codas) rather than main vowel (cf. Eom 2005; Li et al. 2006).

Apart from two-layer comparison, Eom (1991) and Lee (1994) explores the date and sources of Sino-Korean by multiple languages. Eom (1991) claims that the source of Sino-Paekche, a dialect earlier than Sino-Korean, is related to *Go-on* (呉音) of Sino-Japanese as well as Southern Min dialect. Lee (1994) proposes that Sino-Korean is dated back to Late Middle Chinese (LMC)[8].

Now that how the layers of Southern Min, Sino-Japanese and Sino-Korean connect with one another is perspicuous, we will compare *Literal Reading* (文讀 *Wéndú*) of Southern Min, *Kan-on* (漢音) of Sino-Japanese and Sino-Korean together.

1.2 Issues of the Study

Based on the three layers of Sino-Xeniclanguage and Optimality Theory, the present thesis addresses three research questions.

[7] The other implication from previous studies lies in that *Colloquial Reading* (白讀 *Báidú*) of Southern Min, *Go-on* (呉音) of Sino-Japanese and Sino-Paekche are related to one another.

[8] The borrowing of Chinese Characters is much earlier than the invention of Korean writing system, 訓民正音 (훈민정음, *Hunmin jeongeum*).

(1) How is Optimality Theory applied to historical linguistics on the basis of Sino-Xenic languages?

First, as insatiable with the literature that earlier works of Optimality Theory seldom shed light on historical linguistics until Anttila and Cho (1998), Bermudez (2003, 2005, 2007) and Sanders (2003), the first objective of this study is to see the application of Optimality Theory to sound changes from phonological perspective. Besides, studies of historical phonology pertinent to East Asian languages are hardly investigated by means of modern phonological theories, such as Autosegmental Phonology (Goldsmith 1990) and Government Phonology (Charette 1991), not to mention Optimality Theory (Prince and Smolensky 1993; 2004). Hence, the analyses of historical phonology in East Asian languages, Sino-Xenic languages in particular, based on Optimality Theoretical approach will be a pioneering work.

The theoretical framework heavily depends on Faithfulness, Markedness and Dispersion Optimality Theory (*FMD-OT*, Sanders 2003), for more details see 2.1.1), rather than traditional Chinese Phonological method, which compares 聲母 (onset) and 韻母 (rhyme).

(2) How is Opacity in historical linguistics represented in Optimality Theory by means of Sino-Xenic languages?

The second question concerns Opacity (for more details see 2.1.2) in historical linguistics. As McMahon (2000) and McCarthy (2007) admitted, opacity is a thorny issue that might overthrow Optimality Theory. This is to say, opacity, a phonological process where derivation is irreplaceable, occurs in synchronic phonology as well as diachronic phonology, whereas Optimality Theory forsakes derivation, focusing on the direct mapping of input and output. Although a variety of revision of Optimality Theory has been proposed to solve opacity, few earlier works have attempted to deal with opacity in diachronic phonology. Therefore, through the analyses of data in Chapter 3 and 4, the opacity in historical linguistics is examined by the insight from McCarthy's Candidate Chains (2007).

(3) How does internal syllable structure affect phonological change in Sino-Xenic languages?

Finally, the third research question probes into the role of syllable structure in historical linguistics, focusing on Sino-Xenic languages. Although syllable structure is one factor in vowel change (Trask 1996), how the internal structure of a syllable affects vowel change is not explicitly unveiled yet. Now that this study incorporates with Southern Min, Sino-Japanese and Sino-Korean, the comparison of these three languages is of great help to uncover the role of syllable structure in historical phonology. Specifically, it will be argued that how a syllable branches also attributes to vowel change.

1.3 Methodology

This section explicitly discusses the criteria of how the data in this study are collected and then how the data are presented and investigated.

1.3.1 Data Collection

To solve the three research questions, three Sino-Xenic languages are investigated in this study, inclusive of Southern Min, Sino-Japanese and Sino-Korean. To be more succinct, this current study focuses on *Literal Reading* (文讀 *Wéndú*) in Southern Min and *Kan-On* (漢音) in Sino-Japanese because the three layers are pertinent to one another.

In this study, data are collected based on wordlists and dictionaries. The first reference is 方言調查字表 (*Fāngyán Diàochá Zìbiǎo*, A wordlist for dialectal research). This wordlist is published by Institute of Linguistics, Chinese Academy of Social Sciences (中國社會科學院語言研究所), covering approximate 3700 characters. The primary purpose to design this wordlist is for fieldwork of Chinese dialects. This work is compiled according to *Guǎngyǜn* (廣韻), a rime book that analyzes a Chinese character by parameters, 聲母 (Shēngmǔ, namely onset), 韻母 (Yǜnmǔ, namely rhyme) and 聲調

(Shēngdiào, namely tone). Based on this wordlist, entering tone[9] includes approximate 600 Chinese characters. Incorporating with the 600 Chinese characters, the pronunciations of *Literal Reading* (文讀 *Wéndú*) of Southern Min, *Kan-on* (漢音) of Sino-Japanese and Sino-Korean are transcribed according to the following dictionaries, which include as many Chinese characters as possible. The main dictionaries are 國台雙語辭典-台華雙語辭典 (*Guótái Shuāngyǔ Cídiǎn-Táihuá Shuāngyǔ Cídiǎn*, Chinese-Taiwanese Bilingual Dictionary) for Southern Min, 新漢語林 (*Shin Kangorin*, New Collection of Sino-Japanese) for Sino-Japanese and 엣센스 한자사전 (*Essenseu Hanja Sajeon*, Essential Sino-Korean Dictionary) for Sino-Korean. Although most of the data can be found in the three dictionaries, some characters are not. In this case, the secondary dictionaries come into effect. For Southern Min, it is 國臺對照活用辭典: 詞性分析、詳注廈漳泉音 (*Guótái Duìzhào Huóyòng Zídiǎn*: *Zíxìngfēngxī, Xiángzhù XiàZhàngChuán Yīn*, Chinese-Taiwanese Dictionary: Analysis of Part of Speech, Detailed *Xia, Zhang, Chuan Dialects*) and it is 角川新字源改訂版 (*Kadokawa Shinjigen Kaiteiban*, Kadokawa New Etymology: New Edition) for Sino-Japanese and 프라임 중한사전 (*Pheuraim Chunghan Sajeon*, Prime Chinese-Korean Dictionary) for Sino-Korean.

1.3.2 Data Representation

Table 1.10 exemplifies the collected data. For more information, see Appendix.

Table 1.10: Examples of collected data (咸攝開口一等合韻)

例字 (word)	韻部 (yùnbù)	聲母 (onset)	聲調 (tone)	閩南語 (Southern Min)	日本漢字音 (Sino-Japanese)	韓國漢字音 (Sino-Korean)
				文讀	漢音	
答	合	端	入	tap4	トウ (to:)	답 (tap)
搭	合	端	入	tap4	トウ (to:)	탑 (t^hap)
踏	合	定	入	tap8	トウ (to:)	답 (tap)

[9] In *Guǎngyùn* (廣韻), there are four tones (Shēngdiào 聲調, 平上去入. According to Zhu (2001), 平聲 (Píng shēng) refers to level tone. 上聲 (Shǎng shēng) indicates rising tone and 去聲 (Qù shēng) is falling tone. Different form the other three, 入聲 (Rù shēng) stands for a group that the coda is stop. Speaking of the translation of 入聲, it can be "Ru Sheng" in Hanyu Pinyin, "Entering tone" from meaning that 入 means enter in Chinese. In this study, entering tone is adopted here and henceforth.

This table is an extraction of 咸攝開口一等合韻. The long title of this table is inclusive of four concepts. First, 攝 (Shè) is one way of grouping characters. In Middle Chinese, Chinese characters that share the same coda will be grouped together. For example, 咸攝 (Xiánshè) refers to bilabial coda, [p] or [m]. Then the second concept is 開口 (Kāikǒu, open mouth), a situation without prevocalic bilabial glide. If there is prevocalic bilabial glide, it is termed as 合口 (Hékǒu, round mouth). The third and forth concepts are related. In one 攝 (Shè), there are four 等 (Děng, divisions), which connect with vowels or openness of mouth. According to Zhu (2001), 一等 (Division I) is the most open and 二等 (Division II) is less open. 三等 (Division III) is less open than 二等 (Division II) and 四等 (Division IV) is the least open. In addition, 三等 (Division III) is characterized of prevocalic palatal glide [j] and 四等 (Division IV) of high front vowel [i], while 一等 (Division I) and 二等 (Division II) are not. How each division in every 攝 (Shè) is presented is based on 韻 (Yǜn, rhyme) where the main vowel is identical. In 合韻, for instance, every character should have low vowel [a] and bilabial stop coda [p].

Aside from the title, Table 1.10 also contains the onset and tone. As for the modern pronunciations of Southern Min, Sino-Japanese and Sino-Korean, they are transcribed in two ways. Southern Min exhibits sounds[10] only. Since Japanese is mainly represented in Kana and Korean in Hangul, to be more precise, Table 1.10 includes not only the sounds but also Kana and Hangul.

Now that this study probes into the phonological change from Middle Chinese to modern time and previous sections have paid attention to the modern forms, it is necessary to offer a picture of what Middle Chinese is. Although a variety of reconstructions related to Middle Chinese have been proposed previously, this current study will not stick to any single scholar. Instead, the reconstruction of Middle Chinese comes from the collection from Pan and Feng (2000), Zhu (2001) and Zhengchang (2003). In accordance with the collection, there are some tendencies and they are listed in Table 1.11 as the data for Middle Chinese in this study.

[10] The number 4 or 8 represents tone. As seen in Yang (1991) and Chang (2001), number 4 is low falling tone and 8 is high level tone.

Table 1.11: Vowel System of entering tone in Middle Chinese

	Front	Central	Back
High	i		u
Mid	e	ə	o
Mid-Low	ɛ / æ		ɔ
Low	a	ɐ	ɑ / ɒ

By the correspondence of Middle Chinese and Modern Sino-Xenic languages, the data evaluated in *FMD-OT* account will be presented in two ways. First of all, the analyses are divided into three parts and analyzed in two chapters, Chapter 3 dealing with [a]-vowel group and Chapter 4 concentrating on non-[a]-vowel group and *Hékǒu* (合口). Secondly, the three analyses evaluate the main change of vowels as well as the exceptions.

1.4 Essential Contributions

In this study, the inspection of Sino-Xenic languages in Optimality-Theoretical approach has three essential contributions for the studies of phonology. First, application of Optimality Theory to Sino-Xenic languages undoubtedly can be considered as a pioneering work owing to the fact that historical Chinese phonology hardly incorporates with modern phonological theories, let alone Optimality Theory. Previous studies on historical Chinese phonology either depict phonological system and its rules of one language or reconstruct the proto-language of one sub-family.

Second, in methodology, this study is chiefly based on vowel rather than ending. Historical Chinese phonology is formulated depending on 攝 (Shè) to represent phonological changes. In other words, characters with similar ending are grouped as one. Long existed and widely accepted as it is, this method is not economical. In fact, vowel changes according to endings do not vary from each other, provided that the ending is not taken into account. For example, the vowel changes of *Xiánshè* (咸攝), *Shānshè* (山攝) and *Dàngshè* (宕攝), in traditional method, are elaborated separately since their endings differ. However, disregarding the endings, these three categories are somehow identical in vowel changes. It is more succinct if they are investigated from the aspect of main vowel (cf. Lin 2004).

Finally, this study amends previous phonological theories. On one hand, this study offers a new dimension, mid vowel, to investigate vowel change, which is not explored in *FMD-OT*. This improves *FMD-OT* more intact on the ground that [ə] does not appear in Sanders' data, but it plays a crucial role in Middle Chinese. On the other hand, the extension of Candidate Chains (McCarthy 2007) for Historical Phonology brings this theory to next level because the extension not only preserves the merits in dealing with synchronic phenomena, but also solves opacity in historical sound changes.

1.5 Organization of the thesis

The remainder of this thesis is organized as the following. Chapter 2 firstly reviews the theoretical approach, Optimality Theory in historical phonology, focusing on input selection and opacity. The second part of Chapter 2 is dedicated to internal syllable structure of Southern Min, Sino-Japanese and Sino-Korean. How phonological change of entering tone from Middle Chinese to Modern time in the three Sino-Xenic languages is represented in Chapter 3 and 4, discussing not merely main changes but also exceptions. Chapter 3 investigates [a]-vowel group and Chapter 4 explores non-[a]-vowel group and *Hékǒu* (合口). How internal syllable structure influences phonological change is also demonstrated in Chapter 4. Finally, Chapter 5 provides the summary of this thesis and some issues for further studies.

Chapter 2 Literature Review

2.0 Overview

This chapter is mainly comprised of reviews of Optimality Theory in historical linguistics (2.1) and syllable structure of Sino-Xenic languages (2.2). Section 2.1 starts with an introduction to Optimality Theory in historical phonology. Offered in 2.1.1, the discussion then concentrates on *Faithfulness, Markedness, and Dispersion in OT*, an approach for vowel changes. Its inadequacy is also investigated. Then the focus turns to opacity where not only previous works are reviewed, but also a new revision is proposed. Section 2.2 emphasizes on syllable structures. A general review of syllable structure of Sino-Xenic languages is offered in 2.2.1. Then the review turns to language-specific syllable structure, paying attention to mora-bearing and internal branching, Southern Min in 2.2.2, Sino-Japanese in 2.2.3, Sino-Korean in 2.2.4. Finally, an overall summary (section 2.3) concludes this chapter.

2.1 Optimality Theory in Historical Phonology

This part reviews how OT is operated in historical phonology. The discussion on the application of OT to historical phonology is not often observed until Anttila & Cho (1998), Crist (2001), Holt (2003), Sanders (2003), McMahan (2004), Bermudez-Otero (2005, 2007, to appear). Previous works have sheded light on two perspectives. The first subcategory consists in the proposal of new types of constraints, such as Dispersion constraints (Sanders 2003), which is discussed in section 2.1.1. The second subcategory copes with theory itself, especially input selection[11] and opacity. Since input selection is of no concern in this study, it is not discussed here. With regard to opacity, it is discussed in section 2.1.2.

[11] According to the premise in standard OT, the inputs are unlimited due to Richness of the Base. However, selecting a single input, which maps to the optimal output, is restricted to Lexicon Optimization. How an input is selected plays a crucial role in historical phonology on the ground that this mechanism ensures that the output will be stored in lexicon and not be eliminated by Richness of the Base. See reviews of Strong Lexicon Optimization from Sanders (2003) and Input Optimization from Bermudez-Oreto (2005, 2007, to appear).

2.1.1 *Faithfulness, Markedness, and Dispersion in OT*

The theoretical approach in this study is Optimality Theory.[12] The analytical framework specifically modifies *Faithfulness, Markedness, and Dispersion in OT* (FMD-OT) advocated by Sanders (2003) rather than standard OT proposed by Prince and Smolensky (1993; 2004) that operates as the primary phonological theory. FMD-OT is designed primarily for vowel changes. The context of FMD-OT does not deviate from the premise of standard OT, except for the following two aspects. First of all, faithfulness and markedness constraints are succinctly represented as $\mathcal{F}$ and $\mathcal{M}$ in FMD-OT. In standard OT, the faithfulness and markedness constraints are written as in (1) and (2).

(1) Faithfulness Constraints (Kager 1999: 68-70)
   a. Max-IO: The value of input segments must have output correspondents (No deletion).
   b. Dep-IO: The value of input segments must have output correspondents (No epenthesis).
   c. Ident-IO: Correspondent segments in input and output have identical values (No changes).

(2) Markedness Constraints
   a. Onset: Syllable must have onsets
   b. *Coda: Syllable must have no codas
   c. *V nasal: Vowels must not be nasal.

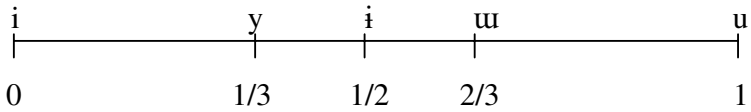
The two groups of constraints are conflict in essence. Faithfulness constraints preserve contrast in lexicon, while markedness constraints maintain structural well-formedness.

However, Sanders (2003) suggests that the problems of (1) and (2) are that it is not necessary to divide faithfulness constraints into MAX-IO, DEP-IO and IDENT-IO and they can be grouped as one, simply termed as $\mathcal{F}$. With regard to markedness constraints, if -a occurs early than -o, it is originally translated as two constraints ranked as *-o > *-a. Nonetheless, in lieu of FMD-OT, -a > -o is paraphrased as $\mathcal{M}$-a » $\mathcal{M}$-o, which is more comprehensible from cognitive process.

[12] Optimality Theory is firstly proposed by Prince and Smolensky (1993; 2004). Different from generative phonology that permits derivations in phonological process, OT, however, forsakes derivations and advocates interaction of constraints. For more information, see Kager (1999), McCarthy (2002, 2008).

Secondly, Sanders (2003) introduces Dispersion Theory (Flemming 1995) to OT, which is translated as dispersion constraints. Dispersion constraints bases on perception of acoustic differences. Put it differently, the longer the perceptual distance for the property is, the more distinguished a pair is. Dispersion constraints result from calculating the distance of each vowel. Take (3), the five high vowels, as an example, [i] and [u] are the extremes and the distance of vowel is regarded as 1. [ɨ] locates in the middle. [y] and [ɯ] are distributed evenly, occupying 1/3 and 2/3.

(3)



(From Sanders 2003: 23)

From (3), the vowels are paired. The distance of [y ɨ] and [ɨ ɯ] is taken as the smallest and that of [i u] as the largest. As (4) shows, the least distinguished pair is titled as $\mathcal{D}_0$. When the distance of paired vowels increases, the number is added.

(4) [y ɨ], [ɨɯ] < [i y], [y ɯ], [ɯ u] < [ɨɨ],[ɨu] < [i ɯ],[y u] < [i u]

$\mathcal{D}_0$ $\mathcal{D}_1$ $\mathcal{D}_2$ $\mathcal{D}_3$ $\mathcal{D}_4$

The ranking of Dispersion constraints is that the least distinguished pairs are ranked the highest and the most distinguished ones are lowest. Namely, $\mathcal{D}_0$ is undominated. $\mathcal{D}_1$ outranks $\mathcal{D}_2$, which dominates $\mathcal{D}_3$. $\mathcal{D}_4$ is ranked lowest.

Sanders points out that vowels in Dispersion constraints are analyzed as two dimentions, color and height. Color refers to sequence of vowels arranged horizontally, such as the vowels from (4), [i, y, ɨ, ɯ, u], all of which are high vowel. On the contrary, height means the squence of vowels arranged vertically, as the vowels [i, e, ɛ, æ, a], which are taken as front vowels. Now that Sanders' analyses only parse features of vowel as high and low, or as front and back, it is insufficient for this study because vowel [ə] is irreplacable in Middle Chinese and it is not seen Sanders' study. Also, the distance of [ə] and other vowels involves in not only color but also height. As a result, in this study,

extra dispersion constraints that conjoint color and height are proposed. The dispersion constraints pertinent to [ə] will be labeled by letters rather than numbers. For example, the squence of vowels [a, ə, ɨ] is paraphrased as the dispersion constraints with their titles in (5). To distinguish our new constraints from those previously shown in Sanders' study, here the least favorable constraint is suggested as $\mathcal{D}_A$. As the vowel space increases, the constraints are proposed alphabetically. Besides, the least favorable constraint is undominated and the most favorable constraint is ranked lowest.

(5) [əɨ] < [aə] < [əi], [əu] < [aɨ]
$\mathcal{D}_A$ height » $\mathcal{D}_B$ height » $\mathcal{D}_C$ height » $\mathcal{D}_D$ height
$\mathcal{D}_B$ color » $\mathcal{D}_C$ color » $\mathcal{D}_D$ color

Since the position of vowel [a] here is front rather than middle low, the sequence of [aə] and [aɨ] are proposed as $\mathcal{D}_B$ color and $\mathcal{D}_D$ color.

2.1.2 Opacity in Historical Phonology

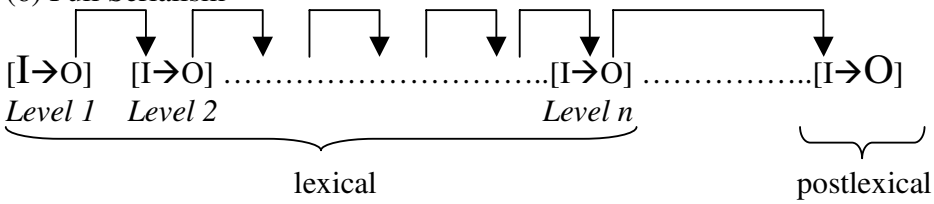
Opacity[13] is a phonological phenomenon where the output forms are shaped by generalizations that are not surface-true (Kager 1999: 372). To paraphrase it, in the rule P that B derives from A in the environment C_D (A→B / C_D), it is opaque when the output remains A, the output B derives from other environment, such as C_E, or the output B that appears in the environment C_D does not derive from rule P. Now that language changes are not discrete but continuous, the direct mapping of input and output hardly contributes to phonological change without encountering opacity because the output of previous stage descends to be the input of next stage and forms sequential correlation connection. In this section the review goes to serialism (Kiparsky 2000; Ito & Mester 2001) and parallelism (Sanders 2003; McCarthy 2007). Besides, opacity in historical linguistics attaches to each theory.

[13] For more details of opacity, see Iggy (1997), Kager (1999), Kiparsky (2000) and McCarthy (2007).

2.1.2.1 Serialism

Serialism refers to the idea that is identical with derivation in generative phonology where derivations are permitted to appear. Kiparsky firstly develops Lexical Phonology (1982) and then extends it to *Lexical Phonology and Morphology OT* (LPM-OT: 2000). Two levels, lexical and postlexical, constitute this theory. As shown in (6) from Ito & Mester (2001: 265), the premise of LPM-OT consists in two perspectives, I/O faithfulness for cyclicity and intermediate levels for opacity.

(6) Full Serialism



LPM-OT, or termed as Stratal OT, has received much attention and been criticized. Kager (1999) points out that there is no independent motivation for strata, rerankings do not explicitly express multi-stratal evaluation and strata are not learnable. In addition, McCarthy (2007) contends that LPM-OT is too powerful because it overpredicts some phenomena that are scarcely seen.

In historical phonology based on serialism, Bermudez-Oreto (2005, 2007, to appear) introduces Stratal OT [14] to historical phonology, which emphasizes on the input optimization [15] and synchronic paradigm effects, depicted in (7). With synchronic paradigm effects, Stratal OT accounts for the life cycle of phonological pattern. The three stages represent the change from 18th century to contemporary Received Pronunciation.

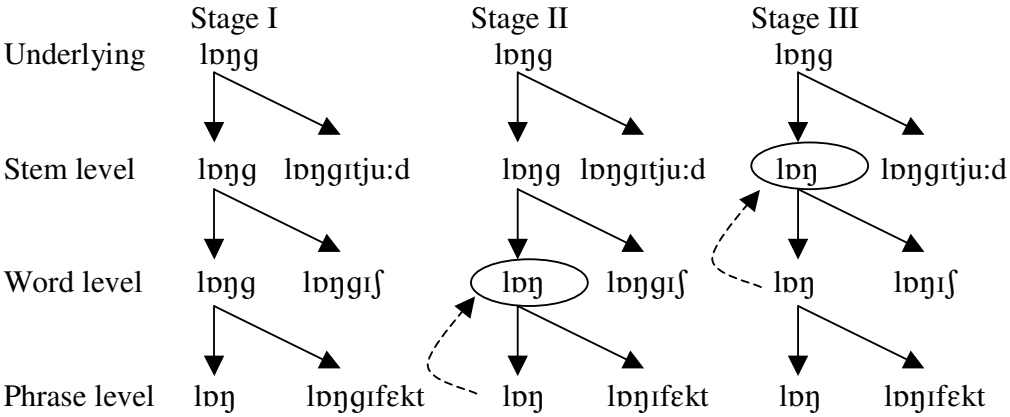
[14] The Stratal OT for historical Phonology varies from that for synchronic phonology, which aims to solve opacity (Kiparsky 2000).

[15] Bermudez-Oreto (2005) contends that input optimization is that

(a) Input representations must be Pareto-optimal;

(b) An input representation is Pareto-optimal if, and only if, it has no competitor that (i) generates **all** output alternants no less efficiently and (ii) generates **some** output alternant more efficiently.

(7) Paradigms of Stratal OT



(From Bermudez-Oreto 2005)

How sounds change lies in how the input is restructured and it relates to lexicalization. From Stage I to Stage II, the domain diminishes from phrase level to word level. This procedure repeats when Stage II moves on to Stage III, a smaller domain that shrinks from word level to stem level.

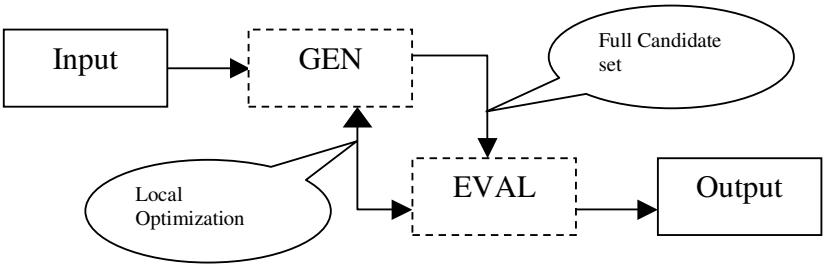
Despite the fact that Stratal OT can explain sound changes under the domain of different levels, this study does not include this model because Chinese phonology is highly related to Chinese characters, a representation with single level, and it is not necessary to evaluate changes in phrase, word and stem levels.

2.1.2.2 Parallelism

Parallelism takes opposite stance on opacity against serialism, proposing that opacity should be dealt with without derivations. One of the methods dealing with opacity from parallelism consists in Benua (1995, 1997) for OO-Correspondence, McCarthy (1998, 1999) for Sympathy Theory, Kawahara (2002) for Output-Variant OT.

The previous studies had one central concept in common, namely, there is no intermediate levels. To solve opacity in lieu of OT, McCarthy (2007) suggested Candidate Chains in OT (henceforth OT-CC), represented in (8).

(8) Basic Architecture of OT-CC (McCarthy 2007: 63)



OT-CC is characterized of three well-formedness conditions (2007: 61):

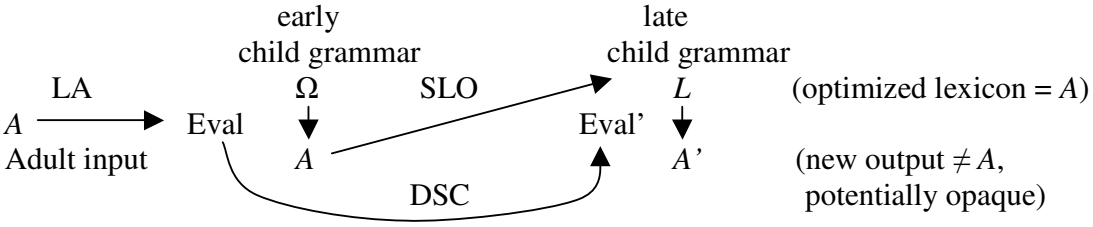
(a) Faithful first member. The first candidate should be fully faithful to the input.

(b) Gradualness. This condition has two relevant requirements. For one thing, the localized unfaithful mappings appearing in the previous representations in a candidate chains have to be stored up. For the other thing, an extra localized unfaithful mapping from the following will be added when a new representation comes into being.

(c) Local Optimality. This condition ensures that each candidate is improved harmonically, being better than its predecessors. Besides, Local Optimality selects the best violation in order to prevent more than one possibility, which might violate the similar faithfulness constraint.

As for the historical phonology that only allows monostratum, Sanders (2003) proposes a model, displayed in (9) named as "Opacity as strong lexicon optimization followed by diachronic sound change."

(9) Opacity as strong lexicon optimization followed by diachronic sound change[16]



(Sanders 2003: 36)

[16] LA here refers to Language Acquisition.

This model has two characteristics. For one thing, opacity in sound change is repaired by Strong Lexicon Optimization (SLO), an intermediate representation. For the other thing, the phonological change referring to Diachronic Sound Change (DSC) is initiated by reranking, Eval to Eval'.

In this study, we propose that the concept of constraint reranking plays a significant role, for the reason that once a sound undergoes change, there will be a new constraint and this new constraint works together with old constraints.

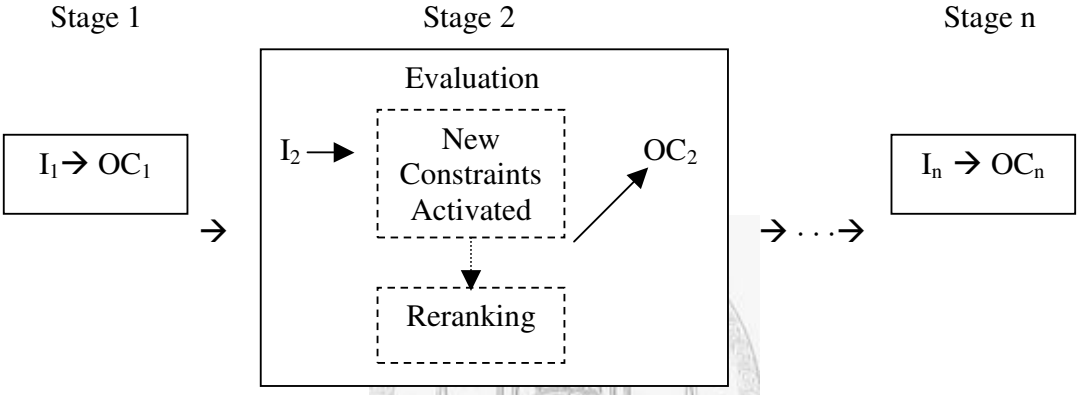
2.1.2.3 Extension of Candidate Chains to Historical Linguistics

The mapping of output in modern time and the first input in history is not possible without facing opacity if sound change takes place, because that there are intermediate levels between the first input and the ultimate output. As aforementioned, Sanders (2003) assumes that sound change in historical phonology is a result of constraints reranking in OT and Bermudez-Oreto (2005, 2007, to appear) suggests that sound changes are restricted to lexicon. Although McMohan (2000) points out that reranking is one method that explains sound changes, this method raises one problem. A single hierarchy that simply reranks constraints for adjacent stages disregards gradual change where each input in different stage might be evaluated by new constraints set for a specific stage. Therefore, in this study, a new method is proposed to explore derivation and constraint evaluation. The premises lie in the following aspects. First of all, derivation is indispensable. The term, derivation, here does not refer to cyclicity but sound change, focusing on the fact of language change, say, continuity. Following Bermudez-Oreto (2005, 2007, to appear), since language change is characteristic of continuity, sound change should be comprised of a variety of successive stages, similar to strata in Bermudez-Oreto's terminology or chains in McCarthy's terminology.

Also, in the course of sound change, there is no ultimate output. Outputs in the intermediate stages can be somehow regarded as the candidates in McCarthy's model, in that they are subject to further evaluation. In order to prevent ambiguity and confusion where in standard OT candidate refers to the items generated from input before evaluation, in this study the candidates are termed as output-candidate, specifically indicating the output that appears in the intermediate stages. When a candidate goes on to

next stage, it will be evaluated either by activating new constraints or by reranking. If sound changes do occur, the output-candidate from the previous stage must activate new constraints[17], which are not seen previously and then ranked the new constraints with the constraints from previous stages. These two mechanisms cooperate in the process of evaluation until the final stage. The whole picture is depicted in (10), in which stage 2 offers more details.

(10) Extension of Candidate Chains to Historical Linguistics



(10) has three advantages. First of all, it takes continuity into consideration. Sound changes are comprised of successive stages. Without admitting the existence of intermediate stages, standard OT is never an applicable theory to historical phonology. In this study, four cases, such as *Gěngshè* (梗攝) in Southern Min, Division III of *Shēngshè* (深攝) and *Xiánshè* (咸攝) in Sino-Japanese and *Gěngshè* (梗攝) in Sino-Korean, have led to the involvement in opacity (Further discussion is demonstrated in Chapter 3 and 4, respectively). Secondly, this proposal maintain OT's premise, direct mapping of input and output within one stage. As (10) suggests, the evaluation within each stage bases on parallelism, Candidate Chains in particular, rather than serialism, resulting from the essential difference between synchronic opacity and diachronic opacity. That is to say one change induces one reranking. The third advantage lies in evaluation process. Whenever sounds change, modification occurs. The longer time it is, the more possible it will be opaque. In this light, when sound changes in historical phonology take place, a

[17] Although the premise in McCarthy's *Gradualness* is that "…each step in the chain must introduce a new unfaithful mapping." (McCarthy 2007: 72), in this study it is assumed that the constraints are activated.

new constraint must be activated and then a new set of constraints, which also accumulates previous constraints, is utilized to evaluate new input.

2.1.3 Summary

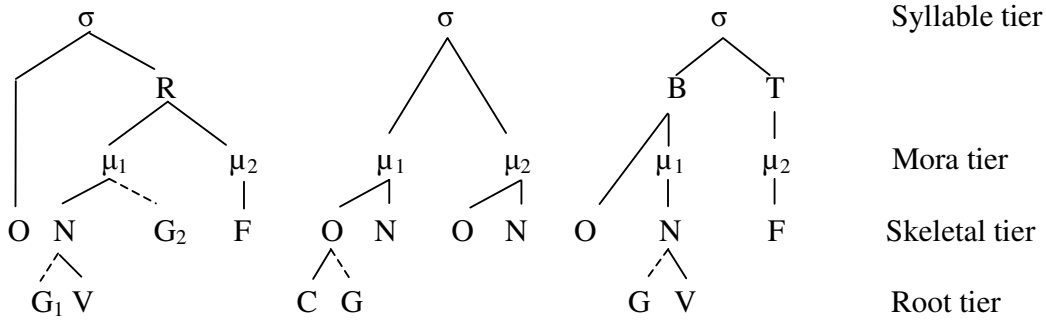
To sum up, this section has reviewed the basic premises of FMD-OT and a new set of dispersion constraints are proposed in this study. The problem of applying OT to historical phonology is raised, i.e. opacity. Then previous works dealing with opacity, serialism and parallelism, are reviewed. Finally, a new method is proposed to explore the opacity in historical phonology.

2.2 Syllable Structure of Sino-Xenic Languages

The purpose of this section is to review the syllable structures in Sino-Xenic languages, concentrating syllable structure of Sino-Xenic languages and then shedding light on the syllable structure of Southern Min, Sino-Japanese and Sino-Korean, respectively. The specific attention is paid to the number of mora and internal branching. The syllable structures on Southern Min, Sino-Japanese and Sino-Korean that appears in this study are summarized in (11). It is concluded that the three Sino-Xenic languages contains two moras and Southern Min is right branching, and Sino-Japanese and Sino-Korean are left branching.

(11) Syllable structure of Sino-Xenic languages

a. Southern Min b. Sino-Japanese c. Sino-Korean

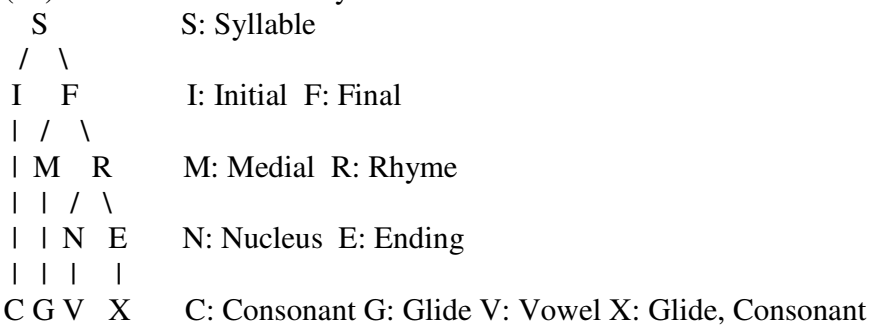


2.2.1 Syllable Structure of Sino-Xenic Languages

The traditioanl view of Chinese characters appears as canonical (C)(G)V(X), translated into two versions. The first version, wildly acknowledged in Chinese

phonology, is seen in Chung (1996), Duanmu (2000) and Lin (1989). A syllable structure is a combination of Initial (*Shēngmǔ* 聲母) and Final (*Yùnmǔ* 韻母), as illustrated in (12).

(12) Traditional Chinese Syllable

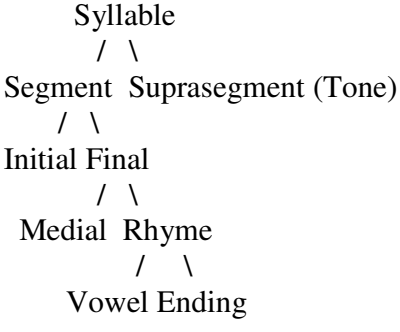


In (12), initial stands for onset and medial for prevocalic glide. In addition, postvocalic glide or consonant, such as nasal and stop, is allowed to be in coda position.

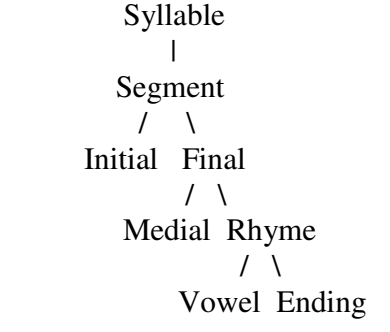
Since the previous syllable structure is limited to Chinese dialects, Lee (1994: 55) proposes a more detailed version, displayed in (13), which distinguishes syllable structure for Chinese dialects from that for Sino-Xenic languages. Lee's claim for Chinese dialects does not diverge far away from previous works, except for tone, which is dominated by node, syllable. However, it is worthwhile to notice the syllabic constituents of Sino-Japanese and Sino-Korean where tone is not presented.

(13) Syllable Structure of Sino-Xenic languages

Syllabic Constituents of Chinese



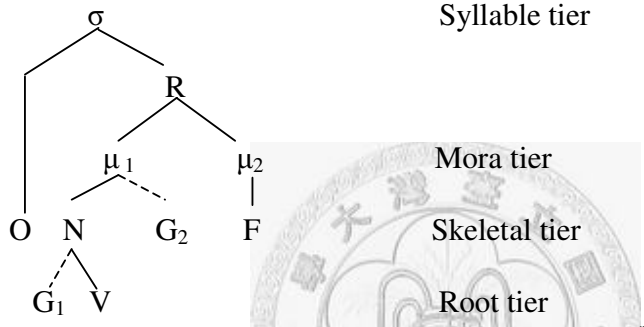
Syllabic Constituents of Sino-Japanese and Sino-Korean



2.2.2 Syllable Structure of Southern Min

Now that this study compares Southern Min with Sino-Japanese and Sino-Korea, both of which are regarded as moraic languages, the syllable structure of Southern Min that is also presented in mora is taken into account. Cheng (2002) proposes Segmental-Moraic syllable structure that Southern Min syllable structure combines segmental and moraic theory where a syllable contains two moras. In (14) we revise Cheng's Segmental-Moraic syllable structure. To avoid ambiguity, the skeletons in skeletal tier is specified.

(14) Southern Min in Segmental-Moraic syllable structure



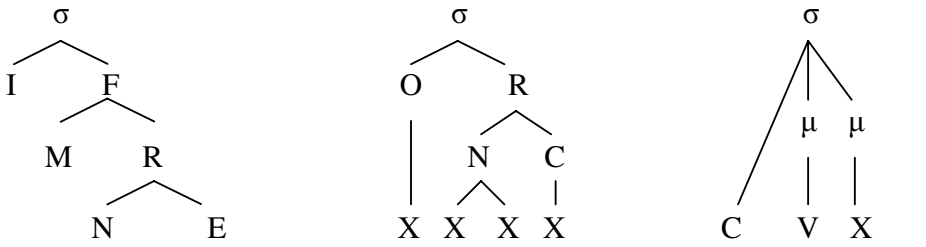
(Revise from Cheng 2002)

In (14) the marks are specified as Onset (O), Nuclear (N), Prevocalic Glide (G_1) in root tier, Post-vocalic Glide (G_2) and Final (F), which includes stop and nasal endings.

The differences of Cheng's proposal and previous works consist in three aspects, mora, coda and prevocalic glide. The most significant aspect of Cheng's proposal is that Cheng introduces mora to Southern Min. The mora in Southern Min functions as phonological domains, [(Oμ 1)(μ 2)], in which onset (O) and the first mora form one domain and the second mora stands alone as the other domain. Many phenomena are restricted to the phonological domains, such as the formation of secret language, the demarcation of nasalization and labial dissimilation.

Besides, as mentioned previously, the traditional view of syllable structure in Chinese is depicted as (12) or as CGVC. In modern phonological theory, syllables structure of Chinese dialects can either be presented in segmental theory (Chung 1996) or in Moraic theory (Duanmu 1990, 1993, 1994, 2000). These three aspects are summarized as follows.

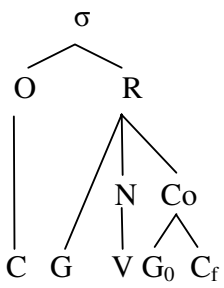
(15) Traditional View　　Segmental Theory　　Moraic Theory



(From Cheng 2002: 32)

Of the three representations of Southern Min syllable structure, they reveal two inadequacies, coda features and prevocalic glide. For one thing, the features that can appear in coda position are not detailed. Contrast to Bao (2000), shown in (16) which distinguishes postvocalic glide (G_0) and consonant (C_f) in coda, Cheng (2002) specifies glide and consonant in coda poison.

(16)



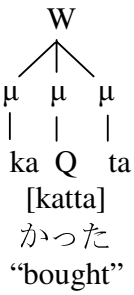
For the other thing, the demarcation of prevocalic glide in (15) is unclear. In traditional view, the prevocalic glide is taken as part of final, while in moraic theory the prevocalic glide is not specified. According to two secret languages, the relationship of *Literal Reading* (文讀 *Wéndú*) and *Colloquial Reading* (白讀 *Báidú*) and literary skills, *Shuang-sheng* (雙聲) and *Die-yun* (疊韻), Cheng proposes that the prevocalic glide of Southern Min should be grouped together with rhyme[18].

[18] The prevocalic glide in Chinese dialects remains controversial. That is to say when dialects vary, the consideration of prevocalic glide in syllable differs. Sun (2006) and Yang (2006) summarize three viewpoints of the prevocalic glide. First, the prevocalic glide is part of onset, shown in (1-a). Second, the prevocalic glide belongs to rhyme, seen in (1-b). Third, the prevocalic glide is independent, presented in (1-c).

2.2.3 Syllable Structure of Sino-Japanese

Japanese is commonly recognized as representative mora-timed language and Tsujimura (1996: 65) suggests three realizations of mora. (a) The basic syllable structure is (C)V where the onset is optional. In other words, え e (picture) and か ka (mosquito) bear the same number of mora. (b) The first part of a long consonant (or the first part of a geminate) contains mora. For example, kaQta[19] かった (bought) is comprised of three moras, exhibited in (17).

(17)



[katta]
かった
"bought"

(c) The syllable final, or moraic nasal bears one mora, shown in (18). That is to say within a syllable boundary only moraic nasal appears in coda position (Blevins 1995).

(18)

[saN]
さ ん (三)
"three"

Furthermore, Japanese permits structure as CGV, grouped together with onset (Kondo 2000) or the prevocalic glide is considered as palatalized onset (Coleman 1998:

---

(1) a.

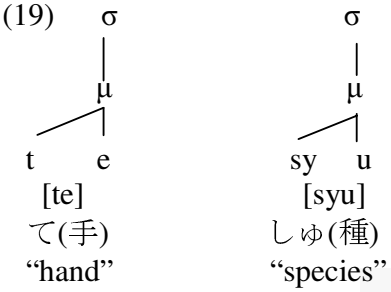
Mandarin Chinese Duanmu (2000) | Southern Min Chiang (1992) | * Yip (2003)

In addition, the prevocalic glides, [j] and [w] function differently (For more details see Hsu 2004).

[19] Following Shibatani (1990), the Q refers to Japanese geminate.

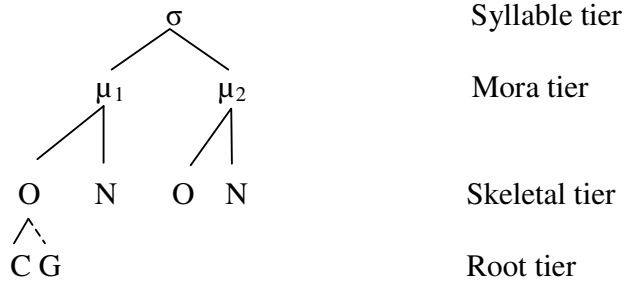
236). The illustrations in (19) vary slightly from Hayes's proposal of moraic theory (1989). In Japanese, the onset is not dominated directly by syllable note. On the contrary, it is dominated by the mora node (Kubozono 1999) because each mora in Japanese is theoretically proposed to be equal in duration (Fujita 2003, Kubozono 1999, 2005; Kubozono & Homma 2005; Shibatani 1990) and proven by phonetic studies (Amanema, Otsubo, Mizutani, 1981; Kawakami 1993; Sugito, 1989, 1997; Warner & Arai 2001).

(19)



Being part of Japanese, Sino-Japanese is no exception that it needs to observe the syllabic constraints of Japanese. The syllable structure of Sino-Japanese is (C)VC(V) (Ito& Mester 1996, Kurisu 2000, Kawahara *et al.* 2003) and consists of two moras (Coleman 1998). Since Japanese permits structure as CGV, Sino-Japanese allows glide to appear between first onset and vowel and the glide is clustered with onset. Based on the arguments above, we propose the hierarchy of Sino-Japanese syllable structure in (20).

(20) Syllable of Sino-Japanese



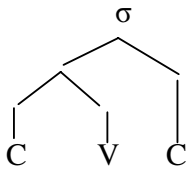
2.2.4 Syllable Structure of Sino-Korean

It is commonly accepted that the canonical sequence of Korean is CGVC (Hong 1997: 12; Kang 2005: 329) or CGV:C (Sohn 1999: 160). However, issues concerned with the internal syllable structure of Korean are not wildly discussed, branching and syllable

weight and prevocalic glide in particular. The following will explicitly review the syllable structure of Sino-Korean.

The branching of Korean syllable structure is proposed as left-branching[20] (Cho 2000: 58, Yoon & Derwing 2001, Cheon 2002, Kang 2005: 332; Saito 2006: 101), shown in (21). Left branching indicates that it is body and tail that constitute Korean syllable structure.

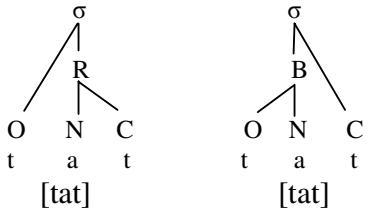
(21) Left branching of Korean Syllable Structure



In addition, the left-branching syllable structure is also proved from sound changes. Kim (1998) suggests that syllable structure of Middle Korean is CV, similar to Japanese. As time goes by, closed syllable structure, CVC, takes place. For example, in Middle Korean, chicken is *tori-ki. The loss of vowel [ɨ] gives rise to *tor-k, which further undergoes vowel change. Then the modern pronunciation is [tak]. As a result, there is one implication from this historical change. That is to say, the nuclear has closer relationship with onset than with coda.

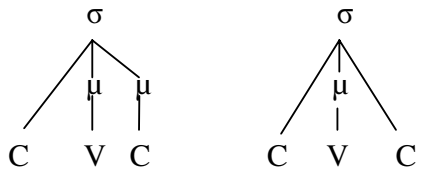
The next part discusses the weight of Korean syllable. In one aspect, CVV and CVC are heavy syllables and CV is light syllable (Kim 1998, Lim 2000). Other arguments (Broselow and Park 1995; Curtis 2002; Kang 2005; Lee 2005), regard CVV as heavy

[20] The internal structure has two branching, right and left (Venneman 1988; Blevins 1995; van der Hulst & Ritter 1999; Yoon & Derwing 2001; Haraguchi 2003). Venneman (1988) divides the canonical sequencing, Onset-nucleus-coda, into two parts. This is offered in below, illustrated by [tat]. The sequence, Onset-Nucleus-Coda, is grouped as Onset and Nucleus-Coda, where nucleus and coda constitute a higher node, rhyme. On the other hand, the sequence, Onset-Nucleus-Coda, also appears as Onset-Nucleus and Coda, in which onset and nucleus form a higher node, body, and coda is termed as tail (Venneman 1988).
(1) Branching of a Syllable



syllable, while CVC and CV are light syllables, the distinction of moraic coda and nonmoraic coda being demonstrated in (22).

(22) The distinction of moraic coda and nonmoraic coda



Although the number of mora of Korean has not come to a conclusion, Kim (1998) and Lim (2000) has specifically propose the number of mora in Sino-Korean. By investigating the position of stress, CVC and CVV are heavy syllable because they carry stress. This phenomenon is seen in the two examples in (23).

(23) a.	b.	
pi. hǽŋ. ki	kjó:. do. so	
飛 行 機	矯 導 所	Sino-Korean
비 행 기	교 도 소	Hangul
L H L	H L L	Pitch
“an airplane”	“prison”	Meaning

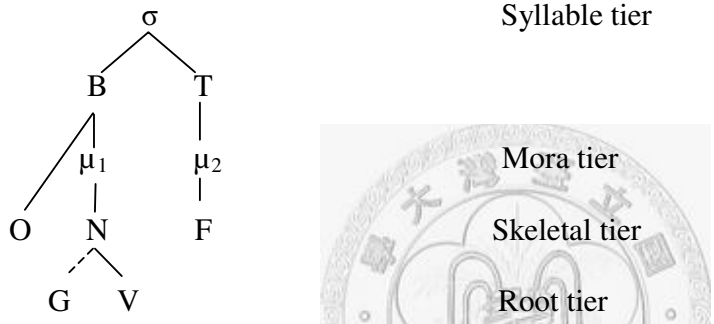
In (23a), the heavy syllable, hæŋ (CVC), attracts stress. In (22b), the stress falls on the heavy syllable, kjó: (CVV). Based on (22), the number of mora in Sino-Korean is assumed as two in this study.

Moreover, how the prevocalic glide is arranged is under question. Cheon (2002) and Kang (2005) assume that the prevocalic glide of Korean is part of onset. However, the claim that prevocalic glide is part of nucleus is supported by Lee (1998) and Cho (2000). In our study, the prevocalic glide is clustered with nucleus in CGVC sequence. First of all, Cheon (2002) contends that the prevocalic glide of Korean is part of onset according to phonetic evidence, glide formation and insertion, language games, phonotactic constraints, reduplication and vowel harmony. However, the glide [w] or [j] in Cheon’s data almost appears word initially, suggesting that the glide functions as onset. Since Cheon’s data hardly support her proposal that prevocalic glide is tied with onset,

prevocalic glide is not considered as part of onset. Secondly, Lee (1998) displays evidences in which the glide is not word-initial, namely, the glide is preceded by an onset. The prevocalic glide is taken as part of nucleus because in Korean the prevocalic glide forms light diphthong with a following vowel.

In accordance with the previous literature, we propose the syllable structure of Sino-Korean is (24). The branching is left, Body (B) and Tail (T). There are two moras and the prevocalic glide is clustered with main vowels. The F in skeletal tier represents final endings, inclusive of stop and nasal endings and postvocalic glide.

(24) Syllable strucutre of Sino-Korean



2.2.4 Summary

This section has firstly reviewed the syllable structure of Sino-Xenic languages and then probes into the internal syllable structures of Southern Min, Sino-Japanese and Sino-Korean. Specifically, the number of mora and the internal branching are reviewed. The final version of syllable structure in Sino-Xenic languages is inclusive of two moras.

2.3 Summary of Chapter 2

So far, I have reviewed Optimality Theory in historical phonology, coupled with FMD-OT and opacity. The review of opacity (2.1.2) emphasizes another argument, whether OT should be represented in serialism or parallelism. To solve opacity in historical phonology, a new method is proposed in 2.1.2.3. In the following two chapters, FMD-OT deals with the vowel changes. Regarding opacity in historical phonology, it is explored by the revision of Candidate chains in 2.1.2.3.

Aside from phonological theories, the internal structure of syllable structure has also been the other target of this chapter. The syllable structure of Southern Min is a revision of Cheng (2002). According to previous works, we propose our version of syllable structures for Sino-Japanese and Sino-Korean. In Chapter 4, how internal syllable structure influences sound changes is investigated based on (11).

Chapter 3 Entering Tone in Sino-Xenic Languages (I)

3.0 Introduction

This current chapter investigates the [a]-vowel group of entering tone in Southern Min, Sino-Japanese and Sino-Korean, focusing on vowel merger and individual changes.

This chapter is organized as follows. Section 3.1 presents the relevant data of Southern Min, Sino-Japanese and Sino-Korean, respectively, and offers reconstruction of Middle Chinese. Vowel merger is then explored in *FMD-OT* account in section 3.2. Finally section 3.3 discusses the individual changes in the three languages.

3.1 Data

The data that will be conducted in the following sections are represented below. The first part is the modern pronunciation of Southern Min, Sino-Japanese and Sino-Korean. The second part concentrates on the reconstruction of Middle Chinese.

3.1.1 Overview

The Divisions in entering tone among the three languages where the main vowel is [a] are demonstrated in Table 3.1, 3.2, 3.3 and 3.4, the onset being omitted. Table 3.1 and 3.2 respectively present Division I and Division II. Table 3.3 and 3.4 separately exhibit Division III and Division IV.

Table 3.1 shows the three subdivisions of Division I, including *Xiánshè* (咸攝), *Shānshè* (山攝) and *Dàngshè* (宕攝). The main vowel of Division I is low vowel [a], exclusive of *Dàngshè* (宕攝) in Southern Min and *Xiánshè* (咸攝) in Sino-Japanese.

Table 3.1: Division I in Entering Tone among SM, SJ and SK

Shè (攝)	*Yùnbù* (韻部)	Southern Min	Sino-Japanese	Sino-Korean
Xiánshè (咸攝)	*hé* (合) / *hé* (盍)	-ap	-o:	-ap
Shānshè (山攝)	*hé* (曷)	-at	-atsɯ	-al
Dàngshè (宕攝)	*duó* (鐸)	-ok	-akɯ	-ak

Table 3.2 consists of four subcategories. Apart from *Xiánshè* (咸攝) and *Shānshè* (山攝), which are identical with those in Division I, Division II is comprised of two new parts, *Jiāngshè* (江攝) and *Gěngshè* (梗攝). Regarding the main vowel, [a], three exceptions are found in Division II, *Gěngshè* (梗攝) in Southern Min, *Xiánshè* (咸攝) in Sino-Japanese and *Gěngshè* (梗攝) in Sino-Korean.

Table 3.2: Division II in Entering Tone among SM, SJ and SK

Shè (攝)	*Yùnbù* (韻部)	Southern Min	Sino-Japanese	Sino-Korean
Xiánshè (咸攝)	*qià* (洽) / *xiá* (狎)	-ap	-o:	-ap
Shānshè (山攝)	*xiá* (黠) / *xiá* (鎋)	-at	-atsɯ	-al
Jiāngshè (江攝)	*jüé* (覺)	-ak	-akɯ	-ak
Gěngshè (梗攝)	*mò* (陌) / *mài*(麥)	-ik	-akɯ	-ɛk

Pronunciations in Table 3.3 have similarity to the previous two tables in terms of main vowel. However, Division III is characteristic of prevocalic glide, which is transcribed as [i] in Southern Min, and [j] in Sino-Japanese and Sino-Korean. The main vowels of each language are various. Southern Min includes three vowels, [a], [o] and [i] and Sino-Japanese contains [a], [o] and [e]. Sino-Korean has [ə] and [a].

Table 3.3: Division III in Entering Tone among SM, SJ and SK

Shè (攝)	*Yùnbù* (韻部)	Southern Min	Sino-Japanese	Sino-Korean
Xiánshè (咸攝)	*yè* (葉) / *yè* (業)	-iap	-jo:	-əp
Shānshè (山攝)	*xüē* (薛)/ *yuè* (月)	-iat	-etsɯ	-əl
Dàngshè (宕攝)	*yào (藥)*	-iok	-jakɯ	-ak
Gěngshè (梗攝)	*xí* (昔) / *mò* (陌)	-ik	-eki	-ək

Table 3.4 demonstrates Division IV. In this category, main vowel of the three subcategories, *Xiánshè* (咸攝), *Shānshè* (山攝) and *Gěngshè* (梗攝), are identical. Although Division IV carries vowel [i], it functions as glide in Division III. In other words, vowel [i] is known as [i] in Southern Min and [j] in Sino-Japanese and Sino-Korean. As fore the main vowels, Southern Min is [a] and [i], Sino-Japanese is [o] and [e], and Sino-Korean is [ə].

Table 3.4: Division IV in Entering Tone among SM, SJ and SK

Shè (攝)	*Yùnbù* (韻部)	Southern Min	Sino-Japanese	Sino-Korean
Xiánshè (咸攝)	*tiě* (帖)	-iap	-jo:	-əp
Shānshè (山攝)	*xiè* (屑)	-iat	-etsɯ	-əl
Gěngshè (梗攝)	*xí* (錫)	-ik	-eki	-ək

It can be concluded from Table 3.1-3.4. Division I and II of *Xiánshè* (咸攝) merge as one in the three languages, so does *Shānshè* (山攝). Merger of two divisions also occurs in Division III and IV of *Xiánshè* (咸攝) and *Shānshè* (山攝). As for *Dàngshè* (宕攝), Division I and III do not merge as one[21] due to the glide in Division III. *Gěngshè* (梗攝), however, develops differently in the three languages. In Southern Min, Division II, III and IV converge as one, whereas in Sino-Japanese and Sino-Korean, only Division III and IV merge as one and Division II stands alone separately.

3.1.2 Southern Min

Division I of entering tone in Southern Min has two vowels, [a] and [o], exemplified by Table 3.5. The former appears in *Xiánshè* (咸攝) and *Shānshè* (山攝); the latter shows up in *Dàngshè* (宕攝). The percentage of Division I is also provided in Table 3.5[22]. All of *Xiánshè* (咸攝) is -ap. *Shānshè* (山攝) has no exception. The examples of *Dàngshè* (宕攝) are homogeneous, showing 100%.

[21] From Table 3.1 and 3.3, it seems that Division I and III of Sino-Korean merge as one. In fact, it is a consequence of glide deletion in Division III when the onset is [s], [ts] or [t^hs]. Woo (2005) offers an example, 長 tjang > tsjang > tsang. Here some words do not under this process. Therefore I do not jump into conclusion that the Division I and III *Dàngshè* (宕攝) merge as one.

[22] The tables that show examples and percentage for different division in each language (also for those in Chapter 3 and 4) include Chinese characters and its pronunciation in the parathenses. Then the tokens are shown, along with percentage. *Xiánshè* (咸攝) has 21 tokens in Table 3.5.

Table 3.5: Examples and the percentage of Division I in Southern Min

Xiánshè (咸攝)		*Shānshè* (山攝)	*Dàngshè* (宕攝)
hé (合)	*hé* (盍)	*hé* (曷)	*duó* (鐸)
踏 (tap8) 拉 (lap8) 盒 (hap8)	塔 (t^hap4) 臘 (lap8) 磕 (k^hap4)	獺 (t^hat4) 辣 (lat8) 葛 (kat4)	泊 (pok8) 踱 (tok8) 各 (kok4)
-ap (21) 100%		-at (12) 100%	-ok (34) 100%
Total: 21 (100%)		Total: 12 (100%)	Total: 34 (100%)

As illustrated in Table 3.6 and 3.7, Division II of entering tone in Southern Min has two vowels, [a] and [i]. Vowel [a] lies in *Xiánshè* (咸攝), *Shānshè* (山攝) and *Jiāngshè* (江攝). Vowel [i] is merely seen in *Gěngshè* (梗攝). Table 3.6 and 3.7 detail Division II in percentage. *Xiánshè* (咸攝) and *Gěngshè* (梗攝) have systematic change without variants, both of which are 100%. *Shānshè* (山攝) are comprised of -at (81.82%) and -uat (18.18). *Jiāngshè* (江攝), on the contrary, shows variations. 80.77% of *Jiāngshè* (江攝) is pronouced as [a] and 19.23% as [o]. In *Jiāngshè* (江攝), there is one minor variant, -iok (3.85%) with a glide [j].

Table 3.6: Examples and the percentage of Division II in Southern Min (I)

Xiánshè (咸攝)		*Shānshè* (山攝)	
qià (洽)	*xiá* (狎)	*xiá* (黠)	*xiá* (鍘)
眨 (tsap4) 袷 (kap4)	甲 (kap4) 鴨 (ap4) 壓 (ap4)	抹 (buat4) 札 (tsat4) 軋 (at4)	鍘 (tsat8) 瞎 (hat4) 轄 (hat8)
-ap (17) 100%		-at (9) 81.82% -uat (2) 18.18%	
Total: 17 (100%)		Total: 11 (100%)	

Table 3.7: Examples and the percentage of Division II in Southern Min (II)

Jiāngshè(江攝)	*Gěngshè* (梗攝)	
jüé (覺)	*mò* (陌)	*mài*(麥)
剝 (pak4) 桌 (tak4) 角 (kak4)	柏 (pik4) 澤 (tik8) 格 (kik4)	麥 (bik8) 摘 (tik4) 隔 (kik4)
-ak (21) 80.77% -ok (4) 15.38% -iok (1) 3.85%	-ik (33) 100%	
Total: 26 (100%)	Total: 33 (100%)	

As Table 3.8 and 3.9 illustrate, there are three vowels with glide [i] in Division III of entering tone in Southern Min. First of all, vowel [a] lies in *Xiánshè* (咸攝) and *Shānshè* (山攝), and [o] consists in *Dàngshè* (宕攝). Since glide [i] and main vowel [i] conflict with each other, merely vowel [i] is seen in *Gěngshè* (梗攝). Regarding the percentage of Division III, *Xiánshè* (咸攝), *Shānshè* (山攝), *Dàngshè* (宕攝) and *Gěngshè* (梗攝) change regularly because all of them are 100%.

Table 3.8: Examples and the percentage of Division III in Southern Min (I)

Xiánshè (咸攝)		*Shānshè* (山攝)	
yè (葉)	*yè* (業)	*xüē* (薛)	*yuè* (月)
獵 (liap4) 接 (tsiap4) 靨 (iap4)	劫 (kiap4) 業 (giap8) 脅 (hiap4)	別 (piat4) 列 (liat8) 徹 (t^hiat4)	揭 (kiat4) 歇 (hiat4) 蠍 (hiat4)
-iap (17) 100%		-iat (23) 100%	
Total: 17 (100%)		Total: 23 (100%)	

Table 3.9: Examples and the percentage of Division III in Southern Min (II)

Dàngshè (宕攝)	*Gěngshè* (梗攝)	
yào (藥)	*xí* (昔)	*mò* (陌)
掠 (liok8) 勺 (siok8) 約 (iok4)	璧 (pik4) 籍 (tsik8) 亦 (ik8)	碧 (p^hik4) 戟 (kik4) 逆 (gik8)
-iok (24) 100%	-ik (33) 100%	
Total: 24 (100%)	Total: 33 (100%)	

The three subcategories of Division IV demonstrated in Table 3.10 suggest that the main vowel of *Xiánshè* (咸攝) and *Shānshè* (山攝) is [a] and *Gěngshè* (梗攝) is [i]. Based on the details of percentage of Division IV in Southern Min, *Xiánshè* (咸攝) is comprised of -iap (100%). 84.62 % of *Shānshè* (山攝) is -iat and there is one variation, -iap (7.14%). *Gěngshè* (梗攝) includes only -ik (100%).

Table 3.10: Examples and the percentage of Division IV in Southern Min

Xiánshè (咸攝)	*Shānshè* (山攝)	*Gěngshè* (梗攝)
tiě (帖)	*xiè* (屑)	*xí* (錫)
牒 (tiap8) 挾 (hiap8) 協 (hiap8)	憋 (piat4) 鐵 (t^hiat4) 結 (kiat4)	壁 (pik4) 滴 (tik4) 激 (kik4)
-iap (9) 100%	-iat (13) 92.86% -iap (1) 7.14%	-ik (22) 100%
Total: 11 (100%)	Total: 14 (100%)	Total: 22 (100%)

3.1.3 Sino-Japanese

In Sino-Japanese, Division I of entering tone has two vowels, [a] and [o], illustrated in Table 3.11. Vowel [a] is seen in alveolar and velar stop endings, whereas vowel [o] shows up in bilabial stop ending. Aside from main vowel distribution, in Sino-Japanese merely bilabial stop ending undergoes sound change. In *Xiánshè* (咸攝) the majority is long vowel [o:] (100%). However, the main vowels of *Shānshè* (山攝) and *Dàngshè* (宕攝) are homogeneous because both exhibit 100% in the outcomes.

Table 3.11: Examples and the percentage of Division I in Sino-Japanese

Xiánshè (咸攝)		*Shānshè* (山攝)	*Dàngshè* (宕攝)
hé (合)	*hé* (盍)	*hé* (曷)	*duó* (鐸)
踏 トウ (to:) 拉 ロウ (ro:) 盒 コウ (ko:)	塔 トウ (to:) 臘 ロウ (ro:) 磕 コウ (ko:)	獺タツ (tatsɯ) 辣ラツ (ratsɯ) 葛カツ(katsɯ)	泊 ハク (hakɯ) 踱 タク (takɯ) 各 カク (kakɯ)
-o: (21) 100%		-atɯ (12) 100%	-akɯ (34) 100%
Total: 21 (100%)		Total: 12 (100%)	Total: 34 (100%)

According to Table 3.12 and 3.13, [a] and [o] are the main vowels of Division II in Sino-Japanese. Vowel [a] shows up in *Shānshè* (山攝), *Jiāngshè* (江攝) and *Gěngshè* (梗攝). [o] is only seen in *Xiánshè* (咸攝). The details of Division II in percentage reveal that *Xiánshè* (咸攝), *Shānshè* (山攝) and *Gěngshè* (梗攝) have systematic change without variants. All examples of *Xiánshè* (咸攝) are vowel [o]; *Shānshè* (山攝) and *Gěngshè* (梗攝) are vowel [a].

Table 3.12: Examples and the percentage of Division II in Sino-Japanese (I)

Xiánshè (咸攝)		*Shānshè* (山攝)	
qià (洽)	*xiá* (狎)	*xiá* (黠)	*xiá* (鍘)
眨 ソウ (so:) 裌 コウ (ko:) 狹 コウ (ko:)	甲 コウ (ko:) 鴨 オウ (o:) 壓 オウ (o:)	抹 バツ (batsɯ) 札 サツ (satsɯ) 軋 アツ (atsɯ)	鍘 サツ (satsɯ) 瞎 カツ (katsɯ) 轄 カツ (katsɯ)
-o: (17) 100%		-atsɯ(11)100%	
Total: 17 (100%)		Total: 11 (100%)	

Table 3.13: Examples and the percentage of Division II in Sino-Japanese (II)

Jiāngshè(江攝)	*Gěngshè* (梗攝)	
jüé (覺)	*mò* (陌)	*mài*(麥)
剝 ハク (hakɯ) 桌 タク (takɯ) 角 カク (kakɯ)	柏 ハク (hakɯ) 澤 タク (takɯ) 格 カク (kakɯ)	麥 バク (bakɯ) 摘 タク (takɯ) 隔 カク (kakɯ)
-akɯ (26) 100%	-akɯ (33) 100%	
Total: 26 (100%)	Total: 33 (100%)	

Table 3.14 and 3.15 suggest that Division III of entering tone in Sino-Japanese has three vowels [o], [a] and [e]. Vowel [o] shows up in *Xiánshè* (咸攝) and vowel [a] in *Dàngshè* (宕攝). *Jiāngshè* (江攝) and *Gěngshè* (梗攝) are vowel [e], a coalescence of [i] and [a]. Division III of Sino-Japanese has no variation, this being reflected in the percentage. All of the four categories are 100%.

Table 3.14: Examples and the percentage of Division III in Sino-Japanese (I)

Xiánshè (咸攝)		*Shānshè* (山攝)	
yè (葉)	*yè* (業)	*xüē* (薛)	*yuè* (月)
獵 リョウ (rjo:) 接 ショウ (sjo:) 靨 ヨウ (jo:)	劫 キョウ (kjo:) 業 ギョウ (gjo:) 脅 キョウ (kjo:)	別 ヘツ (hetsɯ) 列 レツ (retsɯ) 徹 テツ (tetsɯ)	揭 ケツ (ketsɯ) 歇 ケツ (ketsɯ) 蠍 ケツ (ketsɯ)
-jo: (17) 100%		-etsɯ (23) 100%	
Total: 17 (100%)		Total: 23 (100%)	

Table 3.15: Examples and the percentage of Division III in Sino-Japanese (II)

Dàngshè (宕攝)	*Gěngshè* (梗攝)	
yào (藥)	*xí* (昔)	*mò* (陌)
掠 リャク (rjakɯ) 勺 シャク (sjakɯ) 約 ヤク (jakɯ)	璧 ヘキ (heki) 籍 セキ (seki) 亦 エキ (eki)	碧 ヘキ (heki) 戟 ケキ (keki) 逆 ゲキ (geki)
-jakɯ (24) 100%	-eki (33) 100%	
Total: 24 (100%)	Total: 33 (100%)	

Division IV of Sino-Japanese is comprised of two vowels, [o] and [e]. [o] exists in *Xiánshè* (咸攝) and [e] in *Shānshè* (山攝) and *Gěngshè* (梗攝). In addition, Table 3.16 details the percentage of Division IV in Sino-Japanese. *Xiánshè* (咸攝) is chiefly [o]. The main vowel of *Gěngshè* (梗攝) is vowel [e]. *Shānshè* (山攝) has no exception since it shows 100%.

Table 3.16: Examples and the percentage of Division IV in Sino-Japanese

Xiánshè (咸攝)	*Shānshè* (山攝)	*Gěngshè* (梗攝)
tiě (帖)	*xiè* (屑)	*xí* (錫)
牒 チョウ (tjo:) 挾 キョウ (kjo:) 協 キョウ (kjo:)	慾 ヘツ (hetsɯ) 鐵 テツ (tetsɯ) 結 ケツ (ketsɯ)	壁 ヘキ (heki) 滴 テキ (teki) 激 ケキ (keki)
-jo: (9) 100%	-etsɯ (14) 100%	-eki (22) 100%
Total: 9 (100%)	Total: 14 (100%)	Total: 22 (100%)

3.1.4 Sino-Korean

The main vowel for Division I of entering tone in Sino-Korean is [a], demonstrated by Table 3.17. Vowel [a] is the vowel for *Xiánshè* (咸攝), *Shānshè* (山攝) and *Dàngshè* (宕攝). From Table 3.17, there is no variant in this three groups.

Table 3.17: Examples and the percentage of Division I in Sino-Korean

Xiánshè (咸攝)		*Shānshè* (山攝)	*Dàngshè* (宕攝)
hé (合)	*hé* (盍)	*hé* (曷)	*duó* (鐸)
踏 답 (tap) 拉 납 (nap) 盒 합 (hap)	塔 탑 (t^hap) 臘 납 (nap) 磕 갑 (kap)	獺 달 (tal) 辣 날 (nal) 葛 갈 (kal)	泊 박 (pak) 踱 탁 (t^hak) 各 각 (kak)
-ap (21) 100%		-al (12) 100%	-ak (34) 100%
Total: 21 (100%)		Total: 12 (100%)	Total: 34 (100%)

As exhibited by Table 3.18 and 3.19, vowels, [a] and [ɛ], are the main vowels of Division II in Sino-Japanese. Vowel [a] lies in *Xiánshè* (咸攝), *Shānshè* (山攝), and *Jiāngshè* (江攝). Vowel [ɛ] is merely seen in *Gěngshè* (梗攝). According to the percentage, Sino-Korean has more variants[23]. In *Xiánshè* (咸攝) the majority is -ap,

[23] Yang (1989) and Lee (2004) pointed out that the complication of modern Sino-Korean results from misreading rather than different layers. The first type is similarity in Chinese characters. For instance, 灣 should be 완 [wan]. However, 灣 is highly similar to 蠻 만 [man]. This leads to misreading that 灣 is pronounced as 만 [man] and not 완 [wan]. The second type is the change of Mandarin Chinese that influences Sino-Korea later. Take 刷 as an example, in Southren Min and Sino-Japanese, the alveolar stop ending is preserved, while in Mandarin Chinese the stop ending is deleted and proounced as [ʂwa]. This deletion affects Sino-Korean so that modern Sino-Korean is [swɛ]. Finally, why some words are misread

which approximates half. The rest part is comprised of -jəp (29.41%) and -əp (11.76%). *Shānshè* (山攝) is the only one without variation. Regarding *Jiāngshè* (江攝), the main vowel is [a] with one character that is preceded by glide [w] (-wak 3.85%). *Gěngshè* (梗攝) is principally composed by -ɛk (63.64%), but some variations, such as -jək (21.21%), -ak (12.12%) and -ək (3.03%), can also be found.

Table 3.18: Examples and the percentage of Division II in Sino-Korean (I)

Xiánshè (咸攝)		*Shānshè* (山攝)	
qià (洽)	*xiá* (狎)	*xiá* (黠)	*xiá* (鎋)
眨 잡 (cap) 袂 겹 (kjəp) 狹 협 (hjəp)	甲 갑 (kap) 鴨 압 (ap) 壓 압 (ap)	抹 말 (mal) 札 찰 (ts^hal) 軋 알 (al)	鍘 찰 (c^hal) 瞎 할 (hal) 轄 할 (hal)
-ap (10) 58.82% -jəp (5) 29.41% -əp (2) 11.76%		-al (11) 100%	
Total: 17 (100%)		Total: 11 (100%)	

Table 3.19: Examples and the percentage of Division II in Sino-Korean (II)

Jiāngshè(江攝)	*Gěngshè* (梗攝)	
jüé (覺)	*mò* (陌)	*mài*(麥)
剝 박 (pak) 桌 탁 (t^hak) 角 각 (kak)	柏 백 (pɛk) 澤 택 (t^hɛk) 格 격 (kjək)	麥 맥 (mɛk) 摘 적 (cək) 隔 격 (kjək)
-ak(25) 96.15 % -wak (1) 3.85 %	-ɛk (21) 63.64% -jək (7) 21.21% -ak (4) 12.12% -ək (1) 3.03%	
Total: 26 (100%)	Total: 33 (100%)	

From Table 3.20 and 3.21, the main vowels of Division III in Sino-Korean are [ə] and [a]. Vowel [ə] lies in *Xiánshè* (咸攝), *Shānshè* (山攝) and *Gěngshè* (梗攝). The

remains unknown. 洽 is a good illustration. It should be 갑 [kap] instead of 흡 [hɨp] since its onset is [k^h] and rime is [ap] in Middle Chinese.
Owing to the three factors, it can be explained why the data of Sino-Korean in this study sometimes are quite confusing and complex.

vowel of *Dàngshè* (宕攝) is [a]. Table 3.20 and 3.21 also provide the details of Division III in percentage, suggesting that Sino-Korean does not change systematically. The main vowel of *Xiánshè* (咸攝) is -əp, approximately 76.47% being -əp and 23.53% being -jəp. *Shānshè* (山攝) has the majority, -əl (95.65%) where -əl occupies 60.87% and -jəl occupies 34.78%. Besides, -al occupies 4.34% in *Shānshè* (山攝). Regarding *Dàngshè* (宕攝), the main vowel is [a] where 66.67% has no glide and 33.33% is accompanied by [j]. 81.82% of *Gěngshè* (梗攝) is mainly composed by -ək (57.58% for -ək and 24.24% for -jək). There are still some variations, such as -ɨk (9.09%), -ɛk (6.06%) and -ik (3.03%).

Table 3.20: Examples and the percentage of Division III in Sino-Korean (I)

Xiánshè (咸攝)		*Shānshè* (山攝)	
yè (葉)	*yè* (業)	*xüē* (薛)	*yuè* (月)
獵 엽 (jəp) 接 접 (cəp) 靨 엽 (jəp)	劫 겁 (kəp) 業 업 (əp) 脅 협 (hjəp)	別 별 (pjəl) 列 열 (jəl) 徹 철 (c^həl)	揭 게 (ke) 歇 헐 (həl) 蠍 갈 (kal)
-əp (13) 76.47% -jəp (4) 23.53%		-əl (14) 60.87% -jəl (8) 34.78% -al (1) 4.35%	
Total: 17 (100%)		Total: 23 (100%)	

Table 3.21: Examples and the percentage of Division III in Sino-Korean (II)

Dàngshè (宕攝)	*Gěngshè* (梗攝)	
yào (藥)	*xí* (昔)	*mò* (陌)
掠 약 (jak) 勺 작 (cak) 約 약 (jak)	璧 벽 (pjək) 籍 적 (cək) 亦 역 (jək)	碧 벽 (pjək) 戟 극 (kɨk) 逆 역 (jək)
-ak (16) 66.67% -jak (8) 33.33%	-ək (19) 57.58% -jək (8) 24.24% -ɨk (3) 9.09% -ɛk (2) 6.06% -ik (1) 3.03%	
Total: 24 (100%)	Total: 33 (100%)	

Table 3.22 shows that the main vowel of Division IV in Sino-Korean is [ə], regardless of the prevocalic glide. The percentage of Division IV in Sino-Korean is detailed in Table 3.22. *Xiánshè* (咸攝) includes -əp (77.78%) and -jəp (22.22%). *Shānshè* (山攝) is primarily formed by -əl (50%) and -jəl (35.71%). However *Shānshè* (山攝) also has one exception, -al, occupying 14.29%. In *Gěngshè* (梗攝), -ək (63.64%) and -jək (31.82%) amounts to 95.46%. The other variant rests in -ik, for which takes 4.54%.

Table 3.22: Examples and the percentage of Division IV in Sino-Korean

Xiánshè (咸攝)	*Shānshè* (山攝)	*Gěngshè* (梗攝)
tiě (帖)	*xiè* (屑)	*xí* (錫)
牒 첩 (c^həp) 挾 협 (hjəp) 協 협 (hjəp)	憼 철 (pəl) 鐵 철 (c^həl) 結 결 (kjəl)	壁 벽 (pjək) 滴 적 (cək) 激 격 (kjək)
-əp (7) 77.78% -jəp (2) 22.22%	-əl (7) 50% -jəl (5) 35.71% -al (2) 14.29%	-ək (14) 63.64% -jək (7) 31.82% -ik (1) 4.54%
Total: 9 (100%)	Total: 14 (100%)	Total: 22 (100%)

3.1.5 Reconstruction of Middle Chinese

In addition to the modern pronunciation in Southern Min, Sino-Japanese and Sino-Korean, the reconstructed Middle Chinese is exhibited below. The following four tables (Table 3.23-3.26) outline the reconstructions of Division I, II, III and IV, respectively. According to Pan and Feng (2000), Zhu (2001) and Zhengchang (2003), the main vowels of Division I in [a]-vowel group are back low vowel, [ɑ] or [ɒ], and the main vowels of Division II are front low vowel, [a] or [ɐ][24]. Division III is characteristic of prevocalic glide [j] and front vowels, [æ] and [ɛ]. Higher than Division III, the main vowel of Division IV is [e], accompanied by vowel [i].

[24] The vowels of Division II are primarily reconstructed [a] or [ɐ]. However there is other vowel, such as [æ] (Dong 2002).

Table 3.23: Reconstruction of Division I in Entering Tone

Shè (攝)	*Yǜnbù* (韻部)	Reconstruction
Xiánshè (咸攝)	*hé* (合) / *hé* (盍)	-ɑp / -ɒp
Shānshè (山攝)	*hé* (曷)	-ɑt
Dàngshè (宕攝)	*duó* (鐸)	-ɑk

Table 3.24: Reconstruction of Division II in Entering Tone

Shè (攝)	*Yǜnbù* (韻部)	Reconstruction
Xiánshè (咸攝)	*qià* (洽) / *xiá* (狎)	-ap /-ɐp
Shānshè (山攝)	*xiá* (黠) / *xiá* (鍇)	-at / -ɐt
Jiāngshè (江攝)	*jüé* (覺)	-ɔk
Gěngshè (梗攝)	*mò* (陌) / *mài*(麥)	-ak /-ɐk

Table 3.25: Reconstruction of Division III in Entering Tone

Shè (攝)	*Yǜnbù* (韻部)	Reconstruction
Xiánshè (咸攝)	*yè* (葉) / *yè* (業)	jæp (jɛp) / -jɐp
Shānshè (山攝)	*xüē* (薛) / *yuè* (月)	jæt (jɛt) / -jɐt
Dàngshè (宕攝)	*yào (藥)*	-jɑk
Gěngshè (梗攝)	*xí* (昔) / *mò* (陌)	jæk / -jɐk

Table 3.26: Reconstruction of Division IV in Entering Tone

Shè (攝)	*Yǜnbù* (韻部)	Reconstruction
Xiánshè (咸攝)	*tiě* (帖)	-iep
Shānshè (山攝)	*xiè* (屑)	-iet
Gěngshè (梗攝)	*xí* (錫)	-iek

Before we go to next section, two things need clarification. First, when one *Shè* (攝) has two *Yǜnbù* (韻部), such as the Division I and II of *Xiánshè* (咸攝) and the Division II of *Gěngshè* (梗攝), the more marked vowel is put before the less marked one, disregarding the reconstruction of each *Yǜnbù* (韻部). Therefore [ɑ] precedes [ɒ] in Division I; [a] comes before [ɐ] in Division II. Second, there are three representations in Division III. This is not redundancy but a result of *Chóngniú* (重紐), more than one representation in one *Yǜnbù* (韻部). Nevertheless what *Chóngniú* (重紐) it is does not

come to a conclusion yet (Chen 2001, Zhu 2001)[25]. Therefore, in the previous tables, *yè* (葉) rhyme and *xüē* (薛) rhyme present two vowels, [æ] and [ɛ].

3.2 Main Change of [a]-vowel group

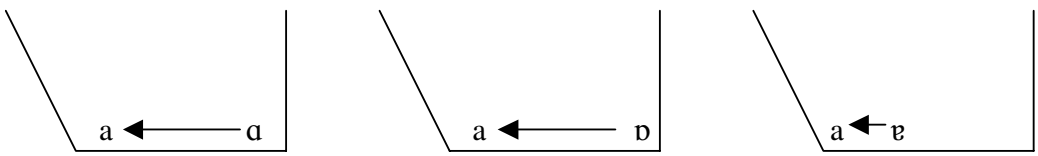
The comparison of modern pronunciations of Sino-Xenic languages (Table 3.1~3.4) and the reconstruction of Middle Chinese (Table 3.45~3.48) shows three tendencies, full merger, partial merger and separate development. Full merger indicates that in *Xiánshè* (咸攝) and *Shānshè* (山攝), Division I and II merge as one and Division III and IV converge as another one. Partial merger refers to *Gěngshè* (梗攝), in which the three languages exhibit different merger. In Southern Min, Division II, III and IV merge as one, all of them being pronounced as -ik. While in Sino-Japanese and Sino-Korean, only Division III and IV merge as one. Separate development means *Dàngshè* (宕攝) and *Jiāngshè* (江攝). Division I and Division III of *Dàngshè* (宕攝) do not merge as one and *Jiāngshè* (江攝), only with Division II, develops on its own. The three tendencies are discussed as follows.

3.2.1 *Xiánshè* (咸攝), *Shānshè* (山攝), *Dàngshè* (宕攝) and *Gěngshè* (梗攝)

As for full merger, it is shown in (1). (1a) and (1b) are the vowel shift of Division I, which depicts the convergence of two back vowels, and (1c) stands for Division II, being marked by the fronting vowel [ɐ].

(1) Merger of Division I and II of *Xiánshè* (咸攝) and *Shānshè* (山攝)

a. b. c.



This change in history of Division I and II is succinctly represented as *-ɑ, *-ɒ, *-ɐ > -a. In *FMD-OT* account, the context is paraphrased as six constraints in (2).

[25] For more details, see Chinese Phonology 6, a collection focusing on *Chóngniú* (重紐).

(2) a. $\mathcal{F}$ color: The output color should be faithful to the input
b. $\mathcal{D}$ color: Pairs of [aɒ], [ɑɐ] » [ɐɒ], [aɑ], [ɐɑ] » [aɒ]
c. $\mathcal{M}$-ɑ: No vowel [ɑ]
d. $\mathcal{M}$-ɒ: No vowel [ɒ]
e. $\mathcal{M}$-ɐ: No vowel [ɐ]
f. $\mathcal{M}$-a: No vowel [a]

(2a) is a faithfulness constraint that prevents vowel(s) from being deleted in phonological change and (2b) is a dispersion constraint that keeps features as distinguished as possible. Furthermore, other constraints (2c-f) are markedness constraints, which base on the phonological change, *-ɑ, *-ɒ, *-ɐ > -a.

In (2b), the distinction stems from the sequence, a-ɐ-ɑ-ɒ, shown in (3).

(3) [aɐ], [ɑɒ] [ɐɒ], [aɑ], [ɐɑ] [aɒ]
$\mathcal{D}_0$ color » $\mathcal{D}_2$ color » $\mathcal{D}_4$ color

In (3) [aɒ] pair ($\mathcal{D}_4$ color) is more distinguished than pairs [ɐɒ], [aɑ] and [ɐɑ] ($\mathcal{D}_2$ color), which are better than the least distinguished pairs [aɐ] and [ɑɒ] ($\mathcal{D}_0$ color). From articulatory effort, the least distinguished pairs are ranked lowest and the most distinguished pair is the highest. Put it differently, $\mathcal{D}_0$ color outranks $\mathcal{D}_2$ color, which also outranks $\mathcal{D}_4$ color.

Since back vowels, [ɑ] and [ɒ], merge as [a], and front vowel [ɐ] unites with [a], this process implies that $\mathcal{D}$ color is ranked highest in that paired vowels are not preferred. In addition, merger, *-ɑ, *-ɒ, *-ɐ > -a, suggests that $\mathcal{M}$-ɑ, $\mathcal{M}$-ɒ, $\mathcal{M}$-ɐ outranks $\mathcal{M}$-a, and faithfulness is not as significant as markedness, leading to the ranking that $\mathcal{M}$ » $\mathcal{F}$. The ranking of (2) is shown in (4).

(4) $\mathcal{D}_0$ color » $\mathcal{D}_2$ color » $\mathcal{D}_4$ color » $\mathcal{M}$-ɑ, $\mathcal{M}$-ɒ, $\mathcal{M}$-ɐ » $\mathcal{M}$-a » $\mathcal{F}$ color

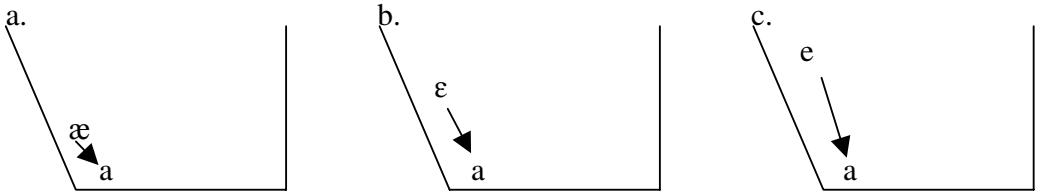
(5)

Input: -a -ɐ -ɑ -ɒ	$\mathcal{D}_0$ color	$\mathcal{D}_2$ color	$\mathcal{D}_4$ color	$\mathcal{M}$-ɑ, $\mathcal{M}$-ɒ, $\mathcal{M}$-ɐ	$\mathcal{M}$-a	$\mathcal{F}$ color
a. -a -ɐ -ɑ -ɒ	*!*	***	*	***	*	
b. -a -ɐ -ɑ	*!	**		**	*	*
c. -a -ɐ -ɒ	*!	*	*	**	*	*
d. -a -ɑ -ɒ	*!	*	*	**	*	*
e. -ɐ -ɑ -ɒ	*!	**		***		*
f. -a -ɐ	*!			*	*	**
g. -a -ɑ		*!		*	*	**
h. -a -ɒ			*!	*	*	**
i. -ɐ -ɑ		*!		**		**
j. -ɐ -ɒ		*!		**		**
k. -ɑ -ɒ	*!			**		**
☞ l. -a					*	***
m. -ɐ				*!		***
n. -ɑ				*!		***
o. -ɒ				*!		***

According to the ranking (4), Tableau (5) shows the results. Violations of the set of $\mathcal{D}$ color constraints eliminate (5a)-(5k). (5a) is the least preferable due to the amount of violation of the undominated constraint. Although (5a) is the most faithful to the input, two violations of highest constraint, $\mathcal{D}_0$ color, give rise to elimination of (5a). Owing to failure to be as far as possible in vowel space, (5b), (5c), (5d), (5e), (5f) and (5k) are eliminated. Then violation of $\mathcal{D}_2$ color leads to the elimination of (5g), (5i) and (5j). Harmonic with the higher constraints as it is, (5h) is disregarded as optimal owing to violation of the lowest $\mathcal{D}$ color constraint. Despite the fact that the rest four options are not evaluated by $\mathcal{D}$ color constraints, (5l)-(5o), on the contrary, are evaluated by other constraints. (5m), (5n) and (5o) violate $\mathcal{M}$-ɑ, $\mathcal{M}$-ɒ, $\mathcal{M}$-ɐ. Consequently they are excluded. (5l) merely violates the lower-ranked constraint, $\mathcal{M}$-a, and faithfulness constraint. As the most harmonic, (5l) surfaces as the optimal.

In addition to merger of Division I and II, Division III and IV of *Xiánshè* (咸攝) and *Shānshè* (山攝) converge as one, as offered in (6). In (6), (6a) and (6b) show the merger of Division III[26], and (6c) refers to Division IV.

(6) Merger of Division III and IV of *Xiánshè* (咸攝) and *Shānshè* (山攝)



The historical change of Division III and IV[27] is summarized as *-æ, *-ɛ, *-e > -a. In *FMD-OT* account, the context is translated into six constraints in (7). (7a) is a faithfulness constraint, preserving the contrast of input and output in height, and (7b) indicates dispersion constraint to keep vowels as distinguished as possible. Other constraints (8c-f) are markedness constraints for the change of *-æ, *-ɛ, *-e > -a.

(7) a. $\mathcal{F}$ height: The output height should be faithful to the input
b. $\mathcal{D}$ height: Pairs of [aæ], [æɛ], [ɛe], [ei] » [aɛ], [æe], [ɛi] » [ae], [æe] » [ai]
c. $\mathcal{M}$-e: No vowel [e]
d. $\mathcal{M}$-ɛ: No vowel [ɛ]
e. $\mathcal{M}$-æ: No vowel [æ]
f. $\mathcal{M}$-a: No vowel [a]

The distinction of (7b) derives from the sequence, a-æ-ɛ-e-i, shown in (8).

(8) [aæ], [æɛ], [ɛe], [ei] » [aɛ], [æe], [ɛi] » [ae], [æi] » [ai]
$\mathcal{D}_2$ height $\mathcal{D}_4$ height $\mathcal{D}_6$ height $\mathcal{D}_8$ height

In (8) [ai] ($\mathcal{D}_8$ height) is the most distinguished pair, better than [ae] and [æe] ($\mathcal{D}_6$ height). The pairs less distinguished than $\mathcal{D}_6$ height are [aɛ], [æe] and [ɛi] ($\mathcal{D}_4$ height) and the least preferred pairs are [aæ], [æɛ], [ɛe] and [ei] ($\mathcal{D}_2$ height). From articulatory

[26] Vowel [ɐ] is not reproduced in (6). For its change, see (1c),
[27] Recall that Division III is marked with glide [j] and Division IV with vowel [i]. However [j] and [i] are reckoned similarly when Division III merges with Division IV.

effort, the least distinguished pairs are ranked lowest and the most distinguished pair is the highest. Therefore $\mathcal{D}_8$ height outranks $\mathcal{D}_6$ height, which also dominates $\mathcal{D}_4$ height. $\mathcal{D}_2$ height is the lowest.

The three front vowels [e], [ɛ] and [æ] are lowered to [a]. This process suggests that the highest constraints are $\mathcal{D}_4$ height because paired vowels are not preferred. Besides, *-e, *-ɛ, *-æ > -a implies that $\mathcal{M}$-e, $\mathcal{M}$-ɛ, $\mathcal{M}$-æ dominates $\mathcal{M}$-a and faithfulness constraint is lower than markedness. The ultimate ranking is shown in (9).

(9) $\mathcal{D}_2$ height » $\mathcal{D}_4$ height » $\mathcal{D}_6$ height » $\mathcal{M}$-e, $\mathcal{M}$-ɛ, $\mathcal{M}$-æ » $\mathcal{M}$-a » $\mathcal{F}$ color

(10)

Input: -a -æ -ɛ -e	$\mathcal{D}_2$ height	$\mathcal{D}_4$ height	$\mathcal{D}_6$ height	$\mathcal{M}$-e, $\mathcal{M}$-ɛ, $\mathcal{M}$-æ	$\mathcal{M}$-a	$\mathcal{F}$ color
a. -a -æ -ɛ -e	*!**	**	*	***	*	
b. -a -æ -ɛ	*!*	*		**	*	*
c. -a -æ -e	*!	*	*	**	*	*
d. -a -ɛ -e	*!	*	*	**	*	*
e. -æ -ɛ -e	*!*	*		***		*
f. -a -æ	*!			*	*	**
g. -a -ɛ		*!		*	*	**
h. -a -e			*!	*	*	**
i. -æ -ɛ	*!			**		**
j. -æ -e		*!		**		**
k. -ɛ -e	*!			**		**
☞ l. -a					*	***
m. -æ				*!		***
n. -ɛ				*!		***
o. -e				*!		***

Ranking (9) results in (10l) of Tableau (10). Violating $\mathcal{D}$ height constraints excludes (10a)-(10k). The most faithful to the input as it is, (10a) is disfavored owing to three violations of the undominated constraint, $\mathcal{D}_2$ height. Failure to be as distinguished as possible and violation of $\mathcal{D}_2$ height, (10b), (10c), (10d), (10e), (10f), (10i) and (10k) are eliminated. Lower constraint, $\mathcal{D}_4$ height, causes (10g), (10h), and (10j) to be eliminated. Besides, pair, such as [a, e] (10h), is not able to surface as the optimal owing to violation

of $\mathcal{D}_6$ height. The rest four options (10l-10o) are then evaluated by markedness constraints. (10m), (10n) and (10o) violate the three constraints, $\mathcal{M}$-e, $\mathcal{M}$-ɛ, $\mathcal{M}$-æ, so they are excluded. Finally, although there are certain violations, abiding by the higher markedness constraints gives rise to the optimality of (10l).

The previous evaluation focuses on vowel [a]. However Division III and IV of Sino-Japanese and Sino-Korean, *Xiánshè* (咸攝), *Shānshè* (山攝), and *Gěngshè* (梗攝) in particular, undergo extra processes: vowel coalescence for Sino-Japanese and vowel raising for Sino-Korean. Vowel coalescence for Sino-Japanese, *-ia > -e is written as six constraints in (11).

(11) a. $\mathcal{F}$ segment: The output segment should be faithful to the input
b. $\mathcal{F}$ uniformity: The output uniformity should be faithful to the input
c. $\mathcal{F}$ place: The output place should be faithful to the input
d. $\mathcal{M}$-a: No vowel [a]
e. $\mathcal{M}$-i: No vowel [i]
f. $\mathcal{M}$-e: No vowel [e]

(11a)-(11c) are faithfulness constraints that function differently. (11a) preserves that mapping of input and output. (11b) prevents vowel coalescence and (11c) prohibits vowel raising. (11d-f) are markedness constraints, maintaining well-formedness of each segment. *-ia > -e denotes that $\mathcal{M}$-a and $\mathcal{M}$-i outrank $\mathcal{M}$-e, and markedness constraints outrank faithfulness constraints, which is shown in (12).

(12) $\mathcal{M}$-a, $\mathcal{M}$-i » $\mathcal{F}$ segment, $\mathcal{F}$ place » $\mathcal{M}$-e » $\mathcal{F}$ uniformity

(13)

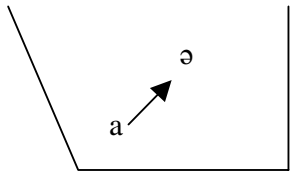
Input: -ia	$\mathcal{M}$-a, $\mathcal{M}$-i	$\mathcal{F}$ segment, $\mathcal{F}$ place	$\mathcal{M}$-e	$\mathcal{F}$ uniformity
a. -ia	*!*			
b. -ie	*!	*	*	
c. -ea	*!	*	*	
d. -a	*!	*		
e. -i	*!	*		
☞ f. -e			*	*

Ranking (12) leads to (13f). Being faithful to the input does not ensure (13a) to become the optimal. However, (13a) is eliminated. This elimination results from two violations of the highest constraints. As the most undominated constraints, violation of

$\mathcal{M}$-a and $\mathcal{M}$-i also fails (13b)-(13e), in which (13b) and (13c) violate $\mathcal{F}$ place, and (13d) and (13e) violate $\mathcal{F}$ segment. Without any violation of the higher constraints, (13f) surfaces as the optimal.

The second phonological process is vowel raising, *-ja > -jə, in Sino-Korean. This raising is exhibited in (14).

(14) Raising of *-ja > -jə



This context is paraphrased as constraints in (15). (15a) is a faithfulness constraint, sustaining the mapping of input and output and (15b) is a dispersion constraint to distinguish vowels as far as possible. (16c) and (16d) are markedness constraints.

(15) a. $\mathcal{F}$ height: The output color should be faithful to the input
b. $\mathcal{D}$ height: Pairs of [əɨ] » [aə] » [əi], [əu] » [aɨ]
c. $\mathcal{M}$-a: No vowel [a]
d. $\mathcal{M}$-ə: No vowel [ə]

The dispersion constraint from (15) results from the sequence, a-ə-ɨ in (16).

(16) [əɨ] » [aə] » [əi], [əu] » [aɨ]
$\mathcal{D}_A$ height $\mathcal{D}_B$ height $\mathcal{D}_C$ height $\mathcal{D}_D$ height
$\mathcal{D}_B$ color $\mathcal{D}_C$ color $\mathcal{D}_D$ color

In (16) the least distinguished pair is [əɨ] ($\mathcal{D}_A$ height). The more distinguished pair is [aə] ($\mathcal{D}_B$ height + $\mathcal{D}_B$ color). The pair marked by $\mathcal{D}_C$ height + $\mathcal{D}_C$ color is [aɨ]. The most distinguished pair is [aɨ] ($\mathcal{D}_D$ height + $\mathcal{D}_D$ color). According to articulatory effort, the least distinguished pairs are ranked lowest and the most distinguished pair is the highest. That is to say, $\mathcal{D}_A$ height outranks $\mathcal{D}_B$ height + $\mathcal{D}_B$ color, which outranks $\mathcal{D}_C$ height + $\mathcal{D}_C$ color. $\mathcal{D}_D$ height + $\mathcal{D}_D$ color is the lowest constraint.

The ranking of (15) is offered in (17). The lowest constraint is the faithfulness constraint and the highest is dispersion constraint. Also, $\mathcal{M}$-a outranks $\mathcal{M}$-ə.

(17) $\mathcal{D}_B$ height + $\mathcal{D}_B$ color » $\mathcal{M}$-a » $\mathcal{M}$-ə » $\mathcal{F}$ height

(18)

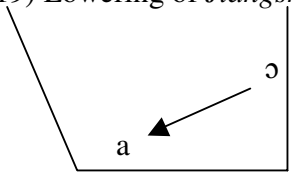
Input: -a -ə	$\mathcal{D}_B$ height + $\mathcal{D}_B$ color	$\mathcal{M}$-a	$\mathcal{M}$-ə	$\mathcal{F}$ height
a. -a -ə	*!	*	*	
b. -a		*!		*
☞ c. -ə			*	*

In (18), because of vital violation, (18a) fails to be the optimal even though it is the most faithful one. (18b) and (18c) are evaluated by the ranking of markedness constraints. Since $\mathcal{M}$-a outranks $\mathcal{M}$-ə, (18b) is eliminated and (18c) surfaces as the optimal.

3.2.2 *Jiāngshè* (江攝)

The *Yǜnbù* (韻部) that is not reconstructed as low vowel is *Jiāngshè* (江攝). *Jiāngshè* (江攝) is generally regarded as the back vowel [ɔ] in history. The correspondence of modern pronunciation and Middle Chinese indicates that the vowel of *Jiāngshè* (江攝) is lowered from [ɔ] to [a], i.e. *-ɔ > -a. This lowering is exhibited in (19).

(19) Lowering of *Jiāngshè* (江攝)



(20) demonstrates the constraints for *Jiāngshè* (江攝). (20a) is the faithfulness constraint and (20b) is the dispersion constraint concerning height for *Jiāngshè* (江攝). (20c) and (20d) are markedness constraints, putting limit on the appearance of [a] and [ɔ].

(20) a. $\mathcal{F}$ height: The output height should be faithful to the input
b. $\mathcal{D}$ height: [ɔo], [ou] » [aɔ], [ɔu] » [ao] » [au]
c. $\mathcal{M}$-a: No vowel [a]
d. $\mathcal{M}$-ɔ: No vowel [ɔ]

The dispersion constraints originate from the height of four vowels, a-ɔ-o-u.

(21) [ɔo], [ou] » [aɔ], [ɔu] » [ao] » [au]
$\mathcal{D}_1$ height $\mathcal{D}_3$ height $\mathcal{D}_5$ height $\mathcal{D}_7$ height

In (21) the most distinguished pair lies in [au] pair ($\mathcal{D}_7$ height), which is better than pair [ao] ($\mathcal{D}_5$ height). The less distinguished pairs are [aɔ] and [ɔu] ($\mathcal{D}_3$ height) and the least preferable pairs are [ɔo] and [ou], since the vowels in each pair are too close to each other. On the basis of articulatory effort, the least distinguished pairs are ranked lowest and the most distinguished pair is the highest. In other words, $\mathcal{D}_1$ height ranks highest, outranking $\mathcal{D}_3$ height. $\mathcal{D}_5$ height follows $\mathcal{D}_3$ height and $\mathcal{D}_7$ height is the lowest. Besides, the markedness constraints are shown in (8c) and (8d).

The ranking of (20) follows the same pattern of (4) where the faithfulness constraint is ranked lowest and dispersion constraint is the highest. In (22) $\mathcal{M}$-ɔ outranks $\mathcal{M}$-a.

(22) $\mathcal{D}_3$ height » $\mathcal{M}$-ɔ » $\mathcal{M}$-a » $\mathcal{F}$ height

(23)

Input: -a -ɔ	$\mathcal{D}_3$ height	$\mathcal{M}$-ɔ	$\mathcal{M}$-a	$\mathcal{F}$ height
a. -a -ɔ	*!	*	*	
☞ b. -a			*	*
c. -ɔ		*!		*

(23b) is a result from ranking (22). The most faithful (23a) fails to be the optimal thanks to violation of the highest constraint. Although they delete one vowel to avoid violation of highest constraint, (23b) and (23c) violate faithfulness constraint. (23b) and (23c) are then evaluated by markedness constraints, $\mathcal{M}$-ɔ and $\mathcal{M}$-a. (23b) surfaces as the optimal because it does not violate the higher markedness constraint.

3.3 Exceptions

The primary change of vowel [a] group in entering tones has been presented previously. However, there are four exceptions: *Dàngshè* (宕攝) and *Gěngshè* (梗攝) in Southern Min, *Xiánshè* (咸攝) in Sino-Japanese and *Gěngshè* (梗攝) in Sino-Korean. Of the four exceptions, exclusive of *Dàngshè* (宕攝) in Southern Min, the other three are the

best illustrations for opacity investigated by the extension of Candidate Chains to historical phonology. In addition, the change of coda is investigated in 3.3.5.

3.3.1 Opacity in entering tone of Sino-Xenic languages

Since the current topic is opacity and in Chapter 2 an extension of Candidate Chains to historical phonology has been proposed. Here the first premise is that in the process of phonological change, an input is evaluated and then becomes an output candidate and then this candidate moves on and becomes another input of next stage. Secondly, new constraints are introduced and reranked with old constraints.

3.3.2 Southern Min: *Dàngshè* (宕攝) and *Gěngshè* (梗攝)

According to Wang (1980), the vowel of *Dàngshè* (宕攝) should follow the same path in *Xiánshè* (咸攝) and *Shānshè* (山攝). That is to say, *-ɑk precedes -ak, also being evaluated by the constraints from (2). Nevertheless, *-ɑk > -ok is another case. This is a consequence that *Dàngshè* (宕攝) merges with other subdivisions. Ang (1999) indicates that *Dàngshè* (宕攝) converges with *Tōngshè* (通攝), which is also -ok in Southern Min. This convergence is represented as the constraints in (24) and (25). (24a) is a faithfulness constraint that preserves contrast of input and output in height. Following (8), (24b) is a set of dispersion constraints. What's more, (24c) and (24d) are markedness constraints in accordance with the change, *-a > -o, revised as ranking $\mathcal{M}$-a » $\mathcal{M}$-o.

(24) a. $\mathcal{F}$ height: The output height should be faithful to the input
b. $\mathcal{D}$ height: [ɔo], [ou] » [aɔ], [ɔu] » [ao] » [au]
c. $\mathcal{M}$-a: No vowel [a]
d. $\mathcal{M}$-o: No vowel [o]

The ranking of (24) is shown in (25). Dispersion constraint is the highest and markedness constraints come after. Faithfulness constraint is the lowest.

(25) $\mathcal{D}_5$ height » $\mathcal{M}$-a » $\mathcal{M}$-o » $\mathcal{F}$ height

(26)

Input: -a -o	$\mathcal{D}_5$ height	$\mathcal{M}$-a	$\mathcal{M}$-o	$\mathcal{F}$ height
a. -a -o	*!	*	*	
b. -a		*!		*
☞ c. -o			*	*

Ranking in (25) results in (26c). The most faithful to the input as it is, (26a) has the fewest chance to be optimal simply because it violate the undominated constraint. (26b) and (26c) delete one vowel to avoid violation of highest constraint, but violate faithfulness constraint. Competition of (26b) and (26c) is judged by the ranking of markedness constraints, $\mathcal{M}$-a and $\mathcal{M}$-o, and (26c) wins, not violating the higher markedness constraint. As a result, (26c) becomes the optimal.

The second exception in Southern Min is *Gěngshè* (梗攝). The correspondence of modern pronunciation and Middle Chinese strongly suggests that there must be a transition because it is not possible to change from low vowel to high vowel without the occurrence of middle vowel. This is confirmed by Ang (1999), who reconstructs *Gěngshè* (梗攝) in Proto-Taiwanese as *-e. Therefore according to Ang (1999), the sound change of *Gěngshè* (梗攝) should be (*-a /*-ɐ > *-a) > *-e > -i. The first part of this sound change is the merger of vowels [a] and [ɐ], which has been shown in (1) and translated as constraints in (2). Then the lower vowel [a] is raised to middle vowel [e]. This context is paraphrased as four constraints in (27).

(27) a. $\mathcal{F}$ height: The output height should be faithful to the input

b. $\mathcal{D}$ height: Pairs of [aæ], [æɛ], [ɛe], [ei] » [aɛ], [æe], [ɛi] » [ae], [æe] » [ai]

c. $\mathcal{M}$-a: No vowel [a]

d. $\mathcal{M}$-e: No vowel [e]

(27a) is a faithfulness constraint that sustains contrast of input and output in height. (27b) is a set of dispersion constraints, which bases on (7). Furthermore, (27c) and (27d) are markedness constraints in accordance with the change, *-a > *-e, revised as ranking $\mathcal{M}$-a » $\mathcal{M}$-e.

The ranking of (27) is proposed as (28). The faithfulness constraint is ranked lowest and dispersion constraint is the highest. In (28) $\mathcal{M}$-a outranks $\mathcal{M}$-e.

(28) $\mathcal{D}_2$ height » $\mathcal{M}$-a » $\mathcal{M}$-e » $\mathcal{F}$ height

(29)

Input: -a -e	$\mathcal{D}_6$ height	$\mathcal{M}$-a	$\mathcal{M}$-e	$\mathcal{F}$ height
a. -a -e	*!	*	*	
b. -a		*!		*
☞ c. -e			*	*

In (29), because of violation of the highest constraint, (29a), the most faithful one, fails to be the optimal. Deleting one vowel to prevent violation of highest constraint but violating the markedness constraints, (29b) and (29c) are evaluated by the ranking of markedness constraints. Since $\mathcal{M}$-a outranks $\mathcal{M}$-e, (29c) surfaces as the output candidate of the current stage and an input for the next evaluation.

The next evaluation turns to *-e > -i. This process evaluates the output candidate from (29) with new constraints in (30). (30a), a faithfulness constraint, maintains contrast of input and output in height. Middle vowel [e] is then raised to high vowel [i], *-e > -i. This change is translated as two markedness constraints, ranked as $\mathcal{M}$-e » $\mathcal{M}$-i.

(30) a. $\mathcal{F}$ height: The output height should be faithful to the input
b. $\mathcal{D}$ height: Pairs of [aæ], [æɛ], [ɛe], [ei] » [aɛ], [æe], [ɛi] » [ae], [æe] » [ai]
c. $\mathcal{M}$-i: No vowel [i]
d. $\mathcal{M}$-e: No vowel [e]

Proposed as (31), the ranking of (30) is shown below. The lowest constraint is the faithfulness constraint and the highest is dispersion constraint. Also, $\mathcal{M}$-e outranks $\mathcal{M}$-i.

(31) $\mathcal{D}_2$ height » $\mathcal{M}$-e » $\mathcal{M}$-i » $\mathcal{F}$ height

(32)

Input: -e -i	$\mathcal{D}_2$ height	$\mathcal{M}$-e	$\mathcal{M}$-i	$\mathcal{F}$ height
a. -e -i	*!	*	*	
b. -e		*!		*
☞ c. -i			*	*

Failure to be as distinguished as possible, (32a), the most faithful one, is eliminated in the first place. The evaluation then focuses on (32b) and (32c) by the ranking of markedness constraints. As $\mathcal{M}$-e outranks $\mathcal{M}$-i, (32c) defeats (32b), and (32c) becomes the optimal.

3.3.3 Sino-Japanese: *Xiánshè* (咸攝)

The exception of Sino-Japanese consists in *Xiánshè* (咸攝)[28]. *Xiánshè* (咸攝) in Sino-Japanese varies after vowel adjustment. *Xiánshè* (咸攝) is strongly affected by Japanese phonology. This change specifically refers to Japanese spirantization (ハ行転呼音), a lenition when a bilabial stop is intervocalic, in (33).

(33) *VpV > *VΦV > VV

Since in (33) VΦV is indispensable in history, there must be a sequential relationship. The change from *VpV > *VΦV is firstly investigated and the context is paraphrased as four constraints in (34).

(34) a. $\mathcal{F}$ segment: Segment in output should be faithful to input
b. $\mathcal{F}$ continuity: Continuity in output should be faithful to input
c. $\mathcal{M}$-VpV: No intervocalic -p-
d. $\mathcal{M}$-VΦV: No intervocalic -Φ-

The constraints in (34) do not work simultaneously. In *VpV > *VΦV, evaluation is chiefly based on the first three constraints. Owing to prohibition of intervocalic -p-, the markedness constraint, $\mathcal{M}$-VpV should not be dominated by any constraint. Besides, two

[28] The first evaluation is resyllabification of Chinese CVC syllable structure to accommodate Japanese CV syllable structure. This requirement is translated as the constraints in (1)
(1) a. $\mathcal{F}$ segment: The output segment should be faithful to the input
b. $\mathcal{M}$-CVC: No CVC syllable structure
c. $\mathcal{M}$-CV: No CV syllable structure
d. $\mathcal{M}$-CVCV: No CVCV syllable structure
Regarding the ranking, $\mathcal{M}$-CVC is the highest since Japanese refuses coda. The lower ranking goes to $\mathcal{M}$-CV » $\mathcal{M}$-CVCV, because Japanese prefers epenthesis to deletion. The lowest is faithfulness constraint, $\mathcal{F}$ segment. The ranking in (2) is used in Tableau (3).
(2) $\mathcal{M}$-CVC » $\mathcal{M}$-CV » $\mathcal{M}$-CVCV » $\mathcal{F}$ segment
(3)

Input: CVC	$\mathcal{M}$-CVC	$\mathcal{M}$-CV	$\mathcal{M}$-CVCV	$\mathcal{F}$ segment
a. CV		*!		*
b. CVC	*!			
☞ c. CVCV			*	*

On the basis of ranking (2), the result is represented in Tableau (3). Japanese syllable structure restricts the appearance of coda, a least preferable segment. (3b) never surfaces to be the optimal without adoption. (3a) and (3c), both of which violate faithfulness constraint, are the possible candidates. However, the ranking, $\mathcal{M}$-CV » $\mathcal{M}$-CVCV, rejects (3a) to win the competition. As a result, (3c) is the optimal.

faithfulness constraints guarantee the appearance of intervocalic VΦV and prevent intervocalic -p- from being deleted. Hence $\mathcal{F}$ segment outranks $\mathcal{F}$ continuity. The ranking is shown in (35).

(35) $\mathcal{M}$-VpV » $\mathcal{F}$ segment » $\mathcal{F}$ continuity

(36)

Input: -VpV	$\mathcal{M}$-VpV	$\mathcal{F}$ segment	$\mathcal{F}$ continuity
a. -VpV	*!		
b. -VV		*!	
☞ c. -VΦV			*

The evaluation judged by the ranking in (35) gives rise to (36c) as the most harmonious candidate because it violates the lowest constraint. Other candidates, such as (36a) and (36b) are eliminated since they fail to abide by the higher constraints.

The output candidate (36c) continues to be evaluated by a newly introduced constraint, $\mathcal{M}$-VΦV, (34d) for the change of *VΦV > VV. In this stage, $\mathcal{M}$-VpV and $\mathcal{F}$ continuity are turned off and $\mathcal{M}$-VΦV begins to operate. $\mathcal{M}$-VΦV is the highest because it is coupled with $\mathcal{M}$-VpV. New ranking is proposed in (37).

(37) $\mathcal{M}$-VΦV » $\mathcal{F}$ segment » $\mathcal{F}$ continuity

(38)

Input: -VΦV	$\mathcal{M}$-VpV, $\mathcal{M}$-VΦV	$\mathcal{F}$ segment	$\mathcal{F}$ continuity
a. -VΦV	*!		
☞ b. -VV		*	

The output candidate from previous stage is then evaluated by the new ranking in (37) and only (38b) becomes the optimal on the ground that it violates lower constraint.

The interaction of segments continues after the disappearance of intervocalic consonant. Based on Numoto (1989), the interactions of vowels in *Xiánshè* (咸攝) are twofold. Shown in (39) with Chinese Character 塔 (トウ; tower), Division I and II undergo vowel raising. The sound change of Division III and IV is glide formation, exemplified by (40) with one Chinese Character 葉 (ヨウ; leaves). The first two stages in (39) and (40) have been demonstrated in (33)-(38).

(39) 塔 (トウ; tower)

σ	σ	σ	σ	σ	Syllable
/ \	/ \	/ \	/ \	/ \	
μ μ	μ μ	μ μ	μ μ	μ μ	Mora
/\ /\	/\ /\	/\ |	/ \ |	/\/	
t apɯ→	t aΦɯ→	t aɯ →	t o ɯ→	t o	Segment
1	2	3	4	5	Stage

(40) 葉 (ヨウ; leaves)

σ	σ	σ	σ	Syllable
/ \	/ \	/ \	/ \	
μ μ	μ μ	μ μ	μ μ	Mora
| /\	| /\	/\ |	| /	
e pɯ→	eΦɯ→	j o ɯ →	jo	Segment
1	2	3	4	Stage

As observed in (39), after Japanese spirantization (ハ行転呼音), the back high vowel [ɯ] in Division I and II affects the low vowel regressively (stage 4), vowel [a] being raised to [o]. The raising is paraphrased as constraints in (41). (41a), (41b) and (41c) are faithfulness constraints where $\mathcal{F}$ uniformity aims to put limit on coalescence. The rest two constraints are markedness constraints.

(41) a. $\mathcal{F}$ segment: The output segment should be faithful to the input
b. $\mathcal{F}$ uniformity: The output uniformity should be faithful to the input
c. $\mathcal{F}$ place: The output place should be faithful to the input
d. $\mathcal{M}$-a: No vowel [a]
e. $\mathcal{M}$-ɯ: No vowel [ɯ]

The criteria to rank (41) are twofold. For one thing, markedness constraint, $\mathcal{M}$-a, is ranked highest because vowel [a] is affected by [ɯ] and is raised to [o]. For the other thing, the constraints ranked below $\mathcal{M}$-a are two faithfulness constraints, $\mathcal{F}$ segment and $\mathcal{F}$ uniformity. The former avoids deletion and the latter prevents vowel coalescence. Lower than the two faithfulness constraints is another faithfulness constraint, $\mathcal{F}$ place. The lowest is the markedness constraint, $\mathcal{M}$-ɯ. Ranking is represented as in (42).

(42) $\mathcal{M}$-a » $\mathcal{F}$ segment, $\mathcal{F}$ uniformity » $\mathcal{F}$ place » $\mathcal{M}$-ɯ

(43)

Input: -aɯ	*M*-a	*F* segment, *F* uniformity	*F* place	*M*-ɯ
a. -aɯ	*!			*
☞ b. -oɯ			*	*
c. -a	*!	*	*	
d. -o		*!		
e. -ɯ		*!	*	*

Evaluated by the highest constraints, (43a) and (43c) are excluded in the very beginning. Although [a] and [ɯ] unite as one, (43d) violates constraint, *F* uniformity and is disregarded. (43e) deletes vowel [a] to be harmonic. However this deletion leads to elimination because (43e) violates *F* segment. As a result, (43b) surfaces to be the optimal.

Regarding the interaction of vowels for Division III and IV (40), the first vowel [e] is decomposed as [i] and [a] (Takamatsu 1986). Vowel [i] is transferred as glide and vowel [a] interacts with vowel [ɯ], as in (43). The process, *-eɯ > -joɯ is paraphrased as five constraints in (44). (44a) and (44b) are faithfulness constraints to maintain the mapping of input and output. The other three are markedness constraints.

(44) a. *F* segment: The output segment should be faithful to the input
b. *F* place: The output place should be faithful to the input
c. *M*-e: No vowel [e]
d. *M*-o: No vowel [o]
e. *M*-ɯ: No vowel [ɯ]

The ranking of (44) is as the following. Disfavoring -eɯ and changing to -joɯ implies that *M*-e outranks *M*-o and *M*-ɯ. Lower than *M*-e are the two faithfulness constraints where *F* place dominates *F* segment because maintaining the height features of [e] is better than deletion or epenthesis. The lowest constraints are *M*-o and *M*-ɯ. Ranking is proposed in (45).

(45) *M*-e » *F* place » *F* segment » *M*-o, *M*-ɯ

(46)

Input: -eɯ	*M*-e	*F* place	*F* segment	*M*-o, *M*-ɯ
a. -eɯ	*!			*
b. -oɯ		*!		**
c. -e	*!	*	*	
d. -ɯ		*!*	*	*
☞ e. -joɯ			*	**

M-e is undominated, so violation in (46a) and (46c) leads to elimination. (46b), although it keeps two segments, violates *F* place, resulting in elimination. (46d) undergoes deletion of [e] to avoid the highest constraint, *M*-e; however this process violates *F* place twice and leads to exclusion. The maintenance of features of input prevents (46e) from violating the highest two constraints. With the violation of the lower constraints, (46e) hence is the optimal.

Compensatory lengthening comes after vowel adjustment. Compensatory lengthening is fed by Japanese spirantization and restricted by Japanese phonotactics, forbidding two adjacent vowels. In (39) and (40), [oɯ] later is prolonged as [o:] by compensatory lengthening. This process is translated as constraints in (47). The first two constraints (47a) and (47b) are faithfulness constraints, which preserve the mapping of input and output in lieu of height and mora. There are three markedness constraints. *M*-diphthong (47c) aims to protect the delinked mora, and *M*-o (47d) and *M*-ɯ (47e) select the vowel [o].

(47) a. *F* segment: The output segment should be faithful to the input
b. *F* mora: The output mora should be faithful to the input
c. *M*-diphthong: Diphthong is prohibited
d. *M*-o: No vowel [o]
e. *M*-ɯ: No vowel [ɯ]

Forbidding diphthong leads to the understanding that *M*-diphthong undoubtedly is ranked highest. Preservation of mora suggests one faithfulness constraint that ensures the delinked mora is kept. The three constraints in (48) are ranked as *M*-diphthong » *F* segment, *F* mora. Now that diphthong is forbidden, *M*-diphthong outranks *F* segment.

As for the prosodic constraint, *F* mora, it works with *F* segment, in order to save the second mora from deletion.

(48) *M*-diphthong » *M*-ɯ » *F* mora » *M*-o »*F* segment

(49)

Input: -oɯ | | μ μ	*M*-diphthong	*M*-ɯ	*F* mora	*M*-o	*F* segment
a. -oɯ | | μ μ	*!	*		*	
b. -o | μ			*!	*	*
☞ c. -o ∧ μ μ				*	*
d. -ɯ | μ		*!	*		*
e. -ɯ ∧ μ μ		*!			*

Ranking (48) results in (49b). (49a) is firstly disregarded due to diphthong, violating the highest constraint. (49b)-(49e) delete one vowel to obey the undominated constraint, but violate the lowest constraint. Nevertheless *M*-ɯ excludes (49d) and (49e) because Japanese keeps vowel [o] rather than [ɯ]. Then the selection of (49b) and (49c) is determined by faithfulness constraint, *F* mora. Two moras are preserved in modern Sino-Japanese, implying that (49b) fails to surface as the optimal. Hence (49c) is the most harmonic outcome.

3.3.4 Sino-Korean: *Gěngshè* (梗攝) and *Xiánshè* (咸攝)

The exception in Sino-Korean lies in the Division II of *Gěngshè* (梗攝) and *Xiánshè* (咸攝). The main vowel of Division II of *Gěngshè* (梗攝) in Sino-Korean is [ɛ]. Following Kono (1979) and Lee (2004), the change derives from *-ɐk > *-ɐik > *-aik > -ɛk. The first change is the insertion of glide, a consequence of transition from low to high.

Although inserting a glide between two segments, which are far from each other, is quite common, this phenomenon is rather restrictive. The change, *-ɐk > *-ɐik, is merely observed in *Gěngshè* (梗攝), but not in *Dàngshè* (宕攝) and *Jiāngshè* (江攝). Therefore, the constraints for this change are proposed in (50).

(50) a. $\mathcal{F}$ segment: The output segment should be faithful to the input
b. $\mathcal{M}$-ɐk: No syllable structure [ɐk]
c. $\mathcal{M}$-ɐik: No syllable structure [ɐik]

The ranking of (50) is shown in (51). Markedness constraints outrank faithfulness constraint. Of the two markedness constraints, $\mathcal{M}$-ɐk dominates $\mathcal{M}$-ɐik.

(51) $\mathcal{M}$-ɐk » $\mathcal{M}$-ɐik » $\mathcal{F}$ segment

(52)

Input: -ɐk	$\mathcal{M}$-ɐk	$\mathcal{M}$-ɐik	$\mathcal{F}$ segment
a. -ɐk	*!		
☞ b. -ɐik		*	*

After evaluated by the ranking in (51), (52b) surfaces as the optimal. Although (52b) violates two lower constraints, it is (52a) that is eliminated due to vital violation of the highest constraint. Hence, (52b) wins the competition.

An important sound change of Korean results in changing from -ɐik to -aik. According to Ahn (2002), Kono (1979), Lee (1961, 1972), Lee (2004), Woo (2005), vowel [ɐ] disappears[29] in history. Furthermore, Woo (2005) points out that vowel [ɐ] is replaced by [a]. This change is translated as four constraints in (53). (53a) aims to maintain the mapping of input and output. (53b) is a set of dispersion constraints for low vowels. (53c) and (53d) are markedness constraints for well-formedness.

(53) a. $\mathcal{F}$ color: The output color should be faithful to the input
b. $\mathcal{D}$ color: Pairs of [aɒ], [ɑɐ] » [ɐɒ], [aɑ], [ɐɑ] » [aɒ]
c. $\mathcal{M}$-ɐ: No vowel [ɐ]
d. $\mathcal{M}$-a: No vowel [a]

[29] The cause of disppearance of vowel [ɐ] is not concluded yet (see Ahn 2002).

The ranking of (53) is proposed as (54) where the faithfulness constraint is ranked lowest and dispersion constraint is the highest. In (54) $\mathcal{M}$-ɐ outranks $\mathcal{M}$-a.

(54) $\mathcal{D}_0$ color » $\mathcal{M}$-ɐ » $\mathcal{M}$-a » $\mathcal{F}$ color

(55)

Input: -a -ɐ	$\mathcal{D}_0$ color	$\mathcal{M}$-ɐ	$\mathcal{M}$-a	$\mathcal{F}$ color
a. -a -ɐ	*!	*	*	
☞ b. -a			*	*
c. -ɐ		*!		*

Ranking (54) leads to (55b). (55a) violates the highest constraint, being excluded firstly. Deleting one vowel to be distinguished, (55b) and (55c) violate faithfulness constraint. (55b) and (55c) are then evaluated by markedness constraints, $\mathcal{M}$-ɐ and $\mathcal{M}$-a. Not violating the higher markedness constraint, (55b) surfaces as the output candidate for next stage.

The final stage of *Gěngshè* (梗攝) in Sino-Korean is *-aik > -ɛk, resulting from Korean phonotactics in which diphthong is forbidden. Despite the fact that diphthong is not allowed in Korean, the repair strategy consists in vowel coalescence rather than deletion. Theoretically speaking, the coalescence of vowels [a] and [i] can be either [e] or [ɛ]. It is in fact [ɛ] that occurs since coalescence of [ə] and [i] takes the place of [e]. The constraints are shown in (56). (56) is generally divided into two parts. The first three constraints (56a)-(56c) are related to faithfulness, whereas the other five (56e)-(56h) are markedness constraints.

(56) a. $\mathcal{F}$ segment: The output segment should be faithful to the input
b. $\mathcal{F}$ place: The output place should be faithful to the input
c. $\mathcal{F}$ uniformity: The output uniformity should be faithful to the input
d. $\mathcal{M}$-diphthong: No diphthong
e. $\mathcal{M}$-a: No vowel [a]
f. $\mathcal{M}$-ɛ: No vowel [ɛ]
g. $\mathcal{M}$-e: No vowel [e]
h. $\mathcal{M}$-i: No vowel [i]

Ranking of (56) is demonstrated in (57). Strictly forbidden in Korean, $\mathcal{M}$-diphthong, the representation of diphthong, is undoubtedly ranked highest. Below the highest

constraint are the four markedness constraints. Avoiding diphthong [ai] suggests that either [a] or [i] is not allowed. In other words, $\mathcal{M}$-a and $\mathcal{M}$-i outrank the other two constraints. In addition, the $\mathcal{M}$-e ranks higher than $\mathcal{M}$-ɛ because the space of vowel [e] is taken by other vowel coalescence. The other three faithfulness constraints are ranked lower.

(57) $\mathcal{M}$-diphthong » $\mathcal{M}$-a, $\mathcal{M}$-i » $\mathcal{M}$-e » $\mathcal{M}$-ɛ » $\mathcal{F}$ uniformity, $\mathcal{F}$ place, $\mathcal{F}$ segment

(58)

Input: -ai	$\mathcal{M}$-diphthong	$\mathcal{M}$-a, $\mathcal{M}$-i	$\mathcal{M}$-e	$\mathcal{M}$-ɛ	$\mathcal{F}$ uniformity, $\mathcal{F}$ place, $\mathcal{F}$ segment
a. -ai	*!	*			
b. -ae	*!	*	*		*
c. -aɛ	*!	*			*
d. -ɛi	*!	*		*	*
e. -ei	*!	*	*		*
f. -i		*!			*
g. -e			*!		*
☞ h. -ɛ				*	*
i. -a		*!			*

Tableau (58) exhibits the result on the basis of ranking (57). Vital violation of the highest constraint eliminates (58a)-(58e). (58a) is the most faithful to the input, and violation of the highest constraint causes it to be eliminated. Regardless of which vowel is raised, (58b), (58c), (58d) and (58e) are not viewed as possible outputs because they fail to abide by the undominated constraint. The evaluation then turns to (58f)-(58i), the ones with only one vowel. Since vowel [a] and [i] are not preferred, (58f) and (58i) are excluded from the possible outputs. The final two possible outputs are judged by the lower two constraints. Being ranked higher, $\mathcal{M}$-e prevents (58g) from surfacing as the optimal. Hence, (58i), as the most harmonic, surfaces as the optimal.

The second exception in Sino-Korean is *Xiánshè* (咸攝). Recall that in Table 3.20-3.21, there is another vowel, -ək, for *Xiánshè* (咸攝) and *Gěngshè* (梗攝). Appearance of -ək is a consequence of glide formation[30] to fill the gap from transition (Kono 1979).

[30] The glide formation from *ka > *kja is also seen in Southern Min, especially in the colloquial reading (白讀) of *Xiánshè* (咸攝) (Lin 2004). For example, 峽 is hap8 in literal reading, but hiap8 in colloquial reading.

Then the inserted glide raises low vowel to central position [ə]. The raising is shown as, *kak > *kjak > kjək[31]. The glide insertion is a language-specific phenomenon because it happens merely when the onset carries the feature of [velar] (*Qúnmǔ* 群母), such as [k] and [g], or of [glottal] (*Xiámǔ* 匣母), like [h], a prevocalic glide occurs, *ka > kja. This change is context-specific since the prevocalic palatal glide should not appear in Division I and II (Zhu 2001). This insertion is known as three constraints in (59).

(59) a. $\mathcal{F}$ segment: The output segment should be faithful to the input
b. $\mathcal{M}$-ka: No syllable structure [ka]
c. $\mathcal{M}$-kja: No syllable structure [kja]

The ranking of (59) is shown in (60). Markedness constraints outrank faithfulness constraint. Of the two markedness constraints, $\mathcal{M}$-ka dominates $\mathcal{M}$-kja.

(60) $\mathcal{M}$-kja » $\mathcal{M}$-ka » $\mathcal{F}$ segment

(61)

Input: ka	$\mathcal{M}$-ka	$\mathcal{M}$-kja	$\mathcal{F}$ segment
a. ka	*!		
☞ b. kja		*	*

After evaluated by the ranking in (60), (61b) surfaces as the optimal. Although (61b) violates two lower constraints, it is (61a) that is eliminated due to vital violation of the highest constraint. Hence, (61b) wins the competition.

The output candidate from (61) then becomes the input of next stage, undergoing vowel raising *kjak > kjək. This context is paraphrased as constraints in (62). (62a) is a faithfulness constraint, sustaining the mapping of input and output and (62b) is a dispersion constraint that keeps features as distinguished as possible. (62c) and (62d) are markedness constraints.

(62) a. $\mathcal{F}$ height: The output color should be faithful to the input
b. $\mathcal{D}$ height: Pairs of [əɨ] » [aə] » [aɨ]
c. $\mathcal{M}$-a: No vowel [a]
d. $\mathcal{M}$-ə: No vowel [ə]

[31] The low vowel [a] can also refer to [ɐ] before it disappears.

The ranking of (62) is offered in (63). The lowest constraint is the faithfulness constraint and the highest is dispersion constraint. Also, $\mathcal{M}$-a outranks $\mathcal{M}$-ə.

(63) $\mathcal{D}_B$ height » $\mathcal{M}$-a » $\mathcal{M}$-ə » $\mathcal{F}$ height

(64)

Input: -a -ə	$\mathcal{D}_B$ height	$\mathcal{M}$-a	$\mathcal{M}$-ə	$\mathcal{F}$ height
a. -a -ə	*!	*	*	
b. -a		*!		*
☞ c. -ə			*	*

In (64), owing to vital violation, (64a) fails to be the optimal even though it is the most faithful one. (64b) and (64c) are evaluated by the ranking of markedness constraints. Since $\mathcal{M}$-a outranks $\mathcal{M}$-ə, (64b) is eliminated and (64c) surfaces as the optimal.

3.4 Summary of Chapter 3

This chapter has offered the details and explicitly discussed [a]-vowel group of the three Sino-Xenic languages in OT account. It has displayed that the five *Shè* (攝) have been categorized into two major classes, merger and lowering. First, merger is located in *Xiánshè* (咸攝), *Shānshè* (山攝), *Gěngshè* (梗攝) and *Dàngshè* (宕攝). The main vowels of Division I and II merge as one, and those in Division III and IV converge as one. Second, lowering specifically indicates *Jiāngshè* (江攝) where the main vowel is lowered from [ɔ] to [a]. Furthermore, some exceptions are discussed separately. The exceptions of Southern Min result from merger with other *Shè* (攝) and vowel raises from [a] to [e] and then to [i]. Japanese spirantization (ハ行転呼音) brings about the exception of Sino-Japanese in [a]-vowel group. The main vowel of Sino-Korean has been affected by the inserted pre- and post-vocalic glide.

With the basic understating of how historical phonology is evaluated in OT account, the forthcoming chapter continues to analyze non-[a]-vowel group and *Hékǒu* (合口). Also, the next chapter argues the factors of vowel changes.

Chapter 4 Entering Tone in Sino-Xenic Languages (II)

4.0 Introduction

This current chapter not only explores the non-[a]-vowel group and *Hékǒu* (合口) of entering tone in Southern Min, Sino-Japanese and Sino-Korean, but also discusses how internal syllable structure affects phonological change in Sino-Xenic languages.

The organization of this chapter is as the following. The data of non-[a]-vowel group in Sino-Xenic languages and the reconstruction of Middle Chinese are exhibited in section 4.1, and section 4.2 discusses the phonological change in *FMD-OT* account. Section 4.3 displays the data pertinent to *Hékǒu* (合口), along with the reconstruction of Middle Chinese, and the vowel and consonant change of *Hékǒu* (合口) is investigated in section 4.4. The final section is dedicated to the influences of syllable structure in phonological change.

4.1 Data of non-[a]-vowel group

The following section represents the data of non-[a]-vowel group. The modern pronunciation of Southern Min, Sino-Japanese and Sino-Korean is exhibited firstly. Then the reconstruction of Middle Chinese is shown in second part. Table 4.1 and 4.2, without onset, demonstrate Division I and III in entering tone of the three languages when the main vowel is not [a].

As Table 4.1 suggests, only *Zēngshè* (曾攝) is found in non-[a]-vowel group. The main vowels are various in the three languages. Southern Min is [i] and Sino-Japanese is [o]. [ɨ] occurs in Sino-Korean.

Table 4.1: Division I in Entering Tone among SM, SJ and SK

Shè (攝)	*Yǜnbù* (韻部)	Southern Min	Sino-Japanese	Sino-Korean
Zēngshè (曾攝)	*dé* (德)	-ik	-okɯ	-ɨk

Table 4.2 includes three *Yǜnbù* (韻部), Division III in particular. In addition to bilabial endings in *Xiánshè* (咸攝), there are alveolar ending in *Zhēnshè* (臻攝) and velar

ending in *Zēngshè* (曾攝)[32]. As in Division I, the main vowel in Southern Min is [i] for the three endings. The vowels for Sino-Korean show similarity where the main vowel is [i], only part of *Shēngshè* (深攝) being [ɯ]. This consistency is not observed in Sino-Japanese. *Shēngshè* (深攝) is presented as long vowel [ɯ], *Zhēnshè* (臻攝) as [i] and *Zēngshè* (曾攝) as [o].

Table 4.2: Division III in Entering Tone among SM, SJ and SK

Shè (攝)	*Yùnbù* (韻部)	Southern Min	Sino-Japanese	Sino-Korean
Shēngshè (深攝)	*qì* (緝)	-ip	-jɯ:	-ip / -ɨp
Zhēnshè (臻攝)	*zhí*(質) /*qì*(迄)	-it	-itsɯ	-il
Zēngshè (曾攝)	*zhí* (職)	-ik	-jokɯ	-ik

The comparison of Table 4.1 and 4.2 displays that the two divisions of *Zēngshè* (曾攝) in Southern Min have converged as one, which is not observed in Sino-Japanese and Sino-Korean, however.

4.1.1 Southern Min

Exemplified by Table 4.3, Division I of entering tone in Southern Min is primarily pronounced as [i]. However, there is one exception according to the percentage in Table 4.3. 93.33% of *dé* rhyme (德韻) is -ik, whereas 6.67% is -ok.

Table 4.3: Examples and the percentage of Division I in Southern Min

Zēngshè (曾攝)		
dé (德)		
墨 (bik8)	德 (tik4)	克 (k^hik4)
-ik (14) 93.33%		
-ok (1) 6.67%		
Total: 15 (100%)		

[32] The non-[a]-vowel group also includes *Tōngshè* (通攝), which is not discussed here. *Tōngshè* (通攝) includes *Hékǒu* (合口) only, so the discussion is arranged in the section of *Hékǒu* (合口).

Table 4.4 offers Division III of entering tone in Southern Min. The three *Yùnbù* (韻部) are [i] and the percentage shown in Table 4.4 reveals that there is no variation because all of them are 100%.

Table 4.4: Examples and the percentage of Division III in Southern Min

Shēngshè (深攝)	*Zhēnshè* (臻攝)		*Zēngshè* (曾攝)
qì (緝)	*zhí* (質)	*qì* (迄)	*zhí* (職)
立 (lip8) 習 (sip8) 急 (kip4)	筆 (pit4) 七 (ts^hit4) 吉 (kit4)	迄 (hit4) 乞 (k^hit4)	力 (lik8) 式 (sik4) 億 (ik4)
-ip (24) 100%	-it (28) 100%		-ik (28)100%
Total: 24 (100%)	Total: 28 (100%)		Total: 28 (100%)

4.1.2 Sino-Japanese

[o] is the only vowel for Division I of entering tone in Sino-Japanese since, according to Table 4.5, the percentage of *Zēngshè* (曾攝) is 100%.

Table 4.5: Examples and the percentage of Division I in Sino-Japanese

Zēngshè (曾攝)		
dé (德)		
墨 ボク (bokɯ)	德 トク (tokɯ)	克 コク (kokɯ)
-okɯ (15) 100%		
Total: 15 (100%)		

Details in Table 4.6 exhibit Division III of entering tone in Sino-Japanese. *Shēngshè* (深攝) is pronounced as [ɯ], *Zhēnshè* (臻攝) as [i] and *Zēngshè* (曾攝) as [o]. Although the main vowel *Zēngshè* (曾攝) is [o] (92.86%), there is one exception in *Zēngshè* (曾攝), -okɯ without glide (7.14%).

Table 4.6: Examples and the percentage of Division III in Sino-Japanese

Shēngshè (深攝)	*Zhēnshè* (臻攝)		*Zēngshè* (曾攝)
qì (緝)	*zhí* (質)	*qì* (迄)	*zhí* (職)
立 リュウ(rjɯ:) 習 シュウ(sjɯ:) 急 キュウ (kjɯ:)	筆 ヒツ (hitsɯ) 七 シツ (sitsɯ) 吉 キツ (kitsɯ)	迄 キツ (kitsɯ) 乞 キツ (kitsɯ)	力 リョク(rjokɯ) 式 ショク(sjokɯ) 億 オク(okɯ)
-jɯ: (24) 100%	-itsɯ (28) 100%		-jokɯ (26) 92.86% -okɯ (2) 7.14%
Total: 24 (100%)	Total: 28 (100%)		Total: 28 (100%)

4.1.3 Sino-Korean

Based on Table 4.7, the vowels of Division I of entering tone in Sino-Korean are more complicated[33]. Although the main vowel is [ɨ], it occupies more than half of the examples (53.33%). Vowel [u] occupies 20% and vowel [ə] occupies 13.33% of *Zēngshè* (曾攝). Other representations, [a] and [ɛ], also appear once in *Zēngshè* (曾攝), about 6.67% for each.

Table 4.7: Examples and the percentage of Division I in Sino-Korean

Zēngshè (曾攝)		
dé (德)		
墨 묵 (muk)	德 덕 (tək)	克 극 (kɨk)
-ɨk (8) 53.33% -uk (3) 20% -ək (2) 13.33% -ak (1) 6.67% -ɛk(1) 6.67%		
Total: 15 (100%)		

The vowels of Division III of entering tone in Sino-Korean are relatively various, shown in Table 4.8. Vowels [ɨ] and [i] occupy most of each *Yùnbù* (韻部), 95.83% in *Shēngshè* (深攝), 92.86 % in *Zhēnshè* (臻攝), 75% in *Zēngshè* (曾攝). The exception of

[33] See footnote 23 in Chapter 3.

Shēngshè (深攝) is -a (4.17%). *Zhēnshè* (臻攝) includes two variations, -əl (3.57%) and -jul (3.57%). Other vowels, such as [ə] and [ɛ], also show up in *Zēngshè* (曾攝).

Table 4.8: Examples and the percentage of Division III in Sino-Korean

Shēngshè (深攝)	*Zhēnshè* (臻攝)		*Zēngshè* (曾攝)
qì (緝)	*zhí* (質)	*qì* (迄)	*zhí* (職)
立 입 (ip) 習 습 (sɨp) 急 급 (kɨp)	筆 필 (p^hil) 七 칠 (c^hil) 吉 길 (kil)	迄 흘 (hɨl) 乞 걸 (kəl)	力 역 (jək) 式 식 (sik) 億 억 (ək)
-ip (12) 50% -ɨp (11) 45.83% -ap (1) 4.17%	-il (21) 75% -ɨl (5) 17.86% -əl (1) 3.57% -jul (1) 3.57%		-ik(16) 57.14% -ɨk (5)17.86% -ək (3) 10.71% -ɛk (2) 7.14% -jək (2) 7.14%
Total: 24 (100%)	Total: 28 (100%)		Total: 28 (100%)

4.1.4 Reconstruction of Middle Chinese

The following section focuses on the reconstructed Middle Chinese. Based on Pan and Feng (2000), Zhu (2001) and Zhengchang (2003), the main vowel of Division I and III in non-[a]-vowel group is central vowel, [ə]. Table 4.9 summarizes the reconstructions of Division I and Table 4.10 outlines Division III of non-[a]-vowel group. The representations in Division III of *Zhēnshè* (臻攝), *zhí* rhyme (質韻) are twofold, jĕt and jet, resulting from *Chóngniú* (重紐), more than one representation in one *Yùnbù* (韻部).

Table 4.9: Reconstruction of Division I in Entering Tone

Shè (攝)	*Yùnbù* (韻部)	Reconstruction
Zēngshè (曾攝)	*dé* (德)	-ək

Table 4.10: Reconstruction of Division III in Entering Tone

Shè (攝)	*Yùnbù* (韻部)	Reconstruction
Shēngshè (深攝)	*qì* (緝)	-jəp (-jep)
Zhēnshè (臻攝)	*zhí* (質) / *qì* (迄)	jĕt (jet) /-jət
Zēngshè (曾攝)	*zhí* (職)	-jək

4.2 Main changes of non-[a]-vowel group and exception

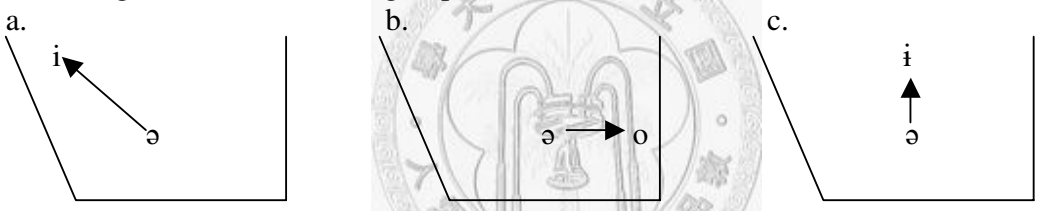
This section demonstrates the three changes of *Shēngshè* (深攝), *Zhēnshè* (臻攝) and *Zēngshè* (曾攝) in non-[a]-vowel group. Besides, this section discusses the exception of non-[a]-vowel, Sino-Japanese: Division III of *Shēngshè* (深攝).

4.2.1 *Shēngshè* (深攝), *Zhēnshè* (臻攝) and *Zēngshè* (曾攝)

From Table 4.9, the modern pronunciation of Sino-Xenic languages, and Table 4.10, the reconstruction of Middle Chinese, the phonological change of these three languages develop separately. There are two reconstructed vowels in non-[a]-vowel group, [ə] and [e]. The changes illustrated in (1) are for [ə] where (1a) stands for fronting from [ə] to [i], (1b) for backing from [ə] to [o] and (1c) for raising from [ə] to [ɨ][34].

(1) Changes of non-[a]-vowel group

a. b. c.



Changes in these three languages are shortly described as *-ə > -i (1a), *-ə > -o (1b) and *-ə > -ɨ (1c). In *FMD-OT* account, the context is translated as constraints in (2). (2a) and (2b) are the faithfulness constraints that remain the contrast of input and output. (2c) and (2d) are set of dispersion constraints to distinguish vowel space as wide as possible. (2e-h) are the markedness constraints.

(2) a. $\mathcal{F}$ color: The output color should be faithful to the input
b. $\mathcal{F}$ height: The output height should be faithful to the input
c. $\mathcal{D}$ height: [əɨ] » [aə] » [əi], [əu] » [aɨ]
d. $\mathcal{D}$ color: [əe], [əo] » [eo]
e. $\mathcal{M}$-ə: No vowel [ə]

[34] This vowel change specifically refers to *Shēngshè* (深攝) in Sino-Korean. Zhu (2001) suggests that the phenomenon of *Chóngniú* (重紐) is retained in Sino-Korean. Although the main vowel of *Shēngshè* (深攝) in Sino-Korean is [i], which undergoes the similar change in (1a), the other vowel [ɨ] takes approximately half of *Shēngshè* (深攝). As a result, the change of [ɨ] is also demonstrated.

f. $\mathcal{M}$-i: No vowel [i]
g. $\mathcal{M}$-o: No vowel [o]
h. $\mathcal{M}$-ɨ: No vowel [ɨ]

In (2), (2d) is a new set of dispersion constraints, stemming from mid vowels, e-ə-o. The most distinguished pair is [eo] ($\mathcal{D}_3$ color), which is better than [əe] and [əo] ($\mathcal{D}_1$ color). According to articulatory effort, the most distinguished constraint is ranked lowest, shown in (3).

(3) [əe], [əo] » [eo]
$\mathcal{D}_1$ color $\mathcal{D}_3$ color

The first ranking for vowel fronting from [ə] to [i] is proposed in (4) where dispersion constraint is the highest and faithfulness constraint is the lowest. Regarding the two markedness constraints, $\mathcal{M}$-ə outranks $\mathcal{M}$-i.

(4) $\mathcal{D}_C$ height » $\mathcal{M}$-ə » $\mathcal{M}$-i » $\mathcal{F}$ height

(5)

Input: -ə -i	$\mathcal{D}_C$ height	$\mathcal{M}$-ə	$\mathcal{M}$-i	$\mathcal{F}$ height
a. -ə -i	*!	*	*	
b. -ə		*!		*
☞ c. -i			*	*

According to ranking (4), the optimal is (5c). Without distinction, (5a) is not favored because it violates the undominated constraint. Selection of (5b) and (5c) depends on the markedness constraints. Now that $\mathcal{M}$-ə outranks $\mathcal{M}$-i, (5b) is excluded. Therefore (5c) surfaces as the most harmonic.

Ranking for vowel backing from [ə] to [o] is offered in (6). Dispersion constraint dominates the other constraints. The markedness constraints follow dispersion constraint, $\mathcal{M}$-ə outranking $\mathcal{M}$-o. Faithfulness constraint is dominated by markedness constraints.

(6) $\mathcal{D}_0$ color » $\mathcal{M}$-ə » $\mathcal{M}$-o » $\mathcal{F}$ color

(7)

Input: -ə -o	$\mathcal{D}_0$ color	$\mathcal{M}$-ə	$\mathcal{M}$-o	$\mathcal{F}$ color
a. -ə -o	*!	*	*	
b. -ə		*!		*
☞ c. -o			*	*

The optimal in (7) is (7c), a result from ranking (6). Unable to distinguish vowel space, (7a) is firstly deleted. Then the choice turns to (7b) and (7c). The criterion, $\mathcal{M}$-ə outranking $\mathcal{M}$-o, determines (7c) to be the most harmonic because it does not violate constraint, $\mathcal{M}$-ə, the higher constraint.

(8) provides the ranking of vowel raising from [ə] to [ɨ]. Dispersion constraint outranks the other constraints, followed by markedness constraints, in which $\mathcal{M}$-ə outranks $\mathcal{M}$-ɨ. Also markedness constraints dominate faithfulness constraint.

(8) $\mathcal{D}_A$ height » $\mathcal{M}$-ə » $\mathcal{M}$-ɨ » $\mathcal{F}$ height

(9)

Input: -ə -ɨ	$\mathcal{D}_A$ height	$\mathcal{M}$-ə	$\mathcal{M}$-ɨ	$\mathcal{F}$ height
a. -ə -ɨ	*!	*	*	
b. -ə		*!		*
☞ c. -ɨ			*	*

Ranking (8) leads to (9c), the optimal outcome. Being the most faithful to the input, (9a), however, is disfavored for the reason that it does not comply with the undominated constraint. For (9b) and (9c), which is more harmonic relies on the markedness constraints. Higher ranking of $\mathcal{M}$-ə prevents (9b) from surfacing as the optimal. Hence (9c) becomes the optimal even though it violates one markedness constraint.

Furthermore, *-e > -i is the second vowel change of non-[a]-vowel group. When it comes to the constraints, there are four in (10). Faithfulness constraint, (10a), maintains contrast of input and output in height. (10b) is the dispersion constraint, distinguishing vowel space. (10c) and (10d) are the markedness constraints.

(10) a. $\mathcal{F}$ height: The output height should be faithful to the input
b. $\mathcal{D}$ height: Pairs of [aæ], [æɛ], [ɛe], [ei] » [aɛ], [æe], [ɛi] » [ae], [æe] » [ai]
c. $\mathcal{M}$-i: No vowel [i]
d. $\mathcal{M}$-e: No vowel [e]

Below, displayed in (11), is the ranking of (10). The lowest constraint is the faithfulness constraint and the highest is dispersion constraint. Also, $\mathcal{M}$-e outranks $\mathcal{M}$-i.

(11) $\mathcal{D}_2$ height » $\mathcal{M}$-e » $\mathcal{M}$-i » $\mathcal{F}$ height

(12)

Input: -e -i	$\mathcal{D}_2$ height	$\mathcal{M}$-e	$\mathcal{M}$-i	$\mathcal{F}$ height
a. -e -i	*!	*	*	
b. -e		*!		*
☞ c. -i			*	*

(12a), the most faithful one, is eliminated in the first place due to its failure to be as distinguished as possible. The evaluation focuses on (12b) and (12c) by the ranking of markedness constraints. As $\mathcal{M}$-e outranks $\mathcal{M}$-i, (12c) defeats (12b) and (12c) becomes the optimal.

4.2.2 Exception: Sino-Japanese: Division III of *Shēngshè* (深攝)

Section 4.2.1 has primarily demonstrated the changes of non-[a]-vowel group. However there is one exception[35], Division III of *Shēngshè* (深攝) in Sino-Japanese. (13) exemplifies the four stages of *Shēngshè* (深攝).

(13) 十 (シュウ; ten)

σ	σ	σ	σ	Syllable
/ \	/ \	/ \	/ \	
μ μ	μ μ	μ μ	μ μ	Mora
/\ /\	/\ /\	/\ |	| /	
si pɯ→	si Φɯ→	si ɯ →	sjɯ	Segment
1	2	3	4	Stage

The first two stages are the ones for intervocalic changes, which have been seen in Chapter 3. Lenition triggers the interaction of the two vowels (stage 3) where [i] is weakened as glide [j]. The context is paraphrased as four constraints in (14). The faithfulness constraints are shown in (14a) and (14b) and markedness constraints are demonstrated in (14c) and (14d).

[35] This exception also relates to opacity. For the two criteria, see section 3.3.1.

(15) is the ranking of (14). First, since vowel [i] is not preserved in modern representation, $\mathcal{M}$-i is not dominated by other constraints. Glide formation implies that $\mathcal{F}$ place outranks $\mathcal{F}$ segment. The lowest constraint is $\mathcal{M}$-ɯ.

(14) a. $\mathcal{F}$ segment: The output segment should be faithful to the input
b. $\mathcal{F}$ place: The output place should be faithful to the input
c. $\mathcal{M}$-i: No vowel [i]
d. $\mathcal{M}$-ɯ: No vowel [ɯ]

(15) $\mathcal{M}$-i » $\mathcal{F}$ place » $\mathcal{F}$ segment » $\mathcal{M}$-ɯ

(16)

Input: -iɯ	$\mathcal{M}$-i	$\mathcal{F}$ place	$\mathcal{F}$ segment	$\mathcal{M}$-ɯ
a. -iɯ	*!			*
b. -ɯ			*!	*
c. -i	*!		*	
☞ d. -jɯ				*

Ranking (15) results in (16d).) Violating the highest constraint, (16a) fails to be optimal. In order to distinguish the vowel space, (16b) and (16c) delete one vowel, which violates faithfulness constraint. Violation of faithfulness constraint leads to elimination of (16b) and (16c). Avoiding $\mathcal{M}$-i and not violating $\mathcal{F}$ place, (16d) surfaces as the output candidate for next stage.

The gap resulting from glide formation is filled by vowel [ɯ] and the second mora is maintained (stage 4), that is, compensatory lengthening. This process has been presented in Chapter 3.

4.3 Data of *Hékǒu* (合口)

Hékǒu (合口) specifically refers to the prevocalic bilabial glide, as either -w- or -u-. The divisions in entering tone among the three languages with *Hékǒu* (合口) are exhibited in the following tables where Table 4.11- 4.14 show the four divisions of [a]-vowel group and Table 4.15-4.16 demonstrate non-[a]-vowel group.

Based on Table 4.11, Division I of [a]-vowel group has two prevocalic bilabial glide, one in *Shānshè* (山攝) of Southern Min, -uat, and the other in *Dàngshè* (宕攝) of Sino-Korean, -wak. Sino-Japanese has no bilabial glide in modern form.

Table 4.11: Division I in Entering Tone among SM, SJ and SK with *Hékǒu* (合口)

Shè (攝)	*Yùnbù* (韻部)	Southern Min	Sino-Japanese	Sino-Korean
Shānshè (山攝)	*mò* (末)	-uat	-atsɯ	-al
Dàngshè (宕攝)	*duó* (鐸)	-ok	-akɯ	-wak

Mentioning Division II of [a]-vowel group with *Hékǒu* (合口), shown in Table 4.12, the bilabial stop exists in *Shānshè* (山攝) of Southern Min, -uat and in Sino-Korean, -wal from *Shānshè* (山攝) and -wek from *Gěngshè* (梗攝). No example is found in Sino-Japanese.

Table 4.12: Division II in Entering Tone among SM, SJ and SK with *Hékǒu* (合口)

Shè (攝)	*Yùnbù* (韻部)	Southern Min	Sino-Japanese	Sino-Korean
Shānshè (山攝)	*xiá* (黠)/*xiá*(鍘)	-uat	-atsɯ	-wal
Gěngshè (梗攝)	*mò*(陌)/*mài*(麥)	-ik	-akɯ	-wek[36]

Divisions III and IV of [a]-vowel group are shown in Table 4.13 and 4.14. Again, Division III and IV of *Shānshè* (山攝) are -uat. In addition, *Xiánshè* (咸攝) is -uat, where originally the coda should be -p instead of -t. Only the bilabial glide of *Dàngshè* (宕攝) in Sino-Korean is maintained in Division III. Sino-Japanese does not preserve any bilabial glide.

Table 4.13: Division III in Entering Tone among SM, SJ and SK with *Hékǒu* (合口)

Shè (攝)	*Yùnbù* (韻部)	Southern Min	Sino-Japanese	Sino-Korean
Xiánshè (咸攝)	*fá* (乏)	-uat	-o:	-əp / -ip
Shānshè (山攝)	*xüē*(薛)/*yuè*(月)	-uat	-etsɯ	-əl
Dàngshè (宕攝)	*yào (藥)*	-ok	-akɯ	-wak
Gěngshè (梗攝)	*xí* (昔) / *mò* (陌)	-ik	-eki	-jək

[36] 왹 can be pronounced as [wek] or [øk] (Sohn 1999).

Table 4.14: Division IV in Entering Tone among SM, SJ and SK with *Hékǒu* (合口)

Shè (攝)	*Yùnbù* (韻部)	Southern Min	Sino-Japanese	Sino-Korean
Shānshè (山攝)	*xiè* (屑)	-uat	-etsɯ	-jəl

Table 4.15 and 4.16 concentrate on the non-[a]-vowel group. *Tōngshè* (通攝) is the subcategory that only keeps the bilabial feature of *Hékǒu* (合口). Neither Division I nor Division III exhibits any prevocalic bilabial glide.

Table 4.15: Division I in Entering Tone among SM, SJ and SK with *Hékǒu* (合口)

Shè (攝)	*Yùnbù* (韻部)	Southern Min	Sino-Japanese	Sino-Korean
Zhēnshè (臻攝)	*mò* (沒)	-ut	-otsɯ	-ol
Zēngshè (曾攝)	*dé* (德)	-ik	-okɯ	-ok
Tōngshè (通攝)	*ū* (屋) / *wò* (沃)	-ok	-okɯ	-ok

Table 4.16: Division III in Entering Tone among SM, SJ and SK with *Hékǒu* (合口)

Shè (攝)	*Yùnbù* (韻部)	Southern Min	Sino-Japanese	Sino-Korean
Zhēnshè (臻攝)	*shù*(術) /*ù* (物)	-ut	-jotsɯ	-ul
Zēngshè (曾攝)	*zhí* (職)	-ik	-jokɯ	-jək
Tōngshè (通攝)	*ū* (屋) / *zhú* (燭)	-iok	-jokɯ	-ok

4.3.1 Southern Min

In [a]-vowel group of Southern Min, only *Shānshè* (山攝) and the Division III of *Xiánshè* (咸攝) preserve *Hékǒu* (合口). Others delete the prevocalic bilabial glide. The percentage of Southern Min is shown in Table 4.17 and 4.18. *Shānshè* (山攝) does not show variants in Division I, both of which occupy 100%. *Dàngshè* (宕攝) is -ok, occupying 100%. In Division II of *Hékǒu* (合口), one-third (33.33%) of *Gěngshè* (梗攝) is pronounced as -ok and two-third (66.67%) as -ik.

Table 4.17: Examples and the percentage of Division I in Southern Min with *Hékǒu* (合口)

Shānshè (山攝)	*Dàngshè* (宕攝)
mò (末)	*duó* (鐸)
撥 (puat4) 奪 (tuat8) 括 (kuat4)	郭 (kok4) 擴 (k^hok4) 霍 (hok4)
-uat (17) 100%	-ok (7) 100%
Total: 17 (100%)	Total: 7 (100%)

Table 4.18: Examples and the percentage of Division II in Southern Min with *Hékǒu* (合口)

Shānshè (山攝)		*Gěngshè* (梗攝)	
xiá (黠)	*xiá* (鎋)	*mò (*陌)	*mài* (麥)
滑 (huat8) 猾 (huat8) 挖 (uat4)	刷 (suat4) 刮 (kuat4)	虢 (kok4)	獲 (hik8) 劃 (hik8)
-uat (5) 100%		-ik (2) 66.67% -ok(1) 33.33%	
Total: 5 (100%)		Total: 3 (100%)	

In Division III and IV of Southern Min with *Hékǒu* (合口), *Xiánshè* (咸攝) as well as *Shānshè* (山攝) contains the prevocalic bilabial glide. *Xiánshè* (咸攝) has undergone another change that does not happen in *Shānshè* (山攝). *Xiánshè* (咸攝), characterized as the bilabial stop ending, -p, changes its bilabial stop ending to alveolar stop ending. This change prevents the conflict of two labials in one phonological domain (Cheng 2002). The percentage of Southern Min concerning Division III and IV shown in Table 4.19, 4.20 and 4.21 suggests that *Xiánshè* (咸攝) and *Gěngshè* (梗攝) do not show variation, all of which occupy 100%. *Shānshè* (山攝) includes one variation, -ut (4.77%), which deletes vowel [a]. The majority of *Dàngshè* (宕攝) is -ok. However one exception of *Dàngshè* (宕攝) is -iok. From the previous three tables, *Shānshè* (山攝) has been taken as a subcategory that keeps bilabial glide. Two examples in Division IV do not follow the same path.

Table 4.19: Examples and the percentage of Division III in Southern Min with *Hékŏu* (合口) (I)

Xiánshè (咸攝)	*Shānshè* (山攝)	
fá (乏)	*xüē* (薛)	*yuè* (月)
法 (huat4) 乏 (huat8)	絕 (tsuat8) 雪 (suat4) 閱 (uat8)	發 (huat4) 月 (guat8) 越 (uat8)
-uat (2) 100%	-uat (20) 95.23% -ut (1) 4.77%	
Total: 2 (100%)	Total: 21 (100%)	

Table 4.20: Examples and the percentage of Division III in Southern Min with *Hékŏu* (合口) (II)

Dàngshè (宕攝)	*Gĕngshè* (梗攝)
yào (藥)	*xí* (昔)
縛 (hok8) 鑊 (kiok4) 籰 (ok)	疫 (ik8) 役 (ik8)
-ok (2) 66.67% -iok (1) 33.33%	-ik (2) 100%
Total: 3 (100%)	Total: 2 (100%)

Table 4.21: Examples and the percentage of Division IV in Southern Min with *Hékŏu* (合口)

Shānshè (山攝)		
xiè (屑)		
決 (kuat4)	缺 (k^huat4)	穴 (hiat8)
-uat (3) 60 % -iat (2) 40 %		
Total: 5 (100%)		

The following three tables put emphasis on Division I and III of non-[a]-vowel group. Although the bilabial glide is not seen in the output, the feature [+bilabial] is preserved in another way. Compare the *Zhēnshè* (臻攝) with and without *Hékŏu* (合口), it is clear that the vowel absorbs feature [+bilabial], transferring [i] to [u]. *Zēngshè* (曾攝) shows the similarity to that without *Hékŏu* (合口), chiefly being -ik. As for *Tōngshè* (通

攝), the main vowel of Divison I and III is identical with each other, with the difference in glide. Division III has glide and Division I does not. The percentage of Division I in non-[a]-vowel group is displayed in Table 4.22. *Zhēnshè* (臻攝) and *Tōngshè* (通攝) change regularly, 100% for both. *Zēngshè* (曾攝) has variants. Two examples out of three are pronounced as [i] and one as [o]. In Division III, *Zhēnshè* (臻攝) and *Zēngshè* (曾攝) are not diverse. *Tōngshè* (通攝), however, shows two tendencies. The main part is -iok (79.66%), while -ok occupies 20.34%[37].

Table 4.22: Examples and the percentage of Division I in Southern Min with *Hékǒu* (合口)

Zhēnshè (臻攝)	*Zēngshè* (曾攝)	*Tōngshè* (通攝)	
mò (沒)	*dé* (德)	*ū* (屋)	*wò* (沃)
沒 (but8) 卒 (tsut4) 骨 (kut4)	國 (kok4) 或 (hik8) 惑 (hik8)	卜 (pok4) 獨 (tok8) 谷 (kok4)	毒 (tok8) 酷 (k^hok4) 沃 (ok4)
-ut (11) 100%	-ik (2) 66.67% -ok (1) 33.33%	-ok (26) 100%	
Total: 11 (100%)	Total: 3 (100%)	Total: 26 (100%)	

Table 4.23: Examples and the percentage of Division III in Southern Min with *Hékǒu* (合口) (I)

Zhēnshè (臻攝)		*Zēngshè* (曾攝)
shù (術)	*ù* (物)	*zhí* (職)
律 (lut8) 戌 (sut4) 出 (ts^hut4)	佛 (hut8) 物 (but4) 掘 (kut4)	域 (ik8)
-ut (20) 100%		-ik (1) 100%
Total: 20 (100%)		Total: 1 (100%)

[37] The minority of *Tōngshè* (通攝), -ok, is related to the onset because in Middle Chinese the onset is gourped as bilabial feature, 非敷奉明.

Table 4.24: Examples and the percentage of Division III in Southern Min with *Hékǒu* (合口) (II)

Tōngshè (通攝)	
ū (屋)	*wò* (沃)
福 (hok4) 目 (bok8) 菊 (kiok4)	足 (tsiok4) 束 (siok4) 玉 (giok8)
-iok (47) 79.66% -ok (12) 20.34%	
Total: 59 (100%)	

4.3.2 Sino-Japanese

Although Sino-Japanese does not show many variations in Division I and II of [a]-vowel group, all of the examples being as [a], there are some differences in history. Numoto (1989) and Huang (2004) indicated that when the onset is dorsal, such as [k], the prevocalic bilabial glide is maintained in Middle Japanese, but deleted later. This phenomenon can be found in *Shānshè* (山攝), *Dàngshè* (宕攝) and *Gěngshè* (梗攝). Take 括 (from Table 4.25) as an example, it has a previous stage as kɯwatsɯ (クヮツ) and after the prevocalic bilabial glide disappears, it becomes katsɯ (カツ)[38]. Sino-Japanese shows only one variation in Division I. As shown in Table 4.25, *Shānshè* (山攝) has -atsɯ (94.12%) and -etsɯ (5.88%). *Dàngshè* (宕攝), Division II of *Shānshè* (山攝) and *Gěngshè* (梗攝) have no variations, occupying 100%.

[38] The prevocalic bilabial glide can be observed in some regions of Japanese (Huang 2004). However, in this study, this difference is not taken into consideration.

Table 4.25: Examples and the percentage of Division I in Sino-Japanese with *Hékǒu* (合口)

Shānshè (山攝)	*Dàngshè* (宕攝)
mò (末)	*duó* (鐸)
撥 ハツ (tatsɯ) 奪 タツ (tatsɯ) 括 カツ (katsɯ)	郭 カク (kakɯ) 擴 カク (kakɯ) 霍 カク (kakɯ)
-atsɯ (16) 94.12% -etsɯ (1) 5.88%	-akɯ (7) 100%
Total: 17 (100%)	Total: 7 (100%)

Table 4.26: Examples and the percentage of Division II in Sino-Japanese with *Hékǒu* (合口)

Shānshè (山攝)		*Gěngshè* (梗攝)	
xiá (黠)	*xiá* (鍘)	*mò* (陌)	*mài* (麥)
滑カツ(katsɯ) 猾カツ(katsɯ) 挖アツ(atsɯ)	刷サツ(satsɯ) 刮カツ(katsɯ)	虢カク(kakɯ)	獲カク(kakɯ) 劃カク(kakɯ)
-atsɯ (5) 100%		-akɯ (3) 100%	
Total: 5 (100%)		Total: 3 (100%)	

With respect to Division III and IV of [a]-vowel group in Sino-Japanese, there are three different vowels. For *Xiánshè* (咸攝), the main vowel is [o], a change from *-ap > -o:. The second main vowel, [a], lies in *Dàngshè* (宕攝). The third is [e], found in *Shānshè* (山攝) as well as *Gěngshè* (梗攝)[39]. On the basis of *Kangorin*, in Division III of *Shānshè* (山攝), the examples known as [etsɯ] in modern form, such as 閱 エツ (etsɯ), are originally recognized as エツ (wetsɯ) where the bilabial glide is deleted. The percentage of Sino-Japanese regarding Division III and IV demonstrated in Table 4.27, 4.28 and 4.29 reveals that *Xiánshè* (咸攝) and *Gěngshè* (梗攝) change regularly, occupying 100%. Division III of *Shānshè* (山攝) is comprised of three parts, -etsɯ (66.67%), -atsɯ

[39] Although *Shānshè* (山攝) and *Gěngshè* (梗攝) have similar vowels, the second vowels vary. *Shānshè* (山攝) is the typical one, -ɯ, whereas *Gěngshè* (梗攝) is the unmarked one, -i.

(28.57%) and -ɯtsɯ (4.76%), and Division IV shows no variation. Twp parts, -akɯ (66.67%) and -jakɯ (33.33%), form *Dàngshè* (宕攝).

Table 4.27: Examples and the percentage of Division III in Sino-Japanese with *Hékǒu* (合口) (I)

Xiánshè (咸攝)	*Shānshè* (山攝)	
fá (乏)	*xüē* (薛)	*yuè* (月)
法 ホウ (ho:) 乏 ホウ (ho:)	絕 セツ (setsɯ) 雪 セツ (setsɯ) 閱 エツ (etsɯ)	發 ハツ (hatsɯ) 月 ゲツ (getsɯ) 越 エツ (etsɯ)
-o: (2) 100%	-etsɯ (14) 66.67% -atsɯ (6) 28.57% -ɯtsɯ (1) 4.76%	
Total: 2 (100%)	Total: 21 (100%)	

Table 4.28: Examples and the percentage of Division III in Sino-Japanese with *Hékǒu* (合口) (II)

Dàngshè (宕攝)	*Gěngshè* (梗攝)
yào (藥)	*xí* (昔)
縛 ハク (hakɯ) 钁 キャク (kjakɯ) 籰 ワク (wakɯ)	疫 エキ (eki) 役 エキ (eki)
-akɯ (2) 66.67% -jakɯ (1) 33.33%	-eki (2) 100%
Total: 3 (100%)	Total: 2 (100%)

Table 4.29: Examples and the percentage of Division IV in Sino-Japanese with *Hékǒu* (合口)

Shānshè (山攝)		
xiè (屑)		
決 ケツ (ketsɯ)	缺 ケツ (ketsɯ)	穴 ケツ (ketsɯ)
-etsɯ (5) 100%		
Total: 5 (100%)		

Although division I of non-[a]-vowel group with *Hékǒu* (合口) in Sino-Japanese exemplified in Table 4.30 is highly homogeneous, the main vowel of *Zhēnsh* (臻攝), *Zēngshè* (曾攝) and *Tōngshè* (通攝) being [o], the percentage offered in Table 4.30 suggests that there is one exception in *Zhēnshè* (臻攝), -ɯtsɯ (9.10%).

Table 4.30: Examples and the percentage of Division I in Sino-Japanese with *Hékǒu* (合口)

Zhēnsh (臻攝)	*Zēngshè*(曾攝)	*Tōngshè* (通攝)	
mò (沒)	*dé* (德)	*ū* (屋)	*wò* (沃)
沒ボツ(botsɯ) 卒ソツ(sotsɯ) 骨コツ(kotsɯ)	國コク(kokɯ) 或コク(kokɯ) 惑コク(kokɯ)	トホク(hokɯ) 獨トク(tokɯ) 谷コク(kokɯ)	毒トク(tokɯ) 酷コク(kokɯ) 沃 オク(okɯ)
-otsɯ (10) 90.90% -ɯtsɯ (1) 9.10%	-okɯ (3) 100%	-okɯ (26) 100%	
Total: 11 (100%)	Total: 3 (100%)	Total: 26 (100%)	

According to Table 4.31 and 4.32, Division III of non-[a]-vowel group with *Hékǒu* (合口) in Sino-Japanese is more diverse than Division I. *Zhēnshè* (臻攝) has three representations, [i], [jɯ] and [ɯ]. These three vowels are complimentarily distributed because [i] and [jɯ], approximately 60.00%, exist in *shù* rhyme (術韻) and [ɯ] (40.00%) in *ù* rhyme (物韻). *Zēngshè* (曾攝) include only one instance, exhibiting vowel [o]. Although *Tōngshè* (通攝) displays five different forms, the distributions are somehow regular. The majority, -jokɯ (40.68%), is exclusively in *wò* rhyme (沃韻) and the other four are all in *ū* rhyme (屋韻). In *ū* rhyme (屋韻), onsets also contribute to the vowel distribution. When the onset is [h], the main vowel is [ɯ] (15.25%); however the main vowel is [o] (5.08%) when the onset is [b][40]. As for -jɯ (13.56%), it is related to the

[40] The onset for vowel [ɯ] is 非敷奉 in Middle Chinese, while the one for vowel [o] is 明 in Middle Chinese.

phonotactic constrain, namely, the onset of -jɯ being [s]. The onset of vowel [i] is less constrained in that it can be alveolar [t, r][41] and velar [k].

Table 4.31: Examples and the percentage of Division III in Sino-Japanese with *Hékǒu* (合口) (I)

Zhēnshè (臻攝)		*Zēngshè* (曾攝)
shù (術)	*ù* (物)	*zhí* (職)
律 リツ (ritsɯ) 戌 シュツ (sjɯtsɯ) 出 シュツ (sjɯtsɯ)	佛 フツ (hɯtsɯ) 物 ブツ (bɯtsɯ) 掘 クツ (kɯtsɯ)	域 ヨク (jokɯ)
-jɯtsɯ (9) 45.00% -ɯtsɯ (8) 40.00% -itsɯ (3) 15.00%		-jokɯ (1) 100%
Total: 20 (100%)		Total: 1 (100%)

Table 4.32: Examples and the percentage of Division III in Sino-Japanese with *Hékǒu* (合口) (II)

Tōngshè (通攝)	
ū (屋)	*wò* (沃)
福 フク (hɯkɯ) 目 ボク (bokɯ) 菊 キク (kikɯ)	足 ショク (sjokɯ) 束 ショク (sjokɯ) 玉 ギョク (gjokɯ)
-jokɯ (24) 40.68% -ikɯ (15) 25.42% -ɯkɯ (9) 15.25% -jɯkɯ (8) 13.56% -okɯ (3) 5.08%	
Total: 59 (100%)	

4.3.3 Sino-Korean

In Sino-Korean, the prevocalic bilabial glide is preserved when the onset is dorsal, like [k] or [h]. Hence, example such as 奪 (탈 t^hal) does not include prevocalic bilabial glide. In Division I of *Shānshè* (山攝) (Table 4.33), Sino-Korean has three parts, -al

[41] The onset of 肉 is neither [t] not [r]. It is ジク [dzikɯ] in *Kanon*.

(58.82%), -wal (35.29%) and -əl (5.82%). In Division II of *Shānshè* (山攝) (Table 4.34), the majority is -wal (80%) and one variant -al (20%). *Dàngshè* (宕攝) and *Gěngshè* (梗攝) are homogeneous, the former being -wak and the latter being -wek.

Table 4.33: Examples and the percentage of Division I in Sino-Korean with *Hékǒu* (合口)

Shānshè (山攝)	*Dàngshè* (宕攝)
mò (末)	*duó* (鐸)
撥 발 (pal) 奪 탈 (t^hal) 括 괄 (kwal)	郭 곽 (kwak) 擴 확 (hwak) 霍 곽 (kwak)
-al (10) 58.82% -wal (6) 35.29% -əl (1) 5.82%	-wak (7) 100%
Total: 17 (100%)	Total: 7 (100%)

Table 4.34: Examples and the percentage of Division II in Sino-Korean with *Hékǒu* (合口)

Shānshè (山攝)		*Gěngshè* (梗攝)	
xiá (黠)	*xiá* (鎋)	*mò* (陌)	*mài* (麥)
滑 활 (hwal) 猾 활 (hwal) 挖 알 (al)	刷 쇄 (swɛ) 刮 괄 (kwal)	虢 괵(kwek)	獲 획 (hwek) 劃 획 (hwek)
-wal (4) 80% -al (1) 20%		-wek (3) 100%	
Total: 5 (100%)		Total: 3 (100%)	

The representations in Division III and IV of Sino-Korean with *Hékǒu* (合口) can be seen in Table 4.35-4.37. *Xiánshè* (咸攝) has two vowels, [ə] and [i]. The main vowels of *Shānshè* (山攝), inclusive of Division IV, and *Gěngshè* (梗攝) remain similar to (開口), both of which are [ə]. *Dàngshè* (宕攝) also shows the similarity in terms of main vowel, [a], along with the prevocalic bilabial glide, however. Table 4.35, 4.36 and 4.37 show the percentage of Division III and IV Sino-Korean. *Xiánshè* (咸攝), *Dàngshè* (宕攝) and *Gěngshè* (梗攝) demonstrate less variation than *Shānshè* (山攝). *Xiánshè* (咸攝) is

formed by [ə] (50%) and [i] (50%), and two third of *Dàngshè* (宕攝) is -wak and one third is -ak. *Gěngshè* (梗攝), with only two examples, shows no variation, -jək (100%). *Shānshè* (山攝) includes six representations[42]. Disregarding the prevocalic glides, -j- and -w-, the majority of *Shānshè* (山攝) is -əl, adding up to 76.19% (33.33% for -əl, 28.57% for -wəl, 14.29% for -jəl). The remaining part of *Shānshè* (山攝) goes to -al (14.29%) -ul (4.76%) and -ol (4.76%), respectively.

Table 4.35: Examples and the percentage of Division III in Sino-Korean with *Hékǒu* (合口) (I)

Xiánshè (咸攝)	*Shānshè* (山攝)	
fá (乏)	*xüē* (薛)	*yuè* (月)
法 법 (pəp) 乏 핍 (p^hip)	絕 절 (cəl) 雪 설 (səl) 閱 열 (jəl)	發 발 (pal) 月 월 (wəl) 越 월 (wəl)
-əp (1) 50% -ip (1) 50%	-əl (7) 33.33% -wəl (6) 28.57% -jəl (3) 14.29% -al (3) 14.29% -ul (1) 4.76% -ol (1) 4.76%	
Total: 2 (100%)	Total: 21 (100%)	

Table 4.36: Examples and the percentage of Division III in Sino-Korean with *Hékǒu* (合口) (II)

Dàngshè (宕攝)	*Gěngshè* (梗攝)
yào (藥)	*xí* (昔)
縛 박 (pak) 鑊 곽 (kwak) 籰 확 (hwak)	疫 역 (jək) 役 역 (jək)
-wak (2) 66.67% -ak (1) 33.33%	-jək (2) 100%
Total: 3 (100%)	Total: 2 (100%)

[42] See footnote 23 in Chapater 3.

Table 4.37: Examples and the percentage of Division IV in Sino-Korean with *Hékǒu* (合口)

Shānshè (山攝)		
xiè (屑)		
決 결 (kjəl)	缺 결 (kjəl)	穴 혈 (hjəl)
-jəl (5) 100%		
Total: 5 (100%)		

Table 4.38 offers the examples as well as the details of Division I with *Hékǒu* (合口) in percentage. *Zhēnshè* (臻攝), first of all, is primarily comprised of vowel, [o] (63.64%). In addition, vowels, such as [u] (27.27%) and [a] (9.09%), complete *Zhēnshè* (臻攝). The majority of *Zēngshè* (曾攝) and *Tōngshè* (通攝) is -ok, occupying 66.67% in *Zēngshè* (曾攝) and 100% in *Tōngshè* (通攝). The exception of *Zēngshè* (曾攝) consists in -uk (33.33%).

Table 4.38: Examples and the percentage of Division I in Sino-Korean with *Hékǒu* (合口)

Zhēnshè (臻攝)	*Zēngshè* (曾攝)	*Tōngshè* (通攝)	
mò (沒)	*dé* (德)	*ū* (屋)	*wò* (沃)
沒 몰 (mol) 卒 졸 (col) 骨 골 (kol)	國 국 (kuk) 或 혹 (hok) 惑 혹 (hok)	卜 복 (pok) 獨 독 (tok) 谷 곡 (kok)	毒 독 (tok) 酷 혹 (hok) 沃 옥 (ok)
-ol (7) 63.64% -ul (3) 27.27% -al (1) 9.09%	-ok (2) 66.67% -uk (1) 33.33%	-ok (26) 100%	
Total: 11 (100%)	Total: 3 (100%)	Total: 26 (100%)	

The examples and the percentage of Division III with *Hékǒu* (合口) are provided in Table 4.39 and 4.40. The main vowel of *Zhēnshè* (臻攝) is [u], with two subtypes -ul (70.00%) and -jul (20.00%). Apart from [u], *Zhēnshè* (臻攝) also has vowel -ol (10.00%). With regard to *Zēngshè* (曾攝), there is no variant, merely -ok. With four types, *Tōngshè* (通攝) can be succinctly grouped as -ok and -uk. 57.63% of *Tōngshè* (通攝) lies in -ok,

50.85% in -ok and 6.78% in -jok. Furthermore, 42.37% of *Tōngshè* (通攝) falls on -uk, where -uk occupies 35.59% and -juk occupies. 6.78%.

Table 4.39: Examples and the percentage of Division III in Sino-Korean with *Hékǒu* (合口) (I)

Zhēnshè (臻攝)		*Zēngshè* (曾攝)
shù (術)	*ù* (物)	*zhí* (職)
律 률 (ljul) 戌 술 (sul) 出 출 (c^hul)	佛 불 (pul) 物 물 (mul) 掘 굴 (kul)	域 역 (jək)
-ul (14) 70.00% -jul (4) 20.00% -ol (2) 10.00%		-jək (1) 100%
Total: 20 (100%)		Total: 1 (100%)

Table 4.40: Examples and the percentage of Division III in Sino-Korean with *Hékǒu* (合口) (II)

Tōngshè (通攝)	
ū (屋)	*wò* (沃)
福 복 (pok) 目 목 (mok) 菊 국 (kuk)	足 족 (cok) 束 속 (sok) 玉 옥 (ok)
-ok (30) 50.85% -uk (21) 35.59% -jok (4) 6.78% -juk (4) 6.78%	
Total: 59 (100%)	

4.3.4 Reconstruction of Middle Chinese with *Hékǒu* (合口)

The following tables depict the reconstructed Middle Chinese. Following Pan and Feng (2000), Zhu (2001) and Zhengchang (2003), the main vowels with *Hékǒu* (合口) are identical with those without *Hékǒu* (合口). Therefore each *Yùnbù* (韻部) is not detailed here. Tables 4.41-4.44 offer the reconstructions of [a]-vowel group and Table 4.45-4.46 provide the reconstructions of non-[a]-vowel group.

Table 4.41: Reconstruction of Division I in Entering Tone

Shè (攝)	*Yùnbù* (韻部)	Reconstruction
Shānshè (山攝)	*mò* (末)	-wɑt
Dàngshè (宕攝)	*duó* (鐸)	-wɑk

Table 4.42: Reconstruction of Division II in Entering Tone

Shè (攝)	*Yùnbù* (韻部)	Reconstruction
Shānshè (山攝)	*xiá* (黠) / *xiá* (鎋)	-wat / -wɐt
Gěngshè (梗攝)	*mò* (陌) / *mài* (麥)	-wak / -wɐk

Table 4.43: Reconstruction of Division III in Entering Tone

Shè (攝)	*Yùnbù* (韻部)	Reconstruction
Xiánshè (咸攝)	*fá* (乏)	-jwɐp
Shānshè (山攝)	*xüē* (薛) / *yuè* (月)	jwæt / -jwɐt
Dàngshè (宕攝)	*yào (藥)*	-jwɑk
Gěngshè (梗攝)	*xí* (昔) / *mò* (陌)	jwæk /-jwɐk

Table 4.44: Reconstruction of Division IV in Entering Tone

Shè (攝)	*Yùnbù* (韻部)	Reconstruction
Shānshè (山攝)	*xiè* (屑)	-iwet

Table 4.45: Reconstruction of Division I in Entering Tone

Shè (攝)	*Yùnbù* (韻部)	Reconstruction
Zhēnshè (臻攝)	*mò* (沒)	-wət
Zēngshè (曾攝)	*dé* (德)	-wək
Tōngshè (通攝)	*ū* (屋) / *wò* (沃)	-uk / -wok

Table 4.46: Reconstruction of Division III in Entering Tone

Shè (攝)	*Yùnbù* (韻部)	Reconstruction
Zhēnshè (臻攝)	*shù* (術) / *ù* (物)	jwĕt (jwet) / -jwət
Zēngshè (曾攝)	*zhí* (職)	-jwək
Tōngshè (通攝)	*ū* (屋) / *zhú* (燭)	-juk / jwok

4.4 Main changes of *Hékǒu* (合口) and exception

This section demonstrates the three changes of Bilabial glide, -w-, *Tōngshè* (通攝) and *Zhēnshè* (臻攝) in *Hékǒu* (合口). Besides, this section discusses the exception of *Hékǒu* (合口), Division II of *Gěngshè* (梗攝) in Sino-Korean.

4.4.1 Bilabial glide, -w-.

The change of prevocalic bilabial glide is either deleted or preserved. For the two options, two constraints are proposed for *Hékǒu* (合口) in *FMD-OT* account.

(17) a. $\mathcal{M}$-Bilabial Glide: No bilabial glide
b. $\mathcal{F}$-Bilabial Glide: The output bilabial glide should be faithful to the input

In (17), V stands for vowel and C for stop endings [p, t (l), k]. If the bilabial glide is preserved, $\mathcal{F}$-Bilabial Glide outranks $\mathcal{M}$-Bilabial Glide. Based on the ranking, therefore (18a) is the optimal because of the harmony of (18a) with the highest constraint.

(18)

Input: -uVC	$\mathcal{F}$-Bilabial Glide	$\mathcal{M}$-Bilabial Glide
☞ a. -uVC		*
b. -VC	*!	

For the case that the glide is deleted, $\mathcal{M}$-Bilabial Glide dominates $\mathcal{F}$-Bilabial Glide. This ranking gives rise to (19b), the optimal output in Tableau (19).

(19)

Input: -uVC	$\mathcal{M}$-Bilabial Glide	$\mathcal{F}$-Bilabial Glide
a. -uVC	*	
☞ b. -VC		*!

In Sino-Japanese the prevocalic bilabial glide is not straight forward. Although the glide, -w-, is deleted in modern form, it is once preserved in history, especially when the onset is [k]. Hence the maintenance of glide in Sino-Japanese is not evaluated by the constraints in (17) due to the restriction of onset. A more language-specific constraint is shown in (20).

(20) a. $\mathcal{M}$-kw: No syllable structure [kw]

The constraint in (20) incorporates with (17b) to select the optimal for Sino-Japanese ($\mathcal{M}$-kw outranks $\mathcal{F}$-Bilabial Glide). (21) demonstrates the result of Sino-Japanese where (21a) surfaces as the optimal because it is more harmonic with the output.

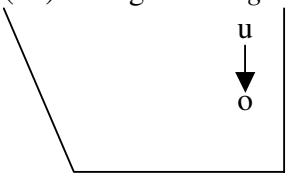
(21)

Input: -kw	$\mathcal{M}$-kw	$\mathcal{F}$-Bilabial Glide
☞ a. -k		*
b. -kw	*!	

4.4.2 *Tōngshè* (通攝)

Aside from the glide, this part discusses the vowel change of *Tōngshè* (通攝), a *Yǜnbù* (韻部) without *Kāikǒu* (開口). The correspondence of Middle Chinese and the modern Sino-Xenic languages indicates that *-u, *-o > -o, demonstrated in (22).

(22) Change of *Tōngshè* (通攝)



In *FMD-OT* account, four constraints come into being for this change in (23).

(23) a. $\mathcal{F}$ height: The output height should be faithful to the input
b. $\mathcal{D}$ height: [ɔo], [ou] » [aɔ], [ɔu] » [ao] » [au]
c. $\mathcal{M}$-u: No vowel [u]
d. $\mathcal{M}$-o: No vowel [o]

(23a), the faithfulness constraint, aims to avoid deletion or insertion. (23b)[43] is the dispersion constraint that functions to distinguish vowels. The other two constraints, (23c) and (23d), are markedness constraints.

Constraints from (23) are ranked as (24). The lowest constraint is the faithfulness constraint and the highest is dispersion constraint. Also, $\mathcal{M}$-u outranks $\mathcal{M}$-o.

(24) $\mathcal{D}_1$ height » $\mathcal{M}$-u » $\mathcal{M}$-o » $\mathcal{F}$ height

(25)

Input: -u -o	$\mathcal{D}_1$ height	$\mathcal{M}$-u	$\mathcal{M}$-o	$\mathcal{F}$ height
a. -u -o	*!	*	*	
b. -u		*!		*
☞ c. -o			*	*

[43] See (21) in chapter 3 for more details about this dispersion constraint.

Firstly, vital violation causes (23a) not to be selected as the optimal although it is faithful to input. (25b) and (25c) are then evaluated by the two markedness constraints. Since $\mathcal{M}$-a dominates $\mathcal{M}$-ə, (25b) is eliminated and (25c) surfaces as the optimal.

4.4.3 *Zhēnshè* (臻攝)

The discussion then turns to *Zhēnshè* (臻攝) with *Hékǒu* (合口). The modern representations of *Zhēnshè* (臻攝) with *Hékǒu* (合口) show that from Middle Chinese the sound change is affected by the prevocalic bilabial glide although it is deleted in the output. Regardless of the divisions of Southern Min, the prevocalic bilabial glide affects the central vowel and moves it to back position, *-(j)wə > -u. This influence can be also observed in Division III of Sino-Japanese and Sino-Korean. This context is paraphrased as four constraints in (26).

(26) a. $\mathcal{F}$ height: The output height should be faithful to the input
b. $\mathcal{D}$ height: [əɨ] » [aə] » [əi], [əu] » [aɨ]
c. $\mathcal{M}$-ə: No vowel [ə]
d. $\mathcal{M}$-u: No vowel [u][44]

(27) shows the ranking of (26). Dispersion constraint is the highest, followed by markedness constraints, $\mathcal{M}$-ə outranking $\mathcal{M}$-u. The faithfulness constraint is the lowest.

(27) $\mathcal{D}_C$ height » $\mathcal{M}$-ə » $\mathcal{M}$-u » $\mathcal{F}$ height

(28)

Input: -ə -u	$\mathcal{D}_C$ height	$\mathcal{M}$-ə	$\mathcal{M}$-u	$\mathcal{F}$ height
a. -ə -u	*!	*	*	
b. -ə		*!		*
☞ c. -u			*	*

Ranking (27) leads to (28c), the optimal outcome. Faithful to the input as it is, (28a) is disfavored due to failure to harmonize with the undominated constraint. (28b) and (28c) are evaluated by the markedness constraints. $\mathcal{M}$-ə forbids (28b) to surface as the optimal. Hence (28c) is the optimal in spite of violation of one markedness constraint.

[44] The -u here also stands for the Japanese unrounded back high vowel [ɯ].

Division I of Sino-Japanese and Sino-Korean develop separately. The constraints for sound change in *Zhēnshè* (臻攝), *-wə > -o, are shown in (29).

(29) a. $\mathcal{F}$ color: The output color should be faithful to the input
b. $\mathcal{D}$ color: [əe], [əo] » [eo]
c. $\mathcal{M}$-ə: No vowel [ə]
d. $\mathcal{M}$-o: No vowel [o]

Ranking of (29) is offered in (30). Dispersion constraint ranks higher than markedness constraints where $\mathcal{M}$-ə outranks $\mathcal{M}$-o. Faithfulness constraint is dominated by markedness constraints.

(30) $\mathcal{D}_0$ color » $\mathcal{M}$-ə » $\mathcal{M}$-o » $\mathcal{F}$ color

(31)

Input: -ə -o	$\mathcal{D}_0$ color	$\mathcal{M}$-ə	$\mathcal{M}$-o	$\mathcal{F}$ color
a. -ə -o	*!	*	*	
b. -ə		*!		*
☞ c. -o			*	*

The optimal is (31c), from the ranking (30). (31a) is firstly deleted owing to vital violation. Then (31b) and (31c) are evaluated, determined by the ranking, $\mathcal{M}$-ə » $\mathcal{M}$-o. (31c) is the most harmonic because it does not violate constraint, $\mathcal{M}$-ə.

4.4.4 Exception: Division II of *Gěngshè* (梗攝) in Sino-Korean

The excpetion in *Hékǒu* (合口) consists in Division II of *Gěngshè* (梗攝)[45]. Although Division II of *Gěngshè* (梗攝) with *Hékǒu* (合口) contains bilabial glide, the main vowel undergoes the change, *-ak > -aik. After the insertion of [i] between [a] and [k], the glide -w- converges with vowel [a], resulting in vowel [o], *-waik > -oik[46] (Woo 2005). In *FMD-OT* account, six constraints are proposed in (32) for this change.

(32) a. $\mathcal{F}$ segment: The output segment should be faithful to the input
b. $\mathcal{F}$ place: The output place should be faithful to the input
c. $\mathcal{F}$ uniformity: The output uniformity should be faithful to the input
d. $\mathcal{M}$-w: No glide [w]

[45] This exception also relates to opacity. For the two criteria, see section 3.3.1.
[46] The modern pronunciation of -oik is -wek or -øk

e. $\mathcal{M}$-a: No vowel [a]

f. $\mathcal{M}$-o: No vowel [o]

The first three constraints (32a)-(32c) are faithfulness constraints for different purposes. (32a) prevents insertion or deletion of segment. (32b) avoids the chnaeg in place. (32c) prohibits coalescence. (32d)-(32f) are the markedness constraints where (32d) aims to maintain the well-formedness of glide, -w-, and (32e) and (32f) maintain the well-formedness of vowels, [a] and [o].

*-waik > -oik suggests that $\mathcal{M}$-w and $\mathcal{M}$-a dominate $\mathcal{M}$-o, and markedness constraint outrank faithfulness constraint. The ranking is shown in (33).

(33) $\mathcal{M}$-w, $\mathcal{M}$-a » $\mathcal{F}$ segment, $\mathcal{F}$ place » $\mathcal{M}$-o » $\mathcal{F}$ uniformity

(34)

Input: -wa	$\mathcal{M}$-w, $\mathcal{M}$-a	$\mathcal{F}$ segment, $\mathcal{F}$ place	$\mathcal{M}$-o	$\mathcal{F}$ uniformity
a. -wa	*!*		*	
b. -wo	*!	*	*	
☞ c. -o			*!	*
d. -a	*!	*		

Vital violation of the highest constraint prevents (34a) from being the optimal in spite of its faithfulness to input. (34b), the main vowel being raised from [a] to [o], is deleted due to violation of the undominated constraint. The output, (34d), which deletes the glide, violates not only the highest constraint but also $\mathcal{F}$ segment, giving rise to elimination. (34c), undergoing coalescence, abides by the higher constraints but violates $\mathcal{F}$ uniformity. (34c), as a result, surfaces as the optimal.

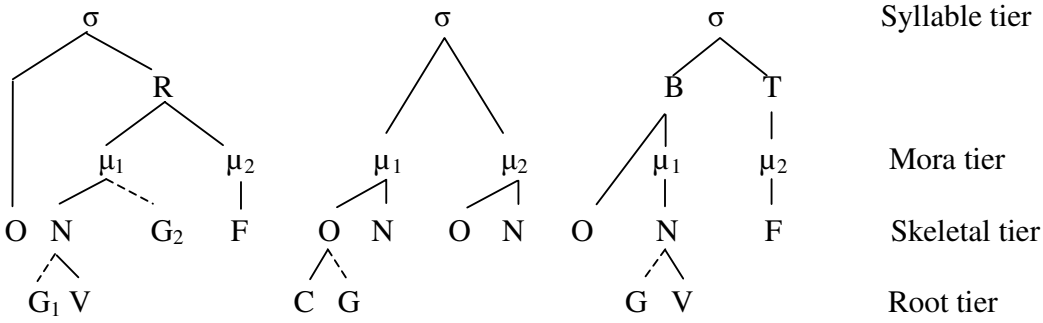
4.5 The Influences of Internal Syllable Structure

This section investigates how internal syllable structure triggers vowel changes and discusses the factors: phonotactic constraints and licensing constraints.

The first factor lies in phonotactic constraints, specifically referring to a result of prohibiting diphthong. Diphthong is generally divided into heavy and light diphthong (Lee 1998). The former refers to main vowel and postvocalic glide, while the latter involves in prevocalic glide and main vowel.

Previously in Chapter 3 and Chapter 4, heavy diphthong is disfavored in Sino-Japanese and Sino-Korean. Heavy diphthong is allowed only in Southern Min[47]. Therefore, the prohibition of heavy diphthong results from the interconstitute syllable structure. (35) demonstrates the internal syllable structures of Southern Min (35a), Sino-Japanese (35b) and Sino-Korean (35c).

(35) a. b. c.



It is proposed that if a syllable node branches and the moras belong to one branch of a syllable node, the segments below this node do not interact with each other. This refers to (35a). Since the moras locate within rhyme node, the nuclear will not interact with G_2. On the contrary, if the mora is dominated by different branch of syllable node, the interaction occurs. This situation indicates (35b) and (35c). The vowels below the mora tier might interact with other segment(s). Furthermore, the languages that interaction occurs can be categorized into mora-prominent and non-mora-prominent. As aforementioned in Chapter 3, *Xiánshè* (咸攝) of Sino-Japanese, after the lenition of [p] and the interaction of vowels, in order to maintain the number of moras, the vowel is prolonged. However, Sino-Korean is not mora-prominent. Sino-Korean does not tend to preserve numbers of mora. Exemplified by *Gěngshè* (梗攝), the new mora generated from vowel [i] is deleted, which results in vowel coalescence.

Besides, the interaction of internal constitutes occurs in light diphthong. In Southern Min, owing to the phonotactic constraints where the moras are not directly dominated by syllable branch, light diphthong (glide + vowel), such as well as heavy diphthong (vowel

[47] Although heavy diphthongs, [ai] and [au], are legitimate in Southern Min, in this study, entering tone does not include heavy diphthong. The examples of heavy diphthong are *kau* (dog) and *hai* (海, sea).

+ glide) is permitted. As shown in Table 4.47, the prevocalic glide in Southern Min has no relation to sound change, as (b), (c) and (d) in Table 4.47.

Table 4.47: Examples of light diphthongs in Sino-Xenic languages

Chinese Character	Southern Min	Sino-Japanese	Sino-Korean
a. 譯 (梗開 3)	ik8	eki	jək
b. 約 (宕開 3)	iok4	jakɯ	jak
c. 結 (山開 4)	kiat4	ketsɯ	kjəl
d. 括 (山合 1)	kuat	katsɯ	kwal

Different from Southern Min, the two moras of Sino-Japanese and Sino-Korean belong to different branches of a syllable node. The segments dominated by a mora node might interact with each other. Despite the fact that interconstitutes interact, light diphthong is restricted, depending on language-specific licensing constraints. Comparison of the instances in Table 4.47 indicates that Sino-Korean does not restrict light diphthong since prevocalic glides are preserved in modern representations. However, Sino-Japanese restricts light diphthong. Table 4.47-a and Table 4.47-b are characterized as velar stop ending and they are in Division III, which includes glide [j] in Middle Chinese. It can be observed that *Gěngshè* (梗攝) fuses glide [j] and vowel [a] to a new vowel [e] (Table 4.47-a) (Takamatsu 1986); *Dàngshè* (宕攝), however, maintains the distinction between the prevocalic glide and main vowel (Table 4.47-b).

Some repair strategies should operate to prevent heavy diphthong. This prohibition is related to the second factor, licensing constraints. As manifested in Chapter 3 and 4, Sino-Japanese has three types of internal interaction and Sino-Korean has two types. The following section discusses the licensing constraints of Sino-Japanese and Sino-Korean, respectively.

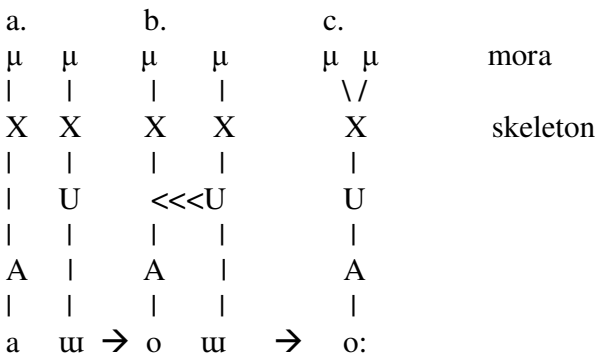
First of all, the three types of interaction in Sino-Japanese are reproduced in (36).

(36) a. a - ɯ → o - ɯ → o:
b. (i - a → e) → e - ɯ → jo:
c. i - ɯ → jɯ:

(36a) specifically refers to Division I and II of *Xiánshè* (咸攝), which includes bilabial stop, -p-. Japanese spirantization (ハ行転呼音) leads to dissappearance of

intervocalic stop and triggers interaction of the two vowels. However this process is truncated since only the first vowel is affected, displayed in (37)[48].

(37) Division I and II of *Xiánshè* (咸攝) for Sino-Japanese

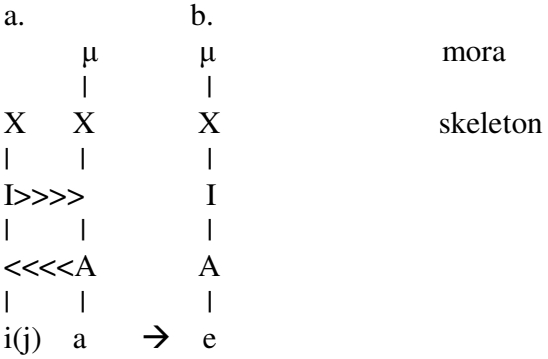


It is suggested that the licensing constraints of Japanese are not limited after the stop disappears, but later 'U' element loses its function as a license operator. In (37a) the diphthong [aɯ] separately bears elements, 'A' and 'U'. Then the spreading of 'U' element yields rasing of vowel [a] to [o] (37b). After 'U' element spreads to the preceding vowel, 'U' element no longer functions as a license operator and is deleted. However the number of mora is maintained, leading to compensatory lengthening.

(36b) is chiefly observed in Division III and IV of *Xiánshè* (咸攝). This change involves in two interactions, the coalescence of [j,i] and [a] and rearrangement of [e] and [ɯ]. (38) firstly exhibits the coalescence of [e], from [j, i] and [a][49]. Since Division III is characterized of glide [j] and Division IV is marked by vowel [i], the feature [+high, +front][50] interacts with low vowel, producing mid vowel [e].

[48] The segmental representations in (37) and the followings are based on element (Lee 1998). There are three basic elements, 'I', 'U' and 'A', being phonetically interpreted as vowels [i], [u] and [a].
[49] The interaction of [j,i] and [a] can be found in *Xiánshè* (咸攝), *Shānshè* (山攝) and *Gěngshè* (梗攝).
[50] The 'I' element in (37) does not carry one mora because it merely represents features.

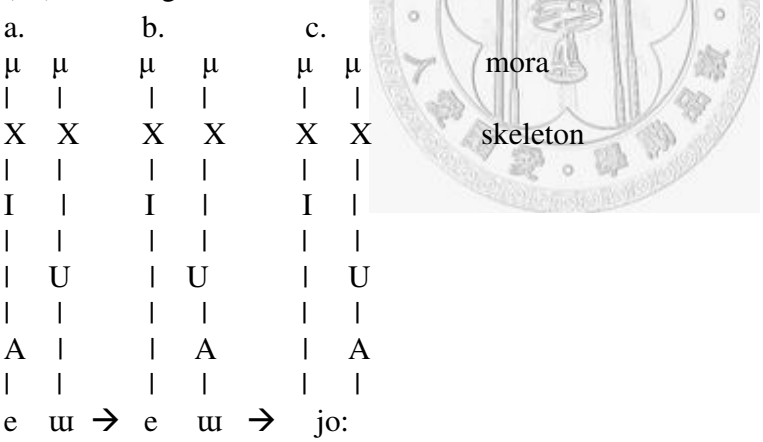
(38) Coalescence of [j, i] and [a] for Sino-Japanese



There are two elements in (38a), 'I' and 'A'. 'I' element stands not only for glide [j] for Division III but also for high front vowel [i] for Division IV. 'A' element represents the low vowel. The mutual spreadings in (38a) yields vowel [e] (38b).

Further interaction turns to mid vowel [e] and high back vowel [ɯ]. The sequence of [e] and [ɯ] results in [jo:], exhibited in (39).

(39) Rearrangement of [e] and [ɯ]

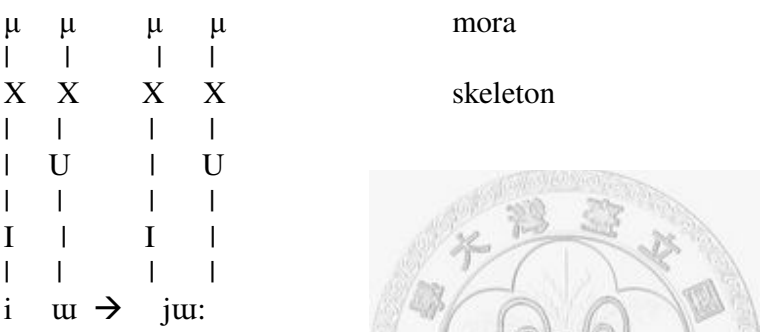


The interaction of [e] and [ɯ] involves in vowel coalescence, glide formation and compensatory lengthening. In (39a), vowel [e] is composed of 'I' and 'A', and [ɯ] is 'U' element. The rearrangement of 'A' element from vowel [e] to vowel [ɯ] leads to vowel [o], a fusion of 'U' and 'A'. The rearrangement of 'A' element (39b), however, causes 'I' to be glide, preventing heavy diphthong. In addition, vowel [e] bears one mora and the arrangement of internal elements leaves 'I' element as glide, which should not carry any

mora. To maintain this mora, compensatory lengthening occurs (39c) so that the main vowel [o] is prolonged.

The third type of interaction in Sino-Japanese (36c) is the combination of [i] and [ɯ], mainly found in *Shēngshè* (深攝). Resulting from Japanese spirantization (ハ行転呼音), the two vowels, [i] and [ɯ], interact. However, it is glide formation rather than vowel coalescence that takes place in the phonological process, shown in (40).

(40) *Shēngshè* (深攝) for Sino-Japanese



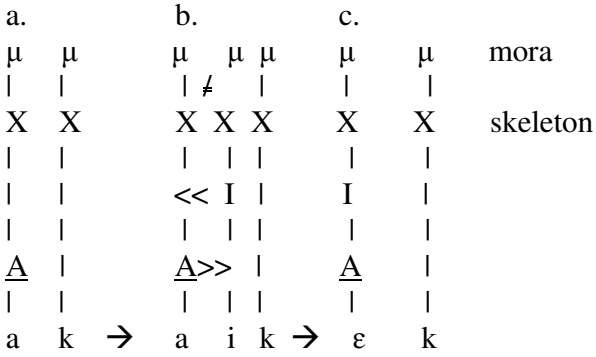
Although Japanese spirantization (ハ行転呼音) triggers interaction, [i] and [ɯ] do not follow vowel coalescence. This is because no vowel exists between [i] and [ɯ] in Japanese vowel system. To avoid deletion of segment, vowel [i] is preserved in a different form, being reduced as glide. The glide, as mentioned in (39), does not carry any mora so that the remaining mora is saved by prolonging vowel [ɯ].

Shedding light on Sino-Korean, two types of interaction are exhibited in (41).

(41) a. a - i → e
b. (w - a →o) → o - i → we

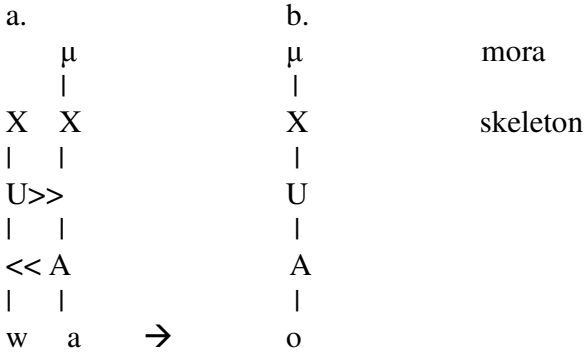
The most typical example for (41a) consists in Division II of *Gěngshè* (梗攝) where vowel [i] is generated to fill the gap between vowel [a] and consonant [k]. The process is displayed in (42).

(42) Division II of *Gěngshè* (梗攝) for Sino-Korean



The insertion of vowel [i] (Kono 1979), change from (42a) to (42b), brings about one problem to Sino-Korean that vowel [i] also carries one mora. Three moras within one syllable are overloaded since the capacity of Sino-Korean is two moras at most, according to the syllable structure (35c). Therefore, one of the three moras is out of question deleted. Restriction to the number of mora causes vowel coalescence, aiming to delete extra mora and preserve the element of vowel [i]. The spreadings of elements 'I' and 'A[51]' form a new vowel [ε] and the unwanted mora generated by vowel [i] is deleted (41c). Two phonological changes are observed in (41b), also in Division II of *Gěngshè* (梗攝) but with *Hékǒu* (合口). The existence of prevocalic bilabial glide invokes the first change, w-a→o, as shown in (43).

(43) Coalescence of [w] and [a]



[51] Following Lee (1998), to distinguish [ε] and [e], the representations of vowel [ε] are 'I' and 'A', whereas the representations of vowel [e] are 'I' and 'A'.

In (43) the coalescence results from 'U' element[52] in consonant [w] and 'A' element in vowel [a]. Then the spreadings of 'U' and 'A' elements yield [o][53] (43b). Then vowel [o] and the newly interested vowel [i] undergo another phonological change. The combination of [o] and [i] results in [we], exhibited in (44).

(44) Division II of *Gěngshè* (梗攝) *Hékǒu* (合口)

a.		b.		c.		
μ	μ	μ	μ		μ	mora
|	|	|	|		|	
X	X	X	X	X	X	skeleton
|	|	|	|	|	|	
U	|	U	|	U	|	
|	|	|	|	|	|	
|	I	|	I	|	I	
|	|	|	|	|	|	
A	|	|	A	|	A	
|	|	|	|	|	|	
o	i →	o	i	→	we	

The interaction of [o] and [i] is concerned with vowel coalescence and glide formation. In (44a), vowel [o] is anatomized as 'U' and 'A' elements, and [I] as 'I' element. (44b) demonstrates the interaction of two vowels by moving 'A' element from vowel [o] to vowel [i]. This movement accounts for a new vowel [e] and leaves 'U' element as glide. However Sino-Korean forsakes the mora that is originally carried by vowel [o] since 'U' element degenerates as glide. Abandoning the first mora indicates that there is no compensatory lengthening in Sino-Korean.

The interaction of vowels in Sino-Japanese and Sino-Korea are outlined as the following. First, the numbers of mora are maintained in Sino-Japanese by compensatory lengthening when vowel coalescence or glide formation takes place. By contrast this preservation of numbers of mora is not so salient in Sino-Korean. In other words, even for the situation that a new vowel is generated, the new mora will be disregarded and repaired by vowel coalescence. Second, as proposed by Lee (1998), 'U' element of Korean is forbidden to be the license operators so that in the interaction of [o] and [i], 'U'

[52] In (43) glide [w] does not carry mora.
[53] Although Lee (1998) suggests that 'U'and '<u>A</u>' represent vowel [o], here for the sake of simiplicity, the elements for vowel [o] are 'U'and 'A'.

element should not license any other element (cf. 44a and 44c). On the contrary, Sino-Japanese is not confined by this constraint. Based on (39), the interactions of [e] and [ɯ] results in [jo:] where 'U' element licenses 'A' element in [o].

4.6 Summary of Chapter 4

This chapter has provided the data as well as the analyses of non-[a]-vowel group and *Hékǒu* (合口). First, three major vowel changes in non-[a]-vowel group are observed, i.e. fronting, backing and raising. Apart from the main changes, exception of non-[a]-vowel group is discussed. Second, the analysis turns to *Hékǒu* (合口), focusing on the prevocalic glide, -w-, *Tōngshè* (通攝) and *Zhēnshè* (臻攝). Similarly, the exception of *Hékǒu* (合口) is discussed. The final part of this chapter discusses the influence of internal syllable structure of phonological change. The first factor is phonotactic constraints are proposed to account for the heavy and light diphthong. Southern Min has the syllable structure where the moras are located in the same branch of a syllable node so that it allows heavy and light diphthong. While the syllable structure of Sino-Japanese and Sino-Korean are comprised of two moras that belong to different branches, indicating that they disfavor diphthong. Second, licensing constraints account for the language-specific changes of vowel. Specifically, the numbers of mora and 'U' element influence the interaction of two sequential vowels.

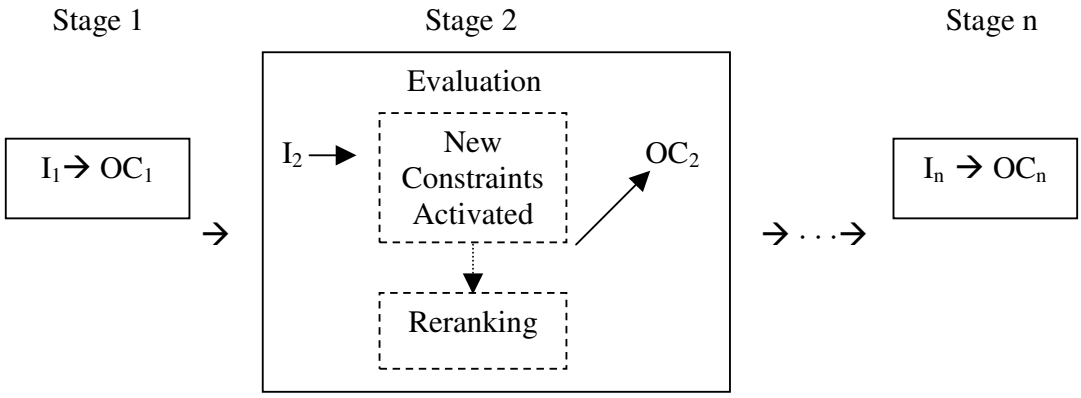
Chapter 5 Conclusion

5.1 Summary

This present thesis originates from the eagerness to answer three questions. The first question concerns the interaction of historical phonology and Optimality theory. The exploration of the relationship of sound changes and modern phonological theories has particularly led to the application of Optimality Theory to sound changes of entering tone in Sino-Xenic languages. It has been clearly displayed thoroughly that Optimality Theory can account for patterns of sound change in Sino-Xenic languages. Specifically, the layers of Sino-Xenic languages that are relevant to one another can be evaluated in one tableau simultaneously. In addition, Faithfulness, Markedness, Dispersion-Optimality Theory (FMD-OT) is more economical because dispersion constraints pair vowels and select the best vowel in one mapping. It no longer takes two steps to describe a phenomenon, such as *Xiánshè* (咸攝), where two *Yùnbù* (韻部) firstly merge as one in the same division and then two divisions converge as one in the same *Shè* (攝). Also, by FMD-OT it is possible to compare different *Shè* (攝). In other words, it is main vowel rather than coda that functions as the criterion for categorization because different *Shè* (攝) in fact develop similarly in vowel change.

Regarding opacity in historical phonology, this study has attempted to modifiy and extend Candidate Chains (McCarthy 2007) to historical phonology, shown below.

(1) Extension of Candidate Chains to Historical Phonology



This proposal has three merits, continuity in sound change, parallelism in evaluation and inauguration of constraints. Inspection of the exceptions of entering tone, such as *Gěngshè* (梗攝) in Southern Min, *Xiánshè* (咸攝) in Sino-Japanese and *Gěngshè* (梗攝) in Sino-Korean, further supports our proposal that continuity is indispensable in historical phonology, direct mapping of input and output is achievable within one stage and activating new constraints is necessary. It is demonstrated that, in view of opacity, our proposal is more promising than derivational rules because not only the correlation of candidate-output and input for next stage but also the gradualness of sound change is taken into account.

The third question addresses the influence of syllable structure and phonological changes in Sino-Xenic languages. Specifically, phonotactic constraints and licensing constraints are proposed to be relevant. First, phonotactic constraints concern internal syllable branching and the location of moras. It has been argued that when moras appear in the same branch of a syllable node, interaction seldom occurs, i.e. Southern Min. In contrast, when moras belong to different branches under one syllable domain, e.g. Sino-Japanese and Sino-Korean, interaction takes place. Furthermore, whether mora is prominent or not distinguishes Sino-Japanese from Sino-Korean. On one hand, if the mora is prominent, the mora is maintained, namely, Sino-Japanese. On the other hand, if the mora is not prominent, the mora is likely to be deleted, i.e. Sino-Korean.

Second, licensing constraints involve in the internal elements and the restriction to element domination. The investigation suggests that 'U' element functions more significantly than 'I' and 'A' elements. Sino-Korean is a language that forbids 'U' element to license other elements and rejects the existence of vowel [o]. On the contrary, Sino-Japanese is a language that imposes no limitation on 'U' element so that vowel [o] generated from interaction is legitimate.

In conclusion, the investigation of entering tone in Sino-Xenic languages in Optimality-Theoretic account has successfully offered a new approach towards historical Chinese phonology since the goal of this study is to seriously apply modern phonological theory to a long-history subject. Through the investigation, the opacity in historical phonology as well as the influence of syllable structure is unveiled.

5.2 Further Research

This current thesis is merely a study on part of historical Chinese phonology. A variety of questions remain unsolved and await further research. First of all, given that this study primarily sheds light on entering tone in Sino-Xenic languages, it is not sufficient enough to mirror the whole picture of historical Chinese phonology. Other categorizations of historical Chinese phonology are not yet elaborated profoundly. Therefore, it is worthwhile to pay more attention to Nasal Endings (*Yáng Shēng Yùn* 陽聲韻) and Glide Endings (*Yīn Shēng Yùn* 陰聲韻) in Sino-Xenic languages.

Although this thesis omits onset and chiefly focuses on rhyme, some interactions are indeed pertinent to onsets, such as the generation of glide [j] in Division II of *Xiánshè* (咸攝) in Southern Min and Sino-Korean and the correlation of onset and main vowel in *ū* rhyme (屋韻) of Sino-Japanese. Only when how onset and main vowel interact is disclosed can it be concluded the influence of syllable structure on the sound changes of Sino-Xenic languages.

Another issue for further research is to explore more Sino-Xenic languages. It is Southern Min, Sino-Japanese and Sino-Korean that are the target languages of this thesis. However, it is obscure whether other languages, such as Sino-Vietnamese, or other Chinese dialects, such as Hakka and Wu, are compatible with the proposal that internal syllable structure influences sound change. As a result, it deserves the comparison of more than three Sino-Xenic languages in one study.

Finally, an issue that discusses the universality and functions of constraints might be intriguing. Although this study integrates three Sino-Xenic languages and investigates language specific phenomena, it is not clear what motivates vowel changes. For example, markedness constraints are sometimes ranked according to whether the vowel is marked or unmarked. However ranking of markedness constraints is also limited to context, which means universal grammar fails. Therefore, it is necessary to find out why and how constraints are reranked.

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Appendix

The appendix demonstrates the examples of *Literal Reading* (文讀 *Wéndú*) in Southern Min, *Kan-On* (漢音 かんおん) in Sino-Japanese and Sino-Korean. According to 方言調查字表 (*Fangyan Diaocha Zibiao,* A wordlist for dialectal research), each table is comprised of 例字 (word), 韻部 (yǜnbù), 聲母 (onset) and 聲調 (tone). The transcription of the three Sino-Xenic languages is presented on the basis of Yang (1991) for Southern Min, Kubozono (1999) for Sino-Japanese and Kang (2003) for Sino-Korean. When using the appendix, it is necessary to be cautious about the following aspects.

(1) To avoid ambiguity, the transcription is exhibited phonemically rather than phonetically, for the reason that the representations after phonological change, such as palatalization, are sometimes controversial. Take Sino-Japanese as an example, the phonetic transcription of ショク can be [ɕokɯ] (Kase 2001; Saito 2006) or [ʃokɯ] (Kubozono 1999).

(2) Although one character should have only one pronunciation, some characters in fact have more than one pronunciation. First, in Southern Min, the multiple readings might result from the difference in onset. Since this study does not take onset into account, the different readings are sometimes maintained in the following tables. Second, in Sino-Korean, some words are marked by >, e.g. 랍 (lap)>납 (nap). This does not refer to phonological changes but different phonological environment, especially in [l]. The onset is [l] in word initial position. While it is not word initial, the onset is [n].

(3) In calculating tokens, there are five criteria.

(I) Only when the Chinese character has three languages can it be counted. Although it has been explicitly documented in Sino-Japanese and Sino-Korean, the pronunciation of 扌百 is unknown in Southern Min. In this case, this character is not included in calculation.

(II) The second criterion deals with the situation that one character has two pronunciations and they are merely different in onset. Although the onset varies, it will not be counted as two tokens but one (tone is irrelevant here).

(III) Another case is that when one character has two irrelevant pronunciations, the selection depends on onset. 攝, for instance, in Sino-Korean can be 섭(səp) and 녑(njəp), and the onset is 書 according to rhyme book, indicating that it relates to [s] instead of [n] and therefore 攝 should be counted as -əp.

(IV) Then the fourth criterion copes with a thorny circumstance, when the rhyme differs but the onsets are identical. The decision is made by comparing its meanings. For example, the character, 拾, has two pronunciations, 습 (sɨp) and 십(sip). When it is 습 (sɨp), it means “to pick up”. When it means “ten”, it is 십(sip). Now that 拾 is grouped with 十 (십 sip), the pronunciation of 拾 should be 십 (sip) rather than 습 (sɨp).

(V) The final criterion deals with the situation when there is no stop ending or the etymology is wrong. Although most of the data include stop ending, some

words do not, probably resulting from the mismatch or later eras. In this case, the character will be shadowed and excluded from calculation. For instance, the Sino-Korean of 劄 from 咸攝開口二等洽韻 is c^ha and it is not taken into account. Also, when the etymology is inaccurate, i.e. 餃, the character is not taken into consideration.

(4) The appendix is a compilation based on dictionaries not on fieldwork. Therefore it does not cope with any dialectal differences.

咸攝開口一等合韻

例字 (word)	韻部 (yǜnbù)	聲母 (onset)	聲調 (tone)	閩南語 (Southern Min)	日本漢字音 (Sino-Japanese)	韓國漢字音 (Sino-Korean)
				文讀	漢音	
答	合	端	入	tap4	トウ (to:)	답 (tap)
搭	合	端	入	tap4	トウ (to:)	탑 (t^hap)
搨	合	透	入	t^hap4	トウ (to:)	탑 (t^hap)
踏	合	定	入	tap8	トウ (to:)	답 (tap)
沓	合	定	入	tap8	トウ (to:)	답 (tap)
納	合	泥	入	lap8	ドウ (do:)	납 (nap)
拉	合	來	入	lap8	ロウ (ro:)	랍>납 (nap)
雜	合	從	入	tsap8	ソウ (so:)	잡 (cap)
合[1]	合	見	入	kap4	コウ (ko:)	갑 (kap)
蛤	合	見	入	kap4	コウ (ko:)	합 (hap)
鴿	合	見	入	kap4	コウ (ko:)	합 (hap)
合[2]	合	匣	入	hap8	コウ (ko:)	합 (hap)
盒	合	匣	入	hap8	コウ (ko:)	합 (hap)
				-ap (13)	-o: (13)	-ap (13)

1 The pronunciation of 合 here is gě in Mandarin Chinese.

2 The pronunciation of 合 here is hé in Mandarin Chinese.

咸攝開口一等盍韻

例字 (word)	韻部 (yǜnbù)	聲母 (onset)	聲調 (tone)	閩南語 (Southern Min)	日本漢字音 (Sino-Japanese)	韓國漢字音 (Sino-Korean)
				文讀	漢音	
塔	盍	透	入	t^hap4	トウ (to:)	탑 (t^hap)
榻	盍	透	入	t^hap4	トウ (to:)	탑 (t^hap)
塌	盍	透	入	t^hap4	トウ (to:)	탑 (t^hap)
溻	盍	透	入	t^hap4	トウ (to:)	탑 (t^hap)
臘	盍	來	入	lap8	ロウ (ro:)	랍>납 (nap)
蠟	盍	來	入	lap8	ロウ (ro:)	랍>납 (nap)
鑞	盍	來	入	lap8	ロウ (ro:)	랍>납 (nap)
磕	盍	溪	入	k^hap4	コウ (ko:)	갑 (kap)
				-ap (8)	-o: (8)	-ap (8)

咸攝開口二等洽韻

例字 (word)	韻部 (yǜnbù)	聲母 (onset)	聲調 (tone)	閩南語 (Southern Min)	日本漢字音 (Sino-Japanese)	韓國漢字音 (Sino-Korean)
				文讀	漢音	
劄[1]	洽	知	入	tap4	トウ (to:)	차 (c^ha)
眨	洽	莊	入	tsap4	ソウ (so:)	잡 (cap)
插	洽	初	入	ts^hap4	ソウ (so:)	삽 (sap)
閘	洽	崇	入	sap8	ソウ (so:)	갑 (kap)
煠	洽	崇	入	sap8	ソウ (so:)	잡 (cap)
夾	洽	見	入	kap4	コウ (ko:)	협 (hjəp)
袷	洽	見	入	kap4	コウ (ko:)	겹 (kjəp)
恰	洽	溪	入	k^hap4	コウ (ko:)	흡 (hɨp)
掐	洽	溪	入	k^hap4	コウ (ko:)	겹 (kjəp)
狹	洽	匣	入	hap8	コウ (ko:)	협 (hjəp)
峽	洽	匣	入	hap8	コウ (ko:)	협 (hjəp)
洽	洽	匣	入	hap8	コウ (ko:)	흡 (hɨp)
				-ap (11)	-o: (11)	-jəp (5)
						-ap (4)
						-ɨp (2)

1 劄 is not included in calculation for the reason that the Sino-Korean does not have stop ending.

咸攝開口二等狎韻

例字 (word)	韻部 (yǜnbù)	聲母 (onset)	聲調 (tone)	閩南語 (Southern Min)	日本漢字音 (Sino-Japanese)	韓國漢字音 (Sino-Korean)
				文讀	漢音	
甲	狎	見	入	kap4	コウ (ko:)	갑 (kap)
胛	狎	見	入	kap4	コウ (ko:)	갑 (kap)
匣	狎	匣	入	hap8	コウ (ko:)	갑 (kap)
鴨	狎	影	入	ap4	オウ (o:)	압 (ap)
押	狎	影	入	ap4	オウ (o:)	압 (ap)
壓	狎	影	入	ap4	オウ (o:)	압 (ap)
				-ap (6)	-o: (6)	-ap (6)

咸攝開口三等葉韻 (重紐)

例字 (word)	韻部 (yǜnbù)	聲母 (onset)	聲調 (tone)	閩南語 (Southern Min)	日本漢字音 (Sino-Japanese)	韓國漢字音 (Sino-Korean)
				文讀	漢音	
聶	葉	泥	入	liap4	ジョウ (zjo:)	섭/접 (səp/cəp)
鑷	葉	泥	入	liap4	ジョウ (zjo:)	섭 (səp)
躡	葉	泥	入	liap8	ジョウ (zjo:)	섭 (səp)
獵	葉	來	入	liap8	リョウ (rjo:)	렵>엽 (jəp)
接	葉	精	入	tsiap4	ショウ (sjo:)	접 (cəp)
妾	葉	清	入	ts^hiap4	ショウ (sjo:)	첩 (c^həp)
捷	葉	從	入	tsiap8	ショウ (sjo:)	첩 (c^həp)
摺	葉	章	入	tsiap4	ショウ (sjo:)	접 (cəp)
褶	葉	章	入	tsiap4	ショウ (sjo:)	첩 (c^həp)
攝[1]	葉	書	入	siap4	ショウ (sjo:)	섭/녑(səp/njəp)
涉	葉	禪	入	siap8	ショウ (sjo:)	섭 (səp)
靨	葉	影	入	iap4	ヨウ (jo:)	엽 (jəp)
葉[2]	葉	以	入	iap8	ヨウ (jo:)	엽/섭 (jəp/səp)
				-iap (13)	jo: (13)	-əp (10)
						-jəp (3)

1 According to the onset, it is 섭 (səp) that is included in calculation.

2 According to the onset, it is 엽 (jəp) that is included in calculation.

咸攝開口三等業韻

例字 (word)	韻部 (yǜnbù)	聲母 (onset)	聲調 (tone)	閩南語 (Southern Min)	日本漢字音 (Sino-Japanese)	韓國漢字音 (Sino-Korean)
				文讀	漢音	
劫	業	見	入	kiap4	キョウ (kjo:)	겁 (kəp)
怯	業	溪	入	k^{h}iap4	キョウ (kjo:)	겁 (kəp)
業	業	疑	入	giap8	ギョウ (kjo:)	업 (əp)
脅	業	曉	入	hiap4	キョウ (kjo:)	협 (hjəp)
				-iap (4)	-jo: (4)	-əp (3)
						-jəp (1)

咸攝開口四等帖韻

例字 (word)	韻部 (yǜnbù)	聲母 (onset)	聲調 (tone)	閩南語 (Southern Min)	日本漢字音 (Sino-Japanese)	韓國漢字音 (Sino-Korean)
				文讀	漢音	
帖	帖	透	入	t^{h}iap4	チョウ (tjo:)	첩 (c^{h}əp)
貼	帖	透	入	t^{h}iap4	チョウ (tjo:)	첩 (c^{h}əp)
疊	帖	定	入	tiap8	チョウ (tjo:)	첩 (c^{h}əp)
碟	帖	定	入	tiap8	チョウ (tjo:)	첩 (c^{h}əp)
牒	帖	定	入	tiap8	チョウ (tjo:)	첩 (c^{h}əp)
蝶	帖	定	入	tiap8	チョウ (tjo:)	접 (cəp)
諜[1]	帖	定	入	tiap8	チョウ (tjo:)	첩/섭(c^{h}əp/səp)
挾	帖	匣	入	hiap8	キョウ (kjo:)	협 (hjəp)
協	帖	匣	入	hiap8	キョウ (kjo:)	협 (hjəp)
				-iap (9)	-jo: (9)	-əp (7)
						-jəp (2)

1 According to the onset, it is 첩 (c^{h}əp) that is included in calculation.

咸攝合口三等乏韻

例字 (word)	韻部 (yǜnbù)	聲母 (onset)	聲調 (tone)	閩南語 (Southern Min)	日本漢字音 (Sino-Japanese)	韓國漢字音 (Sino-Korean)
				文讀	漢音	
法	乏	非	入	huat4	ホウ (ho:)	법 (pəp)
乏	乏	奉	入	huat8	ホウ (ho:)	핍 (p^hip)
				-uat (2)	-o: (2)	-əp (1)
						-ip (1)

深攝開口三等緝韻　(重紐)

例字 (word)	韻部 (yǜnbù)	聲母 (onset)	聲調 (tone)	閩南語 (Southern Min)	日本漢字音 (Sino-Japanese)	韓國漢字音 (Sino-Korean)
				文讀	漢音	
立	緝	來	入	lip8	リュウ (rjɯ:)	립>입 (ip)
笠	緝	來	入	lip8	リュウ (rjɯ:)	립>입 (ip)
粒	緝	來	入	lip8	リュウ (rjɯ:)	립>입 (ip)
緝	緝	清	入	ts^hip4	シュウ (sjɯ:)	집 (cip)
集	緝	從	入	tsip8	シュウ (sjɯ:)	집 (cip)
輯	緝	從	入	tsip4 / ts^hip4	シュウ (sjɯ:)	집 (cip)
習	緝	邪	入	sip8	シュウ (sjɯ:)	습 (sɨp)
襲	緝	邪	入	sip8	シュウ (sjɯ:)	습 (sɨp)
蟄	緝	澄	入	tip8	チュウ (tjɯ:)	칩 (c^hip)
澀	緝	生	入	sip4	シュウ (sjɯ:)	삽 (sap)
執	緝	章	入	tsip4	シュウ (sjɯ:)	집 (cip)
汁[1]	緝	章	入	tsip4	シュウ (sjɯ:)	즙/협 (cɨp/hjəp)
濕	緝	書	入	sip4	シュウ (sjɯ:)	습(sɨp)
十	緝	禪	入	sip8	シュウ (sjɯ:)	십(sip)
什	緝	禪	入	sip8	シュウ (sjɯ:)	십/집(sip/cip)
拾[2]	緝	禪	入	sip8	シュウ (sjɯ:)	십/습(sip /sɨp)
入	緝	日	入	jip8	ジュウ (zjɯ:)	입(ip)
急	緝	見	入	kip4	キュウ (kjɯ:)	급 (kɨp)
級	緝	見	入	kip4	キュウ (kjɯ:)	급 (kɨp)
給	緝	見	入	kip4	キュウ (kjɯ:)	급 (kɨp)
泣	緝	溪	入	k^hip4	キュウ (kjɯ:)	읍 (ɨp)
日昱	緝	溪	入	—	—	—
及	緝	群	入	kip8	キュウ (kjɯ:)	급 (kɨp)
吸	緝	曉	入	hip4	キュウ (kjɯ:)	흡 (hɨp)
揖	緝	影	入	ip4	ユウ (jɯ:)	읍/집 (ɨp/cip)
				-ip (24)	-jɯ: (24)	-ip (12)
						-ɨp (11)
						-ap (1)

1 According to the onset, it is 즙 (cɨp) that is included in calculation.

2 The character, 拾, has two pronunciations, 습 (sɨp) and 십 (sip). When it is 습 (sɨp), it means “to pick up”. When it means “ten”, it is 십 (sip). Here the pronunciation is 십 (sip) here due to its onset and meaning that are related to 十 (십 sip).

山攝開口一等曷韻

例字 (word)	韻部 (yǜnbù)	聲母 (onset)	聲調 (tone)	閩南語 (Southern Min)	日本漢字音 (Sino-Japanese)	韓國漢字音 (Sino-Korean)
				文讀	漢音	
獺	曷	透	入	t^hat4	タツ (tatsɯ)	달 (tal)
達	曷	定	入	tat8	タツ (tatsɯ)	달 (tal)
捺	曷	泥	入	lat8	ダツ (datsɯ)	날 (nal)
辣	曷	來	入	lat8	ラツ (ratsɯ)	랄>날 (nal)
瘌	曷	來	入	lat8	ラツ (ratsɯ)	랄>날 (nal)
擦	曷	從	入	ts^hat4	サツ (satsɯ)	찰 (c^hal)
撒	曷	心	入	sat4	サツ (satsɯ)	살 (sal)
薩	曷	心	入	sat4	サツ (satsɯ)	살 (sal)
割	曷	見	入	kat4	カツ (katsɯ)	할 (hal)
葛	曷	見	入	kat4	カツ (katsɯ)	갈 (kal)
渴	曷	溪	入	k^hat4	カツ (katsɯ)	갈 (kal)
喝	曷	曉	入	hat4	カツ (katsɯ)	갈 (kal)
				-at (12)	-atsɯ (12)	-al (12)

山攝開口二等黠韻

例字 (word)	韻部 (yǜnbù)	聲母 (onset)	聲調 (tone)	閩南語 (Southern Min)	日本漢字音 (Sino-Japanese)	韓國漢字音 (Sino-Korean)
				文讀	漢音	
八	黠	幫	入	pat4	ハツ (hatsɯ)	팔 (p^hal)
拔	黠	並	入	puat8	ハツ (hatsɯ)	발 (pal)
抹	黠	明	入	buat4	バツ (batsɯ)	말 (mal)
札	黠	莊	入	tsat4	サツ (satsɯ)	찰 (c^hal)
紮	黠	莊	入	tsat4	サツ (satsɯ)	찰 (c^hal)
察	黠	初	入	ts^hat4	サツ (satsɯ)	찰 (c^hal)
殺	黠	生	入	sat4	サツ (satsɯ)	살 (sal)
扴葛[1]	黠	溪	入	k^hat4	—	—
軋	黠	影	入	at4	アツ (atsɯ)	알 (al)
				-at (6)	-atsɯ (8)	-al (8)
				-uat (2)		

1 扴葛 is not calculated here since there are no Sino-Japanese and Sino-Korean pronunciations.

山攝開口二等鎈韻

例字 (word)	韻部 (yǜnbù)	聲母 (onset)	聲調 (tone)	閩南語 (Southern Min)	日本漢字音 (Sino-Japanese)	韓國漢字音 (Sino-Korean)
				文讀	漢音	
鍘	鎈	崇	入	tsat8	サツ (satsɯ)	찰 (c^hal)
瞎	鎈	曉	入	hat4	カツ (katsɯ)	할 (hal)
轄	鎈	匣	入	hat8	カツ (katsɯ)	할 (hal)
				-at (3)	-atsɯ (3)	-al (3)

山攝開口三等薛韻　(重紐)

例字 (word)	韻部 (yǜnbù)	聲母 (onset)	聲調 (tone)	閩南語 (Southern Min)	日本漢字音 (Sino-Japanese)	韓國漢字音 (Sino-Korean)
				文讀	漢音	
鼈	薛	幫	入	piat4	ヘツ (hetsɯ)	별 (pjəl)
別	薛	並	入	piat8	ヘツ (hetsɯ)	별 (pjəl)
滅	薛	明	入	biat8	ベツ (betsɯ)	멸 (mjəl)
列	薛	來	入	liat8	レツ (retsɯ)	렬>열 (jəl)
烈	薛	來	入	liat8	レツ (retsɯ)	렬>열 (jəl)
裂	薛	來	入	liat8	レツ (retsɯ)	렬>열 (jəl)
薛	薛	心	入	siat4	セツ (tetsɯ)	설 (səl)
泄	薛	心	入	siat4	セツ (tetsɯ)	설 (səl)
哲	薛	知	入	tiat4	テツ (tetsɯ)	철 (c^həl)
蜇	薛	知	入	tiat4	テツ (tetsɯ)	철 (c^həl)
徹	薛	徹	入	t^hiat4	テツ (tetsɯ)	철 (c^həl)
撤	薛	徹	入	t^hiat4	テツ (tetsɯ)	철 (c^həl)
轍	薛	澄	入	t^hiat8	テツ (tetsɯ)	철 (c^həl)
折	薛	章	入	tsiat4	セツ (setsɯ)	절 (cəl)
浙	薛	章	入	tsiat4	セツ (setsɯ)	절 (cəl)
舌	薛	船	入	siat8	セツ (setsɯ)	설 (səl)
設	薛	書	入	siat4	セツ (setsɯ)	설 (səl)
熱	薛	日	入	jiat8	ゼツ (zetsɯ)	열 (jəl)
傑	薛	群	入	kiat8	ケツ (ketsɯ)	걸 (kəl)
孽	薛	疑	入	giat8	ゲツ (getsɯ)	얼 (əl)
拽	薛	以	入	iat8	エツ (etsɯ)	열 (jəl)
				-iat (21)	-etsɯ (21)	-əl (13)
						-jəl (8)

山攝開口三等月韻

例字 (word)	韻部 (yǜnbù)	聲母 (onset)	聲調 (tone)	閩南語 (Southern Min)	日本漢字音 (Sino-Japanese)	韓國漢字音 (Sino-Korean)
				文讀	漢音	
揭[1]	月	見	入	kiat4	ケツ (ketsɯ)	게 (ke)
歇	月	曉	入	hiat4	ケツ (ketsɯ)	헐 (həl)
蠍	月	曉	入	hiat4	ケツ (ketsɯ)	갈 (kal)
				-iat (2)	-etsɯ (2)	-ə̀l (1)
						-al (1)

1 The character 揭 is excluded from the calculation because the Sino-Korean does not have stop ending.

山攝開口四等屑韻

例字 (word)	韻部 (yǜnbù)	聲母 (onset)	聲調 (tone)	閩南語 (Southern Min)	日本漢字音 (Sino-Japanese)	韓國漢字音 (Sino-Korean)
				文讀	漢音	
憋	屑	幫	入	piat4	ヘツ (hetsɯ)	별 (pjəl)
撇	屑	滂	入	p^hiat4	ベツ (betsɯ)	별 (pjəl)
篾	屑	明	入	biat8	ベツ (betsɯ)	멸 (mjəl)
跌	屑	端	入	tiat8	テツ (tetsɯ)	절 (cəl)
鐵	屑	透	入	t^hiat4	テツ (tetsɯ)	철 (c^həl)
捏	屑	泥	入	liap4 / liap8	デツ (detsɯ)	날 (nal)
苶	屑	泥	入	liat8	デツ (detsɯ)	날 (nal)
節	屑	精	入	tsiat4	セツ (setsɯ)	절 (cəl)
切	屑	清	入	ts^hiat4	セツ (setsɯ)	절 (cəl)
截	屑	從	入	tsiat8	セツ (setsɯ)	절 (cəl)
屑	屑	心	入	siat4	セツ (setsɯ)	설 (səl)
楔	屑	心	入	siat4	セツ (setsɯ)	설 (səl)
結	屑	見	入	kiat4	ケツ (ketsɯ)	결 (kjəl)
潔	屑	見	入	kiat4 / kiat8	ケツ (ketsɯ)	결 (kjəl)
金桀	屑	見	入	—	—	—
噎[1]	屑	影	入	e3	エツ(etsɯ)	열/일 (jəl/il)
				-iat (13)	-etsɯ (14)	-əl (7)
				-iap (1)		-jəl (5)
						-al (2)

1 This character is not included in calculation since the Southern Min does not have stop ending.

山攝合口一等末韻

例字 (word)	韻部 (yǜnbù)	聲母 (onset)	聲調 (tone)	閩南語 (Southern Min)	日本漢字音 (Sino-Japanese)	韓國漢字音 (Sino-Korean)
				文讀	漢音	
鉢	末	幫	入	puat4	ハツ (hatsɯ)	발 (pal)
撥	末	幫	入	puat4	ハツ (hatsɯ)	발 (pal)
潑	末	滂	入	p^huat4	ハツ (hatsɯ)	발 (pal)
鈸	末	並	入	puat8	ハツ (hatsɯ)	발 (pal)
末	末	明	入	buat8	バツ (batsɯ)	말 (mal)
沫	末	明	入	buat8	バツ (batsɯ)	말 (mal)
抹	末	明	入	buat8	バツ (batsɯ)	말 (mal)
掇	末	端	入	tuat8	テツ (tetsɯ)	철 ($c^həl$)
脫	末	透	入	t^huat4	タツ (tatsɯ)	탈 (t^hal)
奪	末	定	入	tuat8	タツ (tatsɯ)	탈 (t^hal)
捋	末	來	入	luat8	ラツ (ratsɯ)	랄 (ral)
撮	末	清	入	tsuat4 / ts^huat4	サツ (satsɯ)	촬 (c^hwal)
括	末	見	入	kuat4	カツ (katsɯ)	괄 (kwal)
聒	末	見	入	kuat4	カツ (katsɯ)	괄 (kwal)
闊	末	溪	入	k^huat4	カツ (katsɯ)	활 (hwal)
豁	末	曉	入	huat4	カツ (katsɯ)	활 (hwal)
活	末	匣	入	huat8	カツ (katsɯ)	활/괄 (hwal/kwal)
				-uat (17)	-atsɯ (16)	-al (10)
					-etsɯ (1)	-wal (6)
						-əl (1)

山攝合口二等黠韻

例字 (word)	韻部 (yǜnbù)	聲母 (onset)	聲調 (tone)	閩南語 (Southern Min)	日本漢字音 (Sino-Japanese)	韓國漢字音 (Sino-Korean)
				文讀	漢音	
滑	黠	匣	入	huat8	カツ (katsɯ)	활 (hwal)
猾	黠	匣	入	huat8	カツ(katsɯ)	활 (hwal)
挖	黠	影	入	uat4	アツ (atsɯ)	알 (al)
				-uat (3)	-atsɯ (3)	-wal (2)
						-al (1)

山攝合口二等鎋韻

例字 (word)	韻部 (yǜnbù)	聲母 (onset)	聲調 (tone)	閩南語 (Southern Min)	日本漢字音 (Sino-Japanese)	韓國漢字音 (Sino-Korean)
				文讀	漢音	
刷	鎋	生	入	suat4	サツ (satsɯ)	솰 (swal)
刮	鎋	見	入	kuat4	カツ (katsɯ)	괄 (kwal)
				-uat (2)	-atsɯ (2)	-wal (2)

山攝合口三等薛韻　(重紐)

例字 (word)	韻部 (yǜnbù)	聲母 (onset)	聲調 (tone)	閩南語 (Southern Min)	日本漢字音 (Sino-Japanese)	韓國漢字音 (Sino-Korean)
				文讀	漢音	
劣	薛	來	入	luat4	レツ (retsɯ)	렬>열 (jəl)
絕	薛	從	入	tsuat8	セツ (setsɯ)	절 (cəl)
雪	薛	心	入	suat4	セツ (setsɯ)	설 (səl)
拙	薛	章	入	tsuat4	セツ (setsɯ)	졸 (col)
說	薛	書	入	suat4	セツ (setsɯ)	설 (səl)
悅[1]	薛	以	入	uat8	エツ (etsɯ)	열 (jəl)
閱[2]	薛	以	入	uat8	エツ (etsɯ)	열 (jəl)
				-uat (7)	-etsɯ (7)	-jəl (3)
						-əl (3)
						-ol (1)

1, 2 悅 and 閱 can be also be [iat] in Southern Min.

山攝合口三等月韻

例字 (word)	韻部 (yǜnbù)	聲母 (onset)	聲調 (tone)	閩南語 (Southern Min)	日本漢字音 (Sino-Japanese)	韓國漢字音 (Sino-Korean)
				文讀	漢音	
髮	月	非	入	huat4	ハツ (hatsɯ)	발 (pal)
發	月	非	入	huat4	ハツ (hatsɯ)	발 (pal)
伐	月	奉	入	huat8	ハツ (hatsɯ)	벌 (pəl)
筏	月	奉	入	huat8	ハツ (hatsɯ)	벌 (pəl)
罰	月	奉	入	huat8	ハツ (hatsɯ)	벌 (pəl)
襪	月	微	入	buat8	バツ (batsɯ)	말 (mal)
厥	月	見	入	kuat4	ケツ (ketsɯ)	궐 (kwəl)
蹶	月	見	入	—	—	—
掘	月	群	入	kut8	クツ (kɯtsɯ)	굴 (kul)
橛	月	群	入	kuat8	ケツ (ketsɯ)	궐 (kwəl)
月	月	疑	入	guat8	ゲツ (getsɯ)	월 (wəl)
噦	月	影	入	uat8	エツ (etsɯ)	얼 (əl)
越	月	云	入	uat8	エツ (etsɯ)	월 (wəl)
曰	月	云	入	uat8	エツ (etsɯ)	왈 (wal)
粵	月	云	入	uat8	エツ (etsɯ)	월 (wəl)
				-uat (13)	-etsɯ (7)	-wəl (6)
				-ut (1)	-atsɯ (6)	-al (3)
					-ɯtsɯ (1)	-əl (4)
						-ul (1)

山攝合口四等屑韻

例字 (word)	韻部 (yǜnbù)	聲母 (onset)	聲調 (tone)	閩南語 (Southern Min)	日本漢字音 (Sino-Japanese)	韓國漢字音 (Sino-Korean)
				文讀	漢音	
決	屑	見	入	kuat4	ケツ (ketsɯ)	결 (kjəl)
訣	屑	見	入	kuat4	ケツ (ketsɯ)	결 (kjəl)
缺	屑	溪	入	k^huat4	ケツ (ketsɯ)	결 (kjəl)
血	屑	曉	入	hiat4	ケツ (ketsɯ)	혈 (hjəl)
穴	屑	匣	入	hiat8	ケツ (ketsɯ)	혈 (hjəl)
				-uat (3)	-etsɯ (5)	-jəl (5)
				-iat (2)		

臻攝開口三等質韻　(重紐)

例字 (word)	韻部 (yǜnbù)	聲母 (onset)	聲調 (tone)	閩南語 (Southern Min)	日本漢字音 (Sino-Japanese)	韓國漢字音 (Sino-Korean)
				文讀	漢音	
筆	質	幫	入	pit4	ヒツ (hitsɯ)	필 (p^hil)
畢	質	幫	入	pit4	ヒツ (hitsɯ)	필 (p^hil)
必	質	幫	入	pit4	ヒツ (hitsɯ)	필 (p^hil)
匹	質	滂	入	p^hit4	ヒツ (hitsɯ)	필 (p^hil)
弼	質	並	入	pit8	ヒツ (hitsɯ)	필 (p^hil)
密	質	明	入	bit8	ビツ (bitsɯ)	밀 (mil)
蜜	質	明	入	bit8	ビツ (bitsɯ)	밀 (mil)
栗	質	來	入	lit8	リツ (ritsɯ)	률>율 (jul)
七	質	清	入	ts^hit4	シツ (sitsɯ)	칠 (c^hil)
漆	質	清	入	ts^hit4	シツ (sitsɯ)	칠 (c^hil)
疾	質	從	入	tsit8	シツ (sitsɯ)	질 (cil)
悉	質	心	入	sit4	シツ (sitsɯ)	실 (sil)
膝	質	心	入	sit4	シツ (sitsɯ)	슬 (sɨl)
姪	質	澄	入	tit8 / tsit8	チツ (titsɯ)	질 (cil)
秩	質	澄	入	tit8	チツ (titsɯ)	질 (cil)
瑟	質	生	入	sit4	シツ (sitsɯ)	슬 (sɨl)
蝨	質	生	入	sit4	シツ (sitsɯ)	슬 (sɨl)
質	質	章	入	tsit4	シツ (sitsɯ)	질 (cil)
實	質	船	入	sit8	シツ (sitsɯ)	실 (sil)
失	質	書	入	sit4	シツ (sitsɯ)	실 (sil)
室	質	書	入	sit4	シツ (sitsɯ)	실 (sil)
日	質	日	入	jit8	ジツ (zitsɯ)	일 (il)
吉	質	見	入	kit4	キツ (kitsɯ)	길 (kil)
乙	質	影	入	it4	イツ (itsɯ)	을 (ɨl)
一	質	影	入	it4	イツ (itsɯ)	일 (il)
逸	質	以	入	it8	イツ (itsɯ)	일 (il)
				-it (26)	-itsɯ (26)	-il (21)
						-ɨl (4)
						-ul (1)

臻攝開口三等迄韻

例字 (word)	韻部 (yǜnbù)	聲母 (onset)	聲調 (tone)	閩南語 (Southern Min)	日本漢字音 (Sino-Japanese)	韓國漢字音 (Sino-Korean)
				文讀	漢音	
迄	迄	見	入	kit4	キツ (kitsɯ)	흘 (hɨl)
乞	迄	溪	入	k^hit4	キツ (kitsɯ)	걸 (kəl)
				-it (2)	-itsɯ (2)	-ɨl (1)
						-əl (1)

臻攝合口一等沒韻

例字 (word)	韻部 (yǜnbù)	聲母 (onset)	聲調 (tone)	閩南語 (Southern Min)	日本漢字音 (Sino-Japanese)	韓國漢字音 (Sino-Korean)
				文讀	漢音	
不	沒	幫	入	put4	フツ (hɯtsɯ)	불 (pul)
勃	沒	並	入	put8	ホツ (hotsɯ)	발 (mal)
土孛	沒	並	入	—	—	—
餑	沒	並	入	put8	ホツ (hotsɯ)	물 (mul)
沒	沒	明	入	but8	ボツ (botsɯ)	몰 (mol)
突	沒	定	入	tut8 / t^hut8	トツ (totsɯ)	돌 (tol)
卒	沒	精	入	tsut4	ソツ (sotsɯ)	졸 (col)
猝	沒	清	入	ts^hut4 / tsut4	ソツ (sotsɯ)	졸 (col)
骨	沒	見	入	kut4	コツ (kotsɯ)	골 (kol)
窟	沒	溪	入	k^hut4	コツ (kotsɯ)	굴 (kul)
杌	沒	疑	入	gut8	ゴツ (dotsɯ)	올 (ol)
忽	沒	曉	入	hut4	コツ (kotsɯ)	홀 (hol)
核[1]	沒	匣	入	hut8 / hik8	カク (kakɯ)	핵 (hɛk)
				-ut (11)	-otsɯ (10)	-ol (7)
					-ɯtsɯ (1)	-ul (3)
						-al (1)

1 核 in Southern Min is hut8 and hik8 and this character is excluded from calculation because this character has velar stop ending in the three languages, suggesting that the origin might be wrong.

臻攝合口三等術韻

例字 (word)	韻部 (yǜnbù)	聲母 (onset)	聲調 (tone)	閩南語 (Southern Min)	日本漢字音 (Sino-Japanese)	韓國漢字音 (Sino-Korean)
				文讀	漢音	
律	術	來	入	lut8	リツ (ritsɯ)	률 > 율 (jul)
率[1]	術	來	入	lut8	リツ (ritsɯ)	률 > 율 (jul)
焌	術	清	入	—	—	—
黑俊	術	清	入	—	—	—
戌	術	心	入	sut4	シュツ (sjɯtsɯ)	술 (sul)
恤	術	心	入	sut4	シュツ (sjɯtsɯ)	휼 (hjul)
术[2]	術	澄	入	sut8	シュツ (sjɯtsɯ)	출 (c^hul)
					チュツ (tjɯtsɯ)	
率[3]	術	生	入	sut4	シュツ (sjɯtsɯ)	솔 (sol)
蟀	術	生	入	sut4	シュツ (sjɯtsɯ)	솔 (sol)
出	術	昌	入	ts^hut4	シュツ (sjɯtsɯ)	출 (c^hul)
術	術	船	入	sut8	シュツ (sjɯtsɯ)	술 (sul)
述	術	船	入	sut8	シュツ (sjɯtsɯ)	술 (sul)
秫	術	船	入	sut8	シュツ (sjɯtsɯ)	출 (c^hul)
橘	術	見	入	kut4	キツ (kitsɯ)	귤 (kjul)
				-ut (12)	-jɯtsɯ (9)	-ul (6)
					-itsɯ (3)	-jul (4)
						-ol (2)

1 The pronunciation of 率 here is lǜ in Mandarin Chinese.

2 Although the onset of 术 in Sino-Japanese is ambiguous, being [s] or [t], only one token is calculated.

3 The pronunciation of 率 here is shuài in Mandarin Chinese.

臻攝合口三等物韻

例字 (word)	韻部 (yǜnbù)	聲母 (onset)	聲調 (tone)	閩南語 (Southern Min)	日本漢字音 (Sino-Japanese)	韓國漢字音 (Sino-Korean)
				文讀	漢音	
佛	物	敷	入	hut4	フツ (hɯtsɯ)	불 (pul)
佛	物	奉	入	hut4	フツ (hɯtsɯ)	불 (pul)
物	物	微	入	but4	ブツ (bɯtsɯ)	물 (mul)
勿	物	微	入	but4	ブツ (bɯtsɯ)	물 (mul)
屈	物	溪	入	k^hut4	クツ (kɯtsɯ)	굴 (kul)
掘	物	群	入	kut8	クツ (kɯtsɯ)	굴 (kul)
倔	物	群	入	kut8	クツ (kɯtsɯ)	굴 (kul)
佛	物	敷	入	hut4	フツ (hɯtsɯ)	불 (pul)
				-ut (8)	-ɯtsɯ (8)	-ul (8)

宕攝開口一等鐸韻

例字 (word)	韻部 (yǜnbù)	聲母 (onset)	聲調 (tone)	閩南語 (Southern Min)	日本漢字音 (Sino-Japanese)	韓國漢字音 (Sino-Korean)
				文讀	漢音	
博	鐸	幫	入	pok4	ハク (hakɯ)	박 (pak)
泊	鐸	滂	入	pok8	ハク (hakɯ)	박 (pak)
薄	鐸	並	入	pok8	ハク (hakɯ)	박 (pak)
泊	鐸	並	入	pok8	ハク (hakɯ)	박 (pak)
莫	鐸	明	入	bok8	バク (bakɯ)	막 (mak)
膜	鐸	明	入	bok8	バク (bakɯ)	막 (mak)
幕	鐸	明	入	bok8	バク (bakɯ)	막 (mak)
寞	鐸	明	入	bok8	バク (bakɯ)	막 (mak)
摸[1]	鐸	明	入	mou3	バク (bakɯ)	모 (mo)
託	鐸	透	入	t^hok4	タク (takɯ)	탁 (t^hak)
托	鐸	透	入	t^hok4	タク (takɯ)	탁 (t^hak)
鐸	鐸	定	入	tok4	タク (takɯ)	탁 (t^hak)
踱	鐸	定	入	tok8	タク (takɯ)	탁 (t^hak)
諾	鐸	泥	入	lok8	ダク (dakɯ)	낙 (nak)
落	鐸	來	入	lok8	ラク (rakɯ)	락>낙 (nak)
烙	鐸	來	入	lok8	ラク (rakɯ)	락>낙 (nak)
駱	鐸	來	入	lok8	ラク (rakɯ)	락>낙 (nak)
酪	鐸	來	入	lok8	ラク (rakɯ)	락>낙 (nak)
洛	鐸	來	入	lok8	ラク (rakɯ)	락>낙 (nak)
絡	鐸	來	入	lok8	ラク (rakɯ)	락>낙 (nak)
樂[2]	鐸	來	入	lok8	ラク (rakɯ)	락>낙 (nak)
作	鐸	精	入	tsok4	サク (sakɯ)	작 (cak)
錯	鐸	清	入	ts^hok4	サク (sakɯ)	착 (c^hak)
鑿	鐸	從	入	ts^hok8 / tsok8	サク (sakɯ)	착 (c^hak)
昨	鐸	從	入	tsok8	サク (sakɯ)	작 (cak)
柞	鐸	從	入	tsok8	サク (sakɯ)	작 (cak)
索	鐸	心	入	sok4	サク (sakɯ)	삭 (sak)
各	鐸	見	入	kok4	カク (kakɯ)	각 (kak)
閣	鐸	見	入	kok4	カク (kakɯ)	각 (kak)
擱	鐸	見	入	kok4	カク (kakɯ)	각 (kak)
胳	鐸	見	入	kok4	カク (kakɯ)	각 (kak)
鄂	鐸	疑	入	gok8	ガク (gakɯ)	악 (ak)

郝	鐸	曉	入	hok4	カク (kakɯ)	학 (hak)
藃	鐸	曉	入	—	—	—
鶴	鐸	匣	入	hok8	カク (kakɯ)	학 (hak)
惡	鐸	匣	入	ok4	アク (akɯ)	악 (ak)
				-ok (34)	-akɯ (34)	-ak (34)

1 This character 摸 in Southern Min and Sino-Korean is obviously affected by Modern Mandarin, which is pronounced as mo. Therefore this character is not included.
2 The pronunciation of 樂 here is lè in Mandarin Chinese.

宕攝開口三等藥韻

例字 (word)	韻部 (yǜnbù)	聲母 (onset)	聲調 (tone)	閩南語 (Southern Min)	日本漢字音 (Sino-Japanese)	韓國漢字音 (Sino-Korean)
				文讀	漢音	
略	藥	來	入	liok8	リャク (rjakɯ)	략>약 (jak)
掠	藥	來	入	liok8	リャク (rjakɯ)	략>약 (jak)
爵	藥	精	入	tsiok4	シャク (sjakɯ)	작 (cak)
雀	藥	精	入	tsiok4	シャク (sjakɯ)	작 (cak)
鵲	藥	清	入	ts^{h}iok4	シャク (sjakɯ)	작 (cak)
嚼	藥	從	入	tsiok8	シャク (sjakɯ)	작 (cak)
削	藥	心	入	siok4	シャク (sjakɯ)	삭 (sak)
著	藥	知	入	Tiok4	チャク (tjakɯ)	착(c^{h}ak)
著	藥	澄	入	tiok8	チャク (tjakɯ)	착(c^{h}ak)
酌	藥	章	入	tsiok4	シャク (sjakɯ)	작 (cak)
綽	藥	昌	入	ts^{h}iok4	シャク (sjakɯ)	작 (cak)
卓攴	藥	昌	入	—	—	—
焯	藥	昌	入	tsiok4	シャク (sjakɯ)	작 (cak)
勺	藥	禪	入	siok8	シャク (sjakɯ)	작 (cak)
芍	藥	禪	入	siok8	シャク (sjakɯ)	작 (cak)
若	藥	日	入	jiok8	ジャク (zjakɯ)	약 (jak)
弱	藥	日	入	jiok8	ジャク (zjakɯ)	약 (jak)
腳	藥	見	入	kiok4 / k^{h}iok4	キャク (kjakɯ)	각 (kak)
卻	藥	溪	入	k^{h}iok4	キャク (kjakɯ)	각 (kak)
虐	藥	疑	入	giok8	ギャク (gjakɯ)	학 (hak)
瘧	藥	疑	入	giok8	ギャク (gjakɯ)	학 (hak)
約	藥	影	入	iok4	ヤク (jakɯ)	약 (jak)
藥	藥	以	入	iok8	ヤク (jakɯ)	약 (jak)
鑰	藥	以	入	iok8	ヤク (jakɯ)	약 (jak)
躍	藥	以	入	iok8	ヤク (jakɯ)	약 (jak)
				-iok (24)	-jakɯ (24)	-ak (16)
						-jak (8)

宕攝合口一等鐸韻

例字 (word)	韻部 (yǜnbù)	聲母 (onset)	聲調 (tone)	閩南語 (Southern Min)	日本漢字音 (Sino-Japanese)	韓國漢字音 (Sino-Korean)
				文讀	漢音	
郭	鐸	見	入	kok4	カク (kakɯ)	곽 (kwak)
廓	鐸	溪	入	k^hok4	カク (kakɯ)	확 (hwak)
擴	鐸	溪	入	k^hok4	カク (kakɯ)	확 (hwak)
霍	鐸	曉	入	hok4	カク (kakɯ)	곽 (kwak)
藿	鐸	曉	入	hok4	カク (kakɯ)	곽 (kwak)
劐	鐸	曉	入	hok4	カク (kakɯ)	확 (hwak)
鑊	鐸	匣	入	hok8	カク (kakɯ)	확 (hwak)
				-ok (7)	-akɯ (7)	-wak (7)

宕攝合口三等藥韻

例字 (word)	韻部 (yǜnbù)	聲母 (onset)	聲調 (tone)	閩南語 (Southern Min)	日本漢字音 (Sino-Japanese)	韓國漢字音 (Sino-Korean)
				文讀	漢音	
縛	藥	奉	入	hok8	ハク (hakɯ)	박 (pak)
钁	藥	見	入	kiok4	キャク (kjakɯ)	곽 (kwak)
籰[1]	藥	云	入	ok	ワク (wakɯ)	확 (hwak)
				-ok (2)	-akɯ (2)	-wak (2)
				-iok (1)	-jakɯ (1)	-ak (1)

1 籰 is only found is Wu's dictionary and there is no tone.

江攝開口二等覺韻

例字 (word)	韻部 (yǜnbù)	聲母 (onset)	聲調 (tone)	閩南語 (Southern Min)	日本漢字音 (Sino-Japanese)	韓國漢字音 (Sino-Korean)
				文讀	漢音	
剝	覺	幫	入	pak4	ハク (hakɯ)	박 (pak)
駁	覺	幫	入	pak4	ハク (hakɯ)	박 (pak)
樸	覺	滂	入	p^hok4	ハク (hakɯ)	박 (pak)
朴	覺	滂	入	p^hok4	ハク (hakɯ)	박 (pak)
雹	覺	並	入	pok8	ハク (hakɯ)	박 (pak)
桌	覺	知	入	tak4	タク (takɯ)	탁 (t^hak)
卓	覺	知	入	tak4	タク (takɯ)	탁 (t^hak)
琢	覺	知	入	tak4	タク (takɯ)	탁 (t^hak)
啄 [1]	覺	知	入	tak4 / tok4	タク (takɯ)	탁 (t^hak)
涿	覺	知	入	tak4	タク (takɯ)	탁 (t^hak)
戳	覺	徹	入	ts^hak4	タク (takɯ)	착 (c^hak)
濁	覺	澄	入	tak8 / tsak8	タク (takɯ)	탁 (t^hak)
捉	覺	莊	入	tsak4	サク (sakɯ)	착 (c^hak)
鐲	覺	崇	入	siok8	タク (takɯ)	탁 (t^hak)
浞	覺	崇	入	tsak4	サク (sakɯ)	착 (c^hak)
朔	覺	生	入	sak4	サク (sakɯ)	삭 (sak)
覺	覺	見	入	kak4	カク (kakɯ)	각 (kak)
角	覺	見	入	kak4	カク (kakɯ)	각 (kak)
餃 [2]	覺	見	入	kiau	コウ (ko:)	교 (kjo)
確	覺	溪	入	k^hak4	カク (kakɯ)	확 (hwak)
搉	覺	溪	入	k^hak4	カク (kakɯ)	각 (kak)
殼	覺	溪	入	k^hok4	カク (kakɯ)	각 (kak)
嶽	覺	疑	入	gak8	ガク (gakɯ)	악 (ak)
岳	覺	疑	入	gak8	ガク (gakɯ)	악 (ak)
樂 [3]	覺	疑	入	gak8	ガク (gakɯ)	악 (ak)
學	覺	匣	入	hak8	カク (kakɯ)	학 (hak)
握	覺	影	入	ak4	アク (akɯ)	악 (ak)
				-ak (21)	-akɯ (26)	-ak (25)
				-ok (4)		-wak (1)
				-iok (1)		

1 For 啄, it is tak4 rather than tok4 that is included because the other characters sharing the same onset are tak4.

2 Although the character 餃 is seen in the wordlist, it is not found in *Guǎnyùn* (廣韻) and the three pronunciations suggest that this character should be introduced later. Therefore this character is excluded from calculation.
3 The pronunciation of 樂 here is üè in Mandarin Chinese.

曾攝開口一等德韻

例字 (word)	韻部 (yǜnbù)	聲母 (onset)	聲調 (tone)	閩南語 (Southern Min)	日本漢字音 (Sino-Japanese)	韓國漢字音 (Sino-Korean)
				文讀	漢音	
北	德	幫	入	pok4	ホク (hokɯ)	북 (puk)
墨	德	明	入	bik8	ボク (bokɯ)	묵 (muk)
默	德	明	入	bik8	ボク (bokɯ)	묵 (muk)
得	德	端	入	tik4	トク (tokɯ)	득 (tɨk)
德	德	端	入	tik4	トク (tokɯ)	덕 (tək)
忒	德	透	入	t^hik4	トク (tokɯ)	특 (t^hɨk)
特	德	定	入	tik8	トク (tokɯ)	특 (t^hɨk)
肋	德	來	入	lik8	ロク (rokɯ)	륵>늑 (nɨk)
勒	德	來	入	lik8 / lik4	ロク (rokɯ)	륵>늑 (nɨk)
則	德	精	入	tsik4	ソク (sokɯ)	즉(cɨk)
賊	德	從	入	tsik8	ソク (sokɯ)	적 (cək)
塞	德	心	入	sik4	ソク (sokɯ)	색 (sɛk)
刻	德	溪	入	k^hik4	コク (kokɯ)	각 (kak)
克	德	溪	入	k^hik4	コク (kokɯ)	극 (kɨk)
黑	德	曉	入	hik4	コク (kokɯ)	흑 (hɨk)
				-ik (14)	-okɯ (15)	-ɨk (8)
				-ok (1)		-uk (3)
						-ək (2)
						-ɛk (1)
						-ak (1)

曾攝開口三等職韻

例字 (word)	韻部 (yǜnbù)	聲母 (onset)	聲調 (tone)	閩南語 (Southern Min)	日本漢字音 (Sino-Japanese)	韓國漢字音 (Sino-Korean)
				文讀	漢音	
逼	職	幫	入	pik4	ヒョク (hjokɯ)	벽 (pjək)
匿	職	泥	入	lik8	ジョク (zjokɯ)	닉 (nik)
力	職	來	入	lik8	リョク (rjokɯ)	력>역 (jək)
即	職	精	入	tsik4	ショク (sjokɯ)	즉 (cɨk)
鯽	職	精	入	tsik4	ショク (sjokɯ)	즉 (cɨk)
息	職	心	入	sik4	ショク (sjokɯ)	식 (sik)
熄	職	心	入	sik4	ショク (sjokɯ)	식 (sik)
媳[1]	職	心	入	sik4	セキ (seki)	식 (sik)
稙[2]	職	知	入	sik	チョク (tjokɯ)	직 (cik)
飭	職	徹	入	t^hik4	チョク (tjokɯ)	칙 (c^hik)
直	職	澄	入	tik8	チョク (tjokɯ)	직 (cik)
值[3]	職	澄	入	tik8	チョク (tjokɯ)	치 (c^hi)
側	職	莊	入	ts^hik4	ショク (sjokɯ)	측 (c^hɨk)
測	職	初	入	ts^hik4	ショク (sjokɯ)	측 (c^hɨk)
色	職	生	入	sik4	ショク (sjokɯ)	색 (sɛk)
嗇	職	生	入	sik4	ショク (sjokɯ)	색 (sɛk)
織	職	章	入	tsik4	ショク (sjokɯ)	직 (cik)
職	職	章	入	tsik4	ショク (sjokɯ)	직 (cik)
食	職	船	入	sik8	ショク (sjokɯ)	식 (sik)
蝕	職	船	入	sik8	ショク (sjokɯ)	식 (sik)
識	職	書	入	sik4	ショク (sjokɯ)	식 (sik)
式	職	書	入	sik4	ショク (sjokɯ)	식 (sik)
飾	職	書	入	sik4	ショク (sjokɯ)	식 (sik)
殖	職	禪	入	sik8	ショク (sjokɯ)	식 (sik)
植	職	禪	入	sik8	ショク (sjokɯ)	식 (sik)
極	職	群	入	kik8	キョク (kjokɯ)	극 (kɨk)
憶	職	影	入	ik4	オク (okɯ)	억 (ək)
億	職	影	入	ik4	オク (okɯ)	억 (ək)
抑	職	影	入	ik4	ヨク (jokɯ)	억 (ək)
翼	職	以	入	ik8	ヨク (jokɯ)	익 (ik)
				-ik (28)	-jokɯ (26)	-ik (16)

					-okɯ (2)	-ɨk (5)
						-ək (3)
						-ɛk (2)
						-jək (2)

1 媳 in Sino-Japanese should be ショク (sjokɯ) in theory. However the references suggest that it is セキ (seki). Therefore this character is not included in the calculation.
2 The character, 稙, is only found in Wu's dictionary and there is no tone.
3. Since the Sino-Korean of 値 does not have stop ending, this character is not taken into consideration when it comes to token calculation.

曾攝合口一等德韻

例字 (word)	韻部 (yǜnbù)	聲母 (onset)	聲調 (tone)	閩南語 (Southern Min)	日本漢字音 (Sino-Japanese)	韓國漢字音 (Sino-Korean)
				文讀	漢音	
國	德	見	入	kok4	コク (kokɯ)	국 (kuk)
或	德	匣	入	hik8	コク (kokɯ)	혹 (hok)
惑	德	匣	入	hik8	コク (kokɯ)	혹 (hok)
				-ik (2)	-okɯ (3)	-ok (2)
				-ok (1)		-uk (1)

曾攝合口三等職韻

例字 (word)	韻部 (yǜnbù)	聲母 (onset)	聲調 (tone)	閩南語 (Southern Min)	日本漢字音 (Sino-Japanese)	韓國漢字音 (Sino-Korean)
				文讀	漢音	
域	職	云	入	ik8	ヨク (jokɯ)	역 (jək)
				-ik (1)	-jokɯ (1)	-jək (1)

梗攝開口二等陌韻

例字 (word)	韻部 (yǜnbù)	聲母 (onset)	聲調 (tone)	閩南語 (Southern Min)	日本漢字音 (Sino-Japanese)	韓國漢字音 (Sino-Korean)
				文讀	漢音	
百	陌	幫	入	pik4	ハク (hakɯ)	백 (pɛk)
柏	陌	幫	入	pik4	ハク (hakɯ)	백 (pɛk)
伯	陌	幫	入	pik4	ハク (hakɯ)	백 (pɛk)
迫	陌	幫	入	pik4	ハク (hakɯ)	박 (pak)
拍	陌	滂	入	p^{h}ik4	ハク (hakɯ)	박 (pak)
魄	陌	滂	入	p^{h}ik4	ハク (hakɯ)	백 (pɛk)
白	陌	並	入	pik8	ハク (hakɯ)	백 (pɛk)
帛	陌	並	入	pik8	ハク (hakɯ)	백 (pɛk)
扌百[1]	陌	明	入	—	ハク (hakɯ)	박 (pak)
陌	陌	明	入	bik8	バク (bakɯ)	맥/백 (mɛk/pɛk)
拆	陌	徹	入	t^{h}ik4	タク (takɯ)	탁 (t^{h}ak)
斥皮	陌	徹	入	—	—	—
澤	陌	澄	入	tik8	タク (takɯ)	택 (t^{h}ɛk)
擇	陌	澄	入	tik8	タク (takɯ)	택 (t^{h}ɛk)
宅	陌	澄	入	tik8	タク (takɯ)	택 (t^{h}ɛk)
窄	陌	莊	入	tsik4	サク (sakɯ)	착 (c^{h}ak)
豆昔[2]	陌	初	入	ts^{h}ik4	—	—
格	陌	見	入	kik4	カク (kakɯ)	격 (kjək)
客	陌	溪	入	k^{h}ik4	カク (kakɯ)	객 (kɛk)
額	陌	疑	入	gik8	ガク (gakɯ)	액 (ɛk)
赫	陌	曉	入	hik4	カク (kakɯ)	혁 (hjək)
嚇	陌	曉	入	hik4	カク (kakɯ)	혁 (hjək)
				-ik (19)	-akɯ (19)	-ɛk (12)
						-ak (4)
						-jək (3)

1 扌葛 is not calculated here since there is no Southern Min.

2 Lack of modern pronunciations of Sino-Japanese and Sino-Korean, 豆昔 is not included in calculation.

梗攝開口二等麥韻

例字 (word)	韻部 (yǜnbù)	聲母 (onset)	聲調 (tone)	閩南語 (Southern Min)	日本漢字音 (Sino-Japanese)	韓國漢字音 (Sino-Korean)
				文讀	漢音	
擘	麥	幫	入	pik4	ハク (hakɯ)	벽 (pjək)
檗	麥	幫	入	pik4	ハク (hakɯ)	벽 (pjək)
麥	麥	明	入	bik8	バク (bakɯ)	맥 (mɛk)
脈	麥	明	入	bik8	バク (bakɯ)	맥 (mɛk)
摘	麥	知	入	tik4	タク (takɯ)	적 (cək)
責	麥	莊	入	tsik4	サク (sakɯ)	책 ($c^hɛk$)
策	麥	初	入	ts^hik4	サク (sakɯ)	책 ($c^hɛk$)
冊	麥	初	入	ts^hik4	サク (sakɯ)	책 ($c^hɛk$)
柵	麥	初	入	ts^hik4	サク (kakɯ)	책 ($c^hɛk$)
革	麥	見	入	kik4	カク (kakɯ)	혁 (hjək)
隔	麥	見	入	kik4	カク (kakɯ)	격 (kjək)
核	麥	匣	入	hik8	カク (kakɯ)	핵 (hɛk)
扼	麥	影	入	ik4	アク (akɯ)	액 (ɛk)
軛	麥	影	入	ik4	アク (akɯ)	액 (ɛk)
				-ik (14)	-akɯ (14)	-ɛk (9)
						-jək (4)
						-ək (1)

梗攝開口三等陌韻

例字 (word)	韻部 (yǜnbù)	聲母 (onset)	聲調 (tone)	閩南語 (Southern Min)	日本漢字音 (Sino-Japanese)	韓國漢字音 (Sino-Korean)
				文讀	漢音	
碧	陌	幫	入	p^{h}ik4	ヘキ (heki)	벽 (pjək)
戟	陌	見	入	kik4	ケキ (keki)	극 (kɨk)
劇 [1]	陌	群	入	kik8 / kiok8	ケキ (keki)	극 (kɨk)
屐	陌	群	入	kik8	ケキ (keki)	극 (kɨk)
逆	陌	疑	入	gik8	ゲキ (geki)	역 (jək)
				-ik (5)	-eki (5)	-ɨk (3)
						-jək (2)

1 For the character, 劇, the representative pronunciation is kik8 since the other four examples are -ik.

梗攝開口三等昔韻

例字 (word)	韻部 (yǜnbù)	聲母 (onset)	聲調 (tone)	閩南語 (Southern Min)	日本漢字音 (Sino-Japanese)	韓國漢字音 (Sino-Korean)
				文讀	漢音	
璧	昔	幫	入	pik4	ヘキ (heki)	벽 (pjək)
僻	昔	滂	入	p^hik4	ヘキ (heki)	벽 (pjək)
闢	昔	並	入	p^hik4	ヘキ (heki)	벽 (pjək)
積	昔	精	入	tsik4	セキ (seki)	적 (cək)
跡	昔	精	入	tsik4	セキ (seki)	적 (cək)
脊	昔	精	入	tsik4	セキ (seki)	척 (c^hək)
籍	昔	從	入	tsik8	セキ (seki)	적 (cək)
藉	昔	從	入	tsik8	セキ (seki)	적 (cək)
惜	昔	心	入	sik4	セキ (seki)	석 (sək)
昔	昔	心	入	sik4	セキ (seki)	석 (sək)
席	昔	邪	入	sik8	セキ (seki)	석 (sək)
夕	昔	邪	入	sik8	セキ (seki)	석 (sək)
擲	昔	澄	入	tik8	テキ (teki)	척 (c^hək)
隻	昔	章	入	tsik4	セキ (seki)	척 (c^hək)
炙	昔	章	入	tsik4	セキ (seki)	적 (cək)
赤	昔	昌	入	ts^hik4	セキ (seki)	적 (cək)
斥	昔	昌	入	t^hik4	セキ (seki)	척 (c^hək)
尺	昔	昌	入	ts^hik4	セキ (seki)	척 (c^hək)
射	昔	船	入	sik8	セキ (seki)	석 (sək)
適	昔	書	入	sik4	セキ (seki)	적 (cək)
釋	昔	書	入	sik4	セキ (seki)	석 (sək)
石	昔	禪	入	sik8	セキ (seki)	석 (sək)
益	昔	影	入	ik4	エキ (eki)	익 (ik)
亦	昔	以	入	ik8	エキ (eki)	역 (jək)
譯	昔	以	入	ik8	エキ (eki)	역 (jək)
易	昔	以	入	ik8	エキ (eki)	역 (jək)
液	昔	以	入	ik8	エキ (eki)	액 (ɛk)
腋	昔	以	入	ik8	エキ (eki)	액 (ɛk)
				-ik (28)	-eki (28)	-ək (19)
						-jək (6)
						-ɛk (2)
						-ik (1)

梗攝開口四等錫韻

例字 (word)	韻部 (yǜnbù)	聲母 (onset)	聲調 (tone)	閩南語 (Southern Min)	日本漢字音 (Sino-Japanese)	韓國漢字音 (Sino-Korean)
				文讀	漢音	
壁	錫	幫	入	pik4	ヘキ (heki)	벽 (pjək)
劈	錫	滂	入	p^hik4	ヘキ (heki)	벽 (pjək)
覓	錫	明	入	bik8	ベキ (beki)	멱 (mjək)
的	錫	端	入	tik4 / tik8	テキ (teki)	적 (cək)
滴	錫	端	入	tik4	テキ (teki)	적 (cək)
嫡	錫	端	入	tik4	テキ (teki)	적 (cək)
踢	錫	透	入	t^hik4	テキ (teki)	척 (c^hək)
剔	錫	透	入	t^hik4	テキ (teki)	척 (c^hək)
笛	錫	定	入	tik8	テキ (teki)	적 (cək)
敵	錫	定	入	tik8	テキ (teki)	적 (cək)
狄	錫	定	入	tik8	テキ (teki)	적 (cək)
糴	錫	定	入	tik8	テキ (teki)	적 (cək)
溺	錫	泥	入	lik8	デキ (deki)	닉>익 (ik)
歷	錫	來	入	lik8	レキ (reki)	력>역 (jək)
曆	錫	來	入	lik8	レキ (reki)	력>역 (jək)
績	錫	精	入	tsik4	セキ (seki)	적 (cək)
戚	錫	清	入	ts^hik4	セキ (seki)	척 (c^hək)
寂	錫	從	入	tsik8	セキ (seki)	적 (cək)
錫	錫	心	入	sik4	セキ (seki)	석 (sək)
析	錫	心	入	sik4	セキ (seki)	석 (sək)
擊	錫	見	入	kik4	ケキ (keki)	격 (kjək)
激	錫	見	入	kik4	ケキ (keki)	격 (kjək)
吃 [1]	錫	溪	入	k^hit4	キツ (kitsɯ)	흘 (hił)
				-ik (22)	-eki (22)	-ək (14)
						-jək (7)
						-ik (1)

1 This character 吃 is not included in calculation because its meaning here is “ to stammer” rather than “to eat”.

梗攝合口二等陌韻

例字 (word)	韻部 (yǜnbù)	聲母 (onset)	聲調 (tone)	閩南語 (Southern Min)	日本漢字音 (Sino-Japanese)	韓國漢字音 (Sino-Korean)
				文讀	漢音	
虢	陌	見	入	kok4	カク (kakɯ)	괵 (kwek)
				-ok (1)	-akɯ (1)	-wek (1)

梗攝合口二等麥韻

例字 (word)	韻部 (yǜnbù)	聲母 (onset)	聲調 (tone)	閩南語 (Southern Min)	日本漢字音 (Sino-Japanese)	韓國漢字音 (Sino-Korean)
				文讀	漢音	
獲	麥	匣	入	hik8	カク (kakɯ)	획/확 (hwek)
劃	麥	匣	入	hik8	カク (kakɯ)	획 (hwek)
				-ik (2)	-akɯ (2)	-wek (2)

梗攝合口三等昔韻

例字 (word)	韻部 (yǜnbù)	聲母 (onset)	聲調 (tone)	閩南語 (Southern Min)	日本漢字音 (Sino-Japanese)	韓國漢字音 (Sino-Korean)
				文讀	漢音	
疫	昔	以	入	ik8	エキ (eki)	역 (kjək)
役	昔	以	入	ik8	エキ (eki)	역 (kjək)
				-ik (2)	-eki (2)	-jək (2)

通攝合口一等屋韻

例字 (word)	韻部 (yǜnbù)	聲母 (onset)	聲調 (tone)	閩南語 (Southern Min)	日本漢字音 (Sino-Japanese)	韓國漢字音 (Sino-Korean)
				文讀	漢音	
卜	屋	幫	入	pok4	ホク (hokɯ)	복 (pok)
撲	屋	滂	入	p^hok4	ハク (hakɯ)	복 (pok)
醭	屋	滂	入	p^hok4	ホク (hokɯ)	복 (pok)
仆[1]	屋	滂	入	p^hok4	ホク (hokɯ)	부 (pu)
僕	屋	並	入	pok8	ホク (hokɯ)	복 (pok)
曝	屋	並	入	pok8	ホク (hokɯ)	폭 (p^hok)
瀑	屋	並	入	pok8	ホク (hokɯ)	폭 (p^hok)
木	屋	明	入	bok8	ボク (bokɯ)	목 (mok)
禿	屋	透	入	t^hok4	トク (tokɯ)	독 (tok)
獨	屋	定	入	tok8	トク (tokɯ)	독 (tok)
讀	屋	定	入	tok8	トク (tokɯ)	독 (tok)
牘	屋	定	入	tok8	トク (tokɯ)	독 (tok)
犢	屋	定	入	tok8	トク (tokɯ)	독 (tok)
鹿	屋	來	入	lok8	ロク (rokɯ)	록>녹 (nok)
祿	屋	來	入	lok8	ロク (rokɯ)	록>녹 (nok)
族	屋	從	入	tsok8	ソク (sokɯ)	족 (cok)
速	屋	心	入	sok4	ソク (sokɯ)	속 (sok)
穀	屋	見	入	kok4	コク (kokɯ)	곡 (kok)
谷	屋	見	入	kok4	コク (kokɯ)	곡 (kok)
哭	屋	溪	入	k^hok4	コク (kokɯ)	곡 (kok)
斛	屋	匣	入	hok8	コク (kokɯ)	곡 (kok)
屋	屋	影	入	ok4	オク (okɯ)	옥 (ok)
				-ok (21)	-okɯ (21)	-ok (21)

1 Since Sino-Korean of 仆 does not contain stop ending, it is not included in calculation.

通攝合口一等沃韻

例字 (word)	韻部 (yǜnbù)	聲母 (onset)	聲調 (tone)	閩南語 (Southern Min)	日本漢字音 (Sino-Japanese)	韓國漢字音 (Sino-Korean)
				文讀	漢音	
篤	沃	端	入	tok4	トク (tokɯ)	독 (tok)
督	沃	端	入	tok4	トク (tokɯ)	독 (tok)
毒	沃	定	入	tok8	トク (tokɯ)	독 (tok)
酷	沃	溪	入	k^hok4	コク (kokɯ)	혹 (hok)
沃	沃	影	入	ok4	オク (okɯ)	옥 (ok)
				-ok (5)	-okɯ (5)	-ok (5)

通攝合口三等屋韻

例字 (word)	韻部 (yùnbù)	聲母 (onset)	聲調 (tone)	閩南語 (Southern Min)	日本漢字音 (Sino-Japanese)	韓國漢字音 (Sino-Korean)
				文讀	漢音	
福	屋	非	入	hok4	フク (hɯkɯ)	복 (pok)
幅	屋	非	入	hok4	フク (hɯkɯ)	폭 (p^hok)
蝠	屋	非	入	hok4	フク (hɯkɯ)	복 (pok)
複	屋	非	入	hok4 / hok8	フク (hɯkɯ)	복 (pok)
腹	屋	非	入	hok4	フク (hɯkɯ)	복 (pok)
覆	屋	敷	入	hok4	フク (hɯkɯ)	복 (pok)
服	屋	奉	入	hok8	フク (hɯkɯ)	복 (pok)
伏	屋	奉	入	hok8	フク (hɯkɯ)	복 (pok)
栿	屋	奉	入	—	—	—
復	屋	奉	入	hok4/ hok8	フク (hɯkɯ)	복 (pok)
目	屋	明	入	bok8	ボク (bokɯ)	목 (mok)
穆	屋	明	入	bok8	ボク (bokɯ)	목 (mok)
牧	屋	明	入	bok8	ボク (bokɯ)	목 (mok)
六	屋	來	入	liok8	リク (rikɯ)	륙>육 (juk)
陸	屋	來	入	liok8	リク (rikɯ)	륙>육 (juk)
肅	屋	心	入	siok4	シュク (sjɯkɯ)	숙 (suk)
宿	屋	心	入	siok4	シュク (sjɯkɯ)	숙 (suk)
竹	屋	知	入	tiok4	チク (tikɯ)	죽 (cuk)
築	屋	知	入	tiok4 / tiok8	チク (tikɯ)	축 (c^huk)
畜[1]	屋	徹	入	t^hiok4	チク (tikɯ)	축 (c^huk)
逐	屋	澄	入	tiok8	チク (tikɯ)	축 (c^huk)
軸	屋	澄	入	tiok8	チク (tikɯ)	축 (c^huk)
縮[2]	屋	生	入	siok4 / sok4	シュク (sjɯkɯ)	축 (c^huk)
祝	屋	章	入	tsiok4	シュク (sjɯkɯ)	축 (c^huk)
粥	屋	章	入	tsiok4	シュク (sjɯkɯ)	죽/육 (cuk/juk)
叔	屋	書	入	siok4	シュク (sjɯkɯ)	숙 (suk)
熟	屋	禪	入	siok8	シュク (sjɯkɯ)	숙 (suk)
淑	屋	禪	入	siok4 / siok8	シュク (sjɯkɯ)	숙 (suk)
肉	屋	日	入	jiok8	ジク (zikɯ)	육 (juk)
菊	屋	見	入	kiok4	キク (kikɯ)	국 (kuk)
掬	屋	見	入	kiok4	キク (kikɯ)	국 (kuk)

麴	屋	溪	入	k^{h}iok4	キク (kikɯ)	국 (kuk)
畜[3]	屋	曉	入	hiok4	キク(kikɯ)	축 (c^{h}uk)
蓄	屋	曉	入	hiok4	チク (tikɯ)	축 (c^{h}uk)
郁	屋	影	入	iok4	イク (ikɯ)	욱 (uk)
育	屋	以	入	iok8	イク (ikɯ)	육 (juk)
				-iok (23)	-ikɯ (15)	-uk (19)
				-ok (12)	-ɯkɯ (9)	-ok (12)
					-jɯkɯ (8)	-juk (4)
					-okɯ (3)	

1 The pronunciation of 畜 here is chù in Mandarin Chinese.

2 Although the character, 縮, has two pronunciations, siok4 and sok4, according to Division III, it is siok4 that is taken into consideration.

3 The pronunciation of 畜 here is xù in Mandarin Chinese.

通攝合口三等燭韻

例字 (word)	韻部 (yǜnbù)	聲母 (onset)	聲調 (tone)	閩南語 (Southern Min)	日本漢字音 (Sino-Japanese)	韓國漢字音 (Sino-Korean)
				文讀	漢音	
綠	燭	來	入	liok8	リョク (rjokɯ)	록>녹 (nok)
錄[1]	燭	來	入	liok8 / lok8	リョク (rjokɯ)	록>녹 (nok)
足	燭	精	入	tsiok4	ショク (sjokɯ)	족 (cok)
促	燭	清	入	ts^{h}iok4	ショク (sjokɯ)	촉 (c^{h}ok)
粟	燭	心	入	siok4	ショク (sjokɯ)	속 (sok)
俗	燭	邪	入	siok8	ショク (sjokɯ)	속 (sok)
續	燭	邪	入	siok8	ショク (sjokɯ)	속 (sok)
燭	燭	章	入	tsiok4	ショク (sjokɯ)	촉 (c^{h}ok)
囑	燭	章	入	tsiok4	ショク (sjokɯ)	촉 (c^{h}ok)
觸	燭	昌	入	ts^{h}iok4	ショク (sjokɯ)	촉 (c^{h}ok)
贖	燭	船	入	siok8	ショク (sjokɯ)	속 (sok)
束	燭	書	入	siok4	ショク (sjokɯ)	속 (sok)
蜀	燭	禪	入	siok8	ショク (sjokɯ)	촉 (c^{h}ok)
屬	燭	禪	入	tsiok4 / siok8	ショク (sjokɯ)	촉/속(c^{h}ok/sok)
辱	燭	日	入	jiok8	ジョク (zjokɯ)	욕 (jok)
褥	燭	日	入	jiok8	ジョク (zjokɯ)	욕 (jok)
鍋	燭	見	入	kiok4	キョク (kjokɯ)	국 (kuk)
曲	燭	溪	入	k^{h}iok4	キョク (kjokɯ)	곡 (kok)
局	燭	群	入	kiok8	キョク (kjokɯ)	국 (kuk)
玉	燭	疑	入	giok8	ギョク (gjokɯ)	옥 (ok)
獄	燭	疑	入	giok8	ギョク (gjokɯ)	옥 (ok)
欲	燭	以	入	iok8	ヨク (jokɯ)	욕 (ok)
慾	燭	以	入	iok8	ヨク (jokɯ)	욕 (jok)
浴	燭	以	入	iok8	ヨク (jokɯ)	욕 (jok)
				-iok (24)	-jokɯ (24)	-ok (18)
						-jok (4)
						-uk (2)

1 Although 錄 can also be pronounced as lok, it is not viewed as exception and not calculated as one token.