The Adaptation of Sino-Japanese *kan-on*

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Abstract

Japanese has had historical language contacts with varieties of Chinese in different periods, resulting in the large-scale intake of loanwords. This thesis focuses on the segmental and structural adaptation in Sino-Japanese *kan-on*, i.e. Late Middle Chinese (LMC) loanwords in Early Middle Japanese (EMJ), specifically the adaptation of LMC initial and coda consonants in EMJ. The thesis consists of two corpus analyses and a psycholinguistic experimental study. A database of 2136 *kanji* is assembled for the corpus analyses. The phonological analysis in this thesis is based on the distinctive feature organisation proposed by the *Featurally Underspecified Lexicon* model (Lahiri, 2018). This thesis aims to contribute empirical evidence to the phonetics vs phonology theoretical debate in loanword adaptation literature.

The first corpus analysis investigates the adaptation of LMC initial consonants in EMJ. While some data can be explained by both phonology and perception accounts, there are two pieces of evidence that shows that the adaptation follows the phonology-based perception theory. Perceptual similarity in EMJ is guided by the contrasts and processes in the native phonology.

The second corpus analysis and the experimental study investigate the adaptation of LMC coda consonants in EMJ and Modern Japanese. The corpus analysis presents historical adaptation data. The experimental study tests the historical data in Modern Japanese, revealing aspects of EMJ that persist in Modern Japanese and complementing the corpus results on vowel epenthesis. The findings together show that Japanese avoids illegal coda structures by vowel epenthesis. The quality of the epenthetic vowel is determined by two phonological processes, default insertion and vowel harmony. The default epenthetic vowel is the [DORSAL, HIGH] vowel /u/, but in cases where the nucleus in the source form (1) ends with a [CORONAL, HIGH] segment and (2) undergoes contraction during adaptation, it can trigger an epenthetic vowel harmony. The epenthetic vowel harmony is not affected by coda PLACE. Default insertion

supports the phonetic account, and vowel harmony is better explained by the phonology motivated theories.

The thesis demonstrates that both perception and phonology play a role in Sino-Japanese *kan-on* adaptation. It calls for a unification of the theories for explaining a wider range of loanword adaptation data.

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List of Abbreviations

Pre-OJ	Pre-Old Japanese
OJ	Old Japanese
MJ	Middle Japanese
EMJ	Early Middle Japanese
LMJ	Late Middle Japanese
OC	Old Chinese
MC	Middle Chinese
EMC	Early Middle Chinese
LMC	Late Middle Chinese
EModC	Early Modern Chinese
FUL	The *Featurally Underspecified Lexicon* model
V	Vowel
C	Consonant
G	Glide

Chapter 1 Introduction

1.1 Introduction

Japanese has had extensive historical contact with varieties of the Chinese language, which has resulted in significant Chinese influence on Japanese language and literature. The language contacts took place during roughly three periods: 5th to early 7th centuries, mid 7th to late 9th centuries, and late 12th to 16th centuries (Frellesvig, 2010; Li & Yu, 2018; Ito & Mester, 2015; among others). These historical contacts led to systematic and large-scale borrowings from Chinese into Japanese.

After hundreds of years, Chinese loanwords have become a well-integrated part of the Japanese lexicon. The Modern Japanese lexicon is traditionally divided into three major strata according to their historical origins and different phonological constraints. They are the native Japanese vocabulary (*wago* 和語, or *yamatokotoba* 大和言葉), the Sino-Japanese words (*kango* 漢語), and loanwords from other, mainly western, foreign languages (*gairaigo* 外来語). These strata of the vocabulary differ systematically from each other with respect to their structural properties on the phonological and morphological level (Ito & Mester, 2015).

In the field of loanword adaptation, western loanwords in Japanese have been extensively studied (Kubozono, 2006; Smith, 2006; Dohlous, 2005), whereas Chinese loanwords have received considerably less attention. From philological and textual analysis perspectives, the relation between the sound and structure of the source Chinese forms and adapted Sino-Japanese forms has been researched for centuries, and correspondences have been well established (e.g. Miyake, 2003). However, these studies are different from loanword adaptation research in that they do not (1) give information on the sizes of the corpora, (2) perform statistical analysis and show the consistency of each correspondence; (3) discuss why sounds are adapted in these ways and what motivations are behind Japanese native speaker's choice of adaptation strategy. Due to the historical origin of Sino-Japanese, data on the Chinese and Japanese varieties at the time of adaptation can only be obtained from historical evidence and reconstructions. Despite this challenge, the unique sociolinguistic context and the intensity of borrowing make Sino-Japanese loanwords a valuable subject of study in the field of loanword adaptation. This study aims to fill the gap in literature and investigate Chinese loanwords in Japanese from the perspective of loanword adaptation. It also intends to contribute empirical evidence for the phonology vs phonetics theoretical debate in the loanword adaptation literature, and propose innovative research methodology for historical adaptation studies.

1.2 Sino-Japanese

1.2.1 The nativization of Chinese

When Chinese first came into contact with the Japanese society, it was spoken as a foreign language in Japan. Gradually, Japanese developed a nativized pronunciation system to read Chinese words following Japanese phonology. Sino-Japanese refers to the nativization of Chinese learned and used in Japan, and Sino-Japanese loanwords refer to words of Chinese origin that have been used outside the context of reading Chinese text and carried over into everyday language in Japanese societies (Frellesvig, 2010).

At the early stage of the language contact, Japanese did not yet have its own writing system. Japanese speakers directly borrowed Chinese script to represent the Japanese language. The logographic Chinese characters that were adapted in the Japanese writing system are called 'kanji'. Kanji were adapted in two ways:

1. Semantic adaptation: the meaning of a Chinese character was preserved and the character took on the sound of the native Japanese word of the same meaning. For

example, the character 生 in Chinese can mean 'raw (food)'. The native Japanese word for 'raw' is /nama/ なま. The kanji 生 is read as /nama/ through meaning adaptation. The kanji reading that has a native Japanese origin is called *kun'yomi* 訓読み. A single kanji can have more than one *kun'yomi*. The character 生 in Chinese can also mean "give birth; live; grow". It is therefore assigned different native Japanese readings (*kun'yomi*) in different context. For example, it is pronounced as /u/ in /umu/生む 'to give birth', as /i/ in /ikiru/ 生きる 'to live' and /ha/ in /haeru/ 生える 'to grow'.

2. Sound adaptation: the sound of a Chinese character was kept and it was used to represent either its Chinese meaning or a native Japanese word of the same sound. The 'sound of a Chinese character' here does not refer to the actual pronunciation of the character in Chinese, but the nativized Japanese pronunciation of Chinese, i.e. Sino-Japanese pronunciation. For example, 生 in the source Late Middle Chinese form is read /ʂaːjŋ/ , and the nativized Sino-Japanese *kan-on* reading is /sei/ (pronounced as [seː] in Modern Japanese due to monophthongisation; see Section 2.4.5.3). The kanji reading that has a Chinese origin is called *on'yomi* 音読み, which is also the Sino-Japanese reading. Sino-Japanese is composed of different substrata because Japanese was in contact with different varieties and periods of Chinese. During the three waves of language contact, the Chinese varieties spoken in Japan (as a foreign language) were called *go-on, kan-on*, and *to-on*. These varieties were later nativized into Sino-Japanese *go-on*, *kan-on*, and *to-on*, respectively. A kanji can have several different Sino-Japanese readings which reflect the contemporary pronunciation of the dominant variety of Chinese at the time of the borrowing.

The *on'yomi* and *kun'yomi* readings of individual kanji are listed in specialised Sino-Japanese root dictionaries (漢和辞典 kanwa-jiten). Figure 1 shows the entry for the kanji 生

in one of the Sino-Japanese root dictionaries – *Shinsen Kanwa Jiten* dictionary (Kobayashi, 2011). The kanji is in red on the top left of the figure. 生 is listed in the official *Jōyō-Kanji* list (常用漢字表), the list of Chinese characters designated for everyday use issued by the Japanese Ministry of Education. The bottom left of Figure 1 shows the *on'yomi* and *kun'yomi* readings of the kanji listed in the *Jōyō-Kanji* list (in red). The *on'yomi* readings are in katakana script and *kun'yomi* readings are in hiragana script. On the right side of the *on'yomi* readings, the Sino-Japanese *kan-on*, *go-on* and *to-on* readings are listed. The bolded readings are the common kanji readings in Modern Japanese. It can be seen that the Sino-Japanese *kan-on* and *go-on* readings of the character survived into Modern Japanese as common *on'yomi* readings whereas the *to-on* reading is less used. The historical readings (before sound changes) are shown in brackets.

Figure 1 Shinsen Kanwa Jiten dictionary entry for kanji 生. The figure is annotated for kan-on, go-on, to-on, on'yomi and kun'yomi.

1.2.2 The Sino-Japanese strata in Modern Japanese

There is a vast body of research on the Sino-Japanese stratum in the Modern Japanese lexicon (Ito & Mester, 2015; Tateishi, 1990; Kurisu, 2000). Sino-Japanese loanwords take up a large proportion of the Modern Japanese lexicon, covering a wide range of items from daily conversation to formal discourse. Shibatani (1990: 142–143) reports that 60% of the words in the *Genkai* dictionary (1859), a Modern Japanese dictionary, are Sino-Japanese. The National Institute of the Japanese Language (1962) conducted statistical research to investigate the distribution of loanwords and native words in actual use. They surveyed 90 contemporary magazines from five different fields. The findings revealed that (1) while Sino-Japanese words took up a large percentage in terms of the number of distinct words (47.5%), they are of lower frequency – they only constituted 2.9% in terms of total word count; (2) Sino-Japanese vocabulary is often used in academic and technical fields, or to express abstract concepts. Take Sino-Japanese and native Japanese synonyms as an example. Both the native word /kinoo/ and the Sino-Japanese word /sakuzitu/ mean 'yesterday'. While the native term /kinoo/ is generally used in the colloquial language, the Sino-Japanese counterparts /sakuzitu/ is often used in the literary language. The role of Sino-Japanese loanwords in Modern Japanese is comparable to that of Latinate words in English. While Latinate words takes up a high percentage in the English vocabulary, Germanic words are of higher frequency in ordinary speech. In parallel to Sino-Japanese and native Japanese synonyms, we have examples of Latinate and Germanic synonyms, e.g. Germanic 'help' vs Latinate 'aid'; Germanic 'begin' vs Latinate 'commence', where the Latinate words are of higher formality.

Despite the long history and extensive use, Sino-Japanese still preserves unique morpheme structure, prosody, and segmental composition that distinguish it from the other constituents of the Japanese lexicon. These unique characteristics are the cumulative result of the distinct waves of lexical influx. This thesis focuses on Sino-Japanese root morphemes, represented by *kanji* characters. A Sino-Japanese root consists of either two light syllables with a monosyllabic allomorph (e.g. gaku~gak 学 'study, scholarship'), a single heavy syllable (e.g. nai 内 'internal'), or a single light syllable (e.g. ki 気 'spirit') (Itô & Mester, 2015). Based on the root size restriction, the legitimate segmental structures in Sino-Japanese are CV, CVV, CVN, and CVC(V). Because of the word size restriction, most independently-occurring Sino-Japanese items are compounds. Those compound words are listed in regular Japanese dictionaries (国语辞典 kokugo-jiten). For words in the native Japanese strata, during compound formation, the words are re-syllabified to fulfil the Maximal Onset Principle. In Sino-Japanese, however, cross-morpheme syllabification does not occur even when the second morpheme starts with a vowel (Itô and Mester, 2015). For example, /kan/+/i/ 簡易 'simplicity' is syllabified as /kan.i/ instead of */ka.ni/. As a result, the roots in Sino-Japanese compounds are always clearly recognizable as prosodic units in the output form.

The strata specific patterns are shown to affect the comprehension and processing of modern day native speakers of Japanese in psycholinguistic experiments. For example, for Sino-Japanese CVV syllables, possible vowel compositions are the two diphthongs /ai/ and /ui/, the three long vowels /e:/, /o:/, and /u:/, but not */a:/ or */i:/. By contrast, long vowels are rare in the native stratum, and all five long vowels are common in the stratum of foreign loans (Moreton, Amano and Kondo, 1998). In Moreton and Amano's (1999) speech perception experiment, participants are more likely to associate the stimuli with a particular stratum when they hear sounds that cue stratal affiliation. They tend to judge an [a] sound they hear as short when they perceive the stimuli as belonging to the Sino-Japanese stratum, since [a:] is only allowed in the foreign stratum. Gelbart and Kawahara (2007) have further shown that even in the absence of phonological cues to stratal affiliation, listeners are still more likely to identify final long [a:] in words in the foreign stratum than in the native one.

1.3 Previous studies in loanword adaptation

Loanwords are lexical borrowings as a result of language contact. They are the most common language contact phenomena. Haspelmath and Tadmor (2009) complete a cross-linguistic study of loanwords in 41 languages (the *Loanword Typology* project) and conclude that all languages in the database, and perhaps all languages in the world, have lexical borrowings.

Loanwords are studied from various angles in linguistics, including phonology, morphology, sociolinguistics and historical linguistics. One important research question is how loanwords are adapted from the source language into the borrowing language.

This study looks at loanwords from the perspective of sound adaptation. Loanword adaptation has an important position in the phonetics and phonology literature because adaptation data provides us with insight into the synchronic and diachronic phonology of the languages and reveals aspects of the languages that are not necessarily obvious from the native language data. Empirical studies have investigated adaptations at the segmental level, syllabic level, as well as the tonal/accentual level. This study focuses on the segmental and syllable-structural adaptations.[1]

Segmental adaptations occur when the input from the source language has segments that are foreign to the native phonology of the borrowing language. Speakers of the borrowing language have to identify a native phoneme to represent the foreign segment. Due to the difference in native phonologies and repair strategies, the same input segment is adapted differently in different languages. For example, the English dental fricative /θ/ which is not common cross-linguistically is adapted as / t̪ʰ/ in Bengali, as /t/ in Dutch and as /s/ in German (Lahiri & Kennard, 2019); the French high front rounded vowel /y/ is adapted as the high front vowel /i/ in Mauritian Creole (Jacobs & Gussenhoven, 2000) and as the bi-segmental sequence /ju/ in Japanese (Dohlus, 2005). Mergers are common in the cases where the borrowing language has fewer contrasts in the phonemic inventory than the source language. For example, Hawaiian only has seven consonants, /p, k, ʔ, l, w, n, h/, and all English non-labial obstruents are adapted as Hawaiian /k/ (Uffmann, 2015).

Syllable structural adaptations occur when the input from the source language has structures that are not allowed in the borrowing language. According to syllable markedness, languages

[1] For an overview of tone and accent adaptations, see Kang (2010).

tend to dislike consonant clusters as complex onset, or have restrictions on codas. If the borrowing language has these constraints, the illicit structures from the source language have to be repaired to conform to the phonotactics in the native phonology. There are two repair strategies available: (1) deletion: delete the disallowed segment, or (2) epenthesis: insert materials into the offending structure or after the offending segment. A cross-linguistic survey by Kang (2011) shows that word-initial clusters are predominantly repaired by epenthesis, conforming to the *Preservation Principle* by Paradis and LaCharité (1997) which says that languages favour insertion over deletion because they try to keep as much information as possible from the input. In word-final positions, however, it is less clear whether epenthesis is the dominant strategy to resolve coda consonants or clusters restrictions. Some languages choose one strategy systematically, e.g. Japanese uses epenthesis (Kubozono, 2015); Thai uses deletion (Kenstowicz & Suchato, 2006), while others employ both methods, e.g. Cantonese (Silverman, 1992).

In some cases, segments that do not exist in the native phonemic inventory or structures not attested in the native phonology are exceptionally allowed in loanwords. This process is called importation or non-adaptation, and it introduces new sounds or structures into the borrowing languages (cf. Kennard & Lahiri, 2020). See LaCharité and Paradis (2005) for a survey of importations in large corpora of English and French loanwords in several different languages, and see Kennard & Lahiri (2020) for a phonological analysis of those 'new' phonemes. If the new sounds and structures continue to exist in loanwords but do not widely spread to the native lexicon, it will lead to lexical stratification, which is the case in Modern Japanese as introduced in Section 1.1. Lexicons of different origin display distinct phonological properties. A famous proposal accounting for the phonology of stratified lexicon is the core-periphery structure by Ito & Mester (1993). Native lexicon is in the core domain where all phonological constraints are activated. The constraints increasingly relax towards the periphery. Importations enter the periphery domain where only a subset of the native constraints is active, so foreign structure or segments are more easily tolerated.

A puzzling problem in loanword adaptation is how languages decide on what the best match is for the foreign segment and structure. There is always more than one logically possible strategy to repair (or import) foreign input, yet languages always select a particular approach from various options. Steriade (2001) referred to this issue as the *too-many-solutions* problem. The fierce theoretical debate in loanword adaptation centres around the issue of how languages identify the best repair strategy. In order to address this issue, the first question that needs to be answered is what the input is to loanword adaptations. Do speakers of the borrowing language have access to the underlying phonemes or only to the surface phonetics of the foreign input?

The phonological approach believes that the input to adaptation is the phonological representation of the source language, and the foreign-to-native mapping process is based on phonological equivalent (Haugen, 1950; Hyman, 1970; Paradis & LaCharité, 1997, 2008; LaCharité & Paradis, 2002, 2005; Paradis & Tremblay, 2009; Jacobs & Gussenhoven, 2000). Evidence comes from the observation that borrowing languages tend to preserve phonemic categories from the source languages in spite of acoustic differences. Take English loanwords in Mandarin Chinese as an example: English stops contrast in voicing phonemically (e.g. /p b/), whereas Mandarin stops contrast in aspiration (e.g. /p p^h/). English voiceless stops /p/ can be directly mapped onto Mandarin voiceless stops /p/, but English voiced stops /b/ do not have a phonetic equivalent in Mandarin. It would be a logical option to neutralise English voiced /b/ and voiceless stops /p/ to Mandarin voiceless stops /p/. However, Mandarin preserves the stop contrast in English – English voiced stops /b/ are adapted as Mandarin voiceless stops /p/ and English voiceless stops /p/ are adapted as Mandarin voiceless aspirated stops /p^h/. The logically possible merger does not occur. The process follows the *Category Proximity Principle*

(LaCharité & Paradis, 2005: 227), which says that if a phonological category in the source language does not exist in the borrowing language, this source language category will be replaced by the closest phonological category in the borrowing language, even if there are acoustically closer sounds in the borrowing language inventory. Furthermore, surface phonetic variations in the source language are not mapped onto phonemic categories in the borrowing language. English voiceless stops have aspirated [p^h] and non-aspirated [p] allophones, which are phonetically similar to Mandarin voiceless aspirated /p^h/ and non-aspirated /p/ stop phonemes. However, this phonetic contrast does not influence phonemic categorisation in Mandarin. Both English voiceless aspirated and non-aspirated stop [p p^h] surface forms are consistently mapped onto Mandarin voiceless aspirated stop phonemes /p^h/ (Paradis & Tremblay, 2009).

The opposing position, often referred to as the perceptual or phonetic approach, believes that speakers of the borrowing language only have access to the surface acoustic of the source language. Theories under this approach can be further divided into two different camps with respect to where the foreign input is adapted – whether it is in the raw phonetic perception or in the phonological grammar of the borrowing language. The former view argues that adaptation is purely guided by phonetic similarity, and source forms are adapted as the native segments that most closely approximate the acoustic properties of the inputs. Listeners cannot perceive the acoustic input accurately and the adaptation has already taken place before it reaches the phonological computation (Dupoux et al. 1999; Peperkamp & Dupoux, 2002, 2003; Peperkamp, 2004; Peperkamp et al., 2008; Boersma & Hamann, 2009). This is referred to as *phonological 'deafnesses'* by Peperkamp and Dupoux (2003: 367). A staggering case comes from the adaptation of English consonant clusters in Japanese. Modern Japanese does not allow consonant clusters and those illicit sequences are adapted with the insertion of the default epenthetic /u/ most of the time. Dupoux et al. (1999) find that Japanese listeners report hearing illusory vowel [u] in stimuli like ‘ebzo’ and cannot distinguish stimuli like ‘ebzo’ and ‘ebuzo’. Peperkamp and Dupoux (2003) report similar ‘deafnesses’ in Korean speakers’ perception of [l] vs [r] and French speakers’ perception of stress contrasts.

As for the latter view in the perceptual camp, the parsing of the acoustic input is driven by the native phonology, and the perceived forms are matched with the phonological categories of the borrowing language (Yip, 1993, 2006; Kenstowicz, 2007; Silverman, 1992; Lahiri & Kennard, 2019; Kim, 2008, 2009; Boersma & Hamann, 2009). While categorical perception can be inevitable in certain cases, the theory argues that in most of the cases, phonetic similarity is based on phonology of the native language instead of perceptual *‘deafness’*. A follow-up study on the illusory vowel reported in Dupoux et al. (1999) is carried out by Monahan et al. (2009). Epenthetic [o] is inserted after coronal obstruents /t, d/ in Modern Japanese, and Monahan et al. (2009) find that Japanese speakers have no problem perceiving the differences between stimuli ‘edma’, ‘edoma’ and ‘eduma’. The perceptual ‘deafness’ reported in Dupoux et al. (1999) could be due to the fact that /u/ in Japanese is often shortened or devoiced in production so speakers expect the absence of robust acoustic cue. Another example in support of the phonology-based-perception view comes from the adaptation of English dental fricative /θ/ in two closely related languages, Dutch and German. Lahiri & Kennard (2019) find that while both Dutch and German have the coronals /t/ and /s/, English /θ/ is adapted as /t/ in Dutch and as /s/ in German.[2][3] They attributed this pattern to the differences in phonemic categories in the two languages. English has three coronal fricatives /s θ ʃ/. The three sounds can be distinguished by stridency and tongue height: /θ ʃ/ have higher tongue height and /s/ has lower tongue height; /s ʃ/ are strident while /θ/ is not. German has two coronal fricatives /s ʃ/ and they

[2] Note that [θ] in the cluster [θr] is pronounced as [t] in Standard German because [sr] is not a possible cluster (Lahiri & Kennard, 2019).
[3] Other observations show that many naive German speakers also adapt English /θ/ as /t/ or /d/. The /s/ and /z/ adaptations tends to be more prevalent among speakers who have been instructed that the English sound is a fricative.

differ in their tongue height, with /s/ pronounced with a lower tongue height and /ʃ/ pronounced with a higher tongue height. German speakers extract acoustic cues for coronal high tongue height from English /θ/ and map onto the native coronal high tongue height phoneme /s/. Dutch, however, does not have coronals that contrast in tongue height. There is only one coronal fricative phoneme /s/ and one coronal stop phoneme /t/. They differ in stridency, with /s/ pronounced with strident noise. English /θ/ is not a strident sound so there is no strident cues from the acoustic signal that can match with Dutch /s/. Dutch speakers therefore prefer /t/ as the adaptation form for English /θ/. Acoustic signals from the foreign input are filtered through contrasts in the native phonology of the borrowing language.

The above theories focus on the situations in which loanwords are introduced orally instead of orthographically. What about when loanwords are introduced through written materials? Vendelin and Peperkamp's (2006) examine the influence of orthography through an experimental study. They find that while participants only rely on perception when the stimuli are presented orally, they often apply a grapheme-to-phoneme correspondence that they learned in foreign-language classes when stimuli are presented in both audio and written forms. The result indicates that orthography could give certain information on the phoneme in the source language. Dohlus (2005) investigates the adaptation of French and German mid front rounded vowels /œ ø/ in Japanese. German enters Japan mainly via written media, whereas French is more often used in oral communication. The findings show that the adaptation of French /œ ø/ as Japanese /u/ is based on phonetic approximation, whereas the adaptation of German /œ ø/ as Japanese /e/ reflects phonological approximation, suggesting that phonological adaptation can be triggered when there is a large influence of orthography and a lack of oral input. In the case of Chinese loanwords in Japanese, however, although Chinese came into contact with Japanese both orally and orthographically, Japanese society was illiterate when Chinese was first introduced due to the lack of writing system, and the logographic script of Chinese did not give Japanese speakers any hints about the possible pronunciation. Japanese formally studied the pronunciation of Chinese characters from (native and non-native) speakers of the Chinese language. The context of adaptation was therefore orally based.

Sociolinguistic factors are also shown to play an important role in determining the adaptation strategy. The two factors that have been widely attested to influence the nature of the input are the level of bilingualism and the prestige of the source language in the borrowing language community. The greater the level of bilingualism and the higher the prestige of the source language in the borrowing language community, the more likely it is that borrowers will have access to the phonological representations of the foreign input. In arguing for the phonological approach, Paradis & LaCharité (2008) emphasise the assumption that loanwords are introduced by bilinguals who have profound knowledge of the phonological system in both the source and the borrowing languages. Evidence in support of the influence of sociolinguistics also comes from analyses of Italian loanwords in French (Lev-Ari & Peperkamp, 2014), Spanish loanwords in Mexicano (Lev-Ari et al., 2014), Turkish and French loanwords in Romanian (Friesner, 2009), Chinese loanwords in Korean (Kim, 2015), among many others. Sociolinguistic factors are relevant to our discussion of Sino-Japanese in this thesis. There was a high level of bilingualism in Japanese society and Chinese enjoyed high prestige throughout the language contact periods.

In a lot of cases, the predictions of the different theoretical accounts converge since phonological representations are grounded in phonetics. In other cases, the competing accounts propose different hypotheses. However, empirical studies conducted over the years have provided ample evidence for each theoretical account, suggesting that the theories are perhaps not contradictory but complementary. Empirical evidence that supports one theory does not invalidate another theory. Each language contact case is unique and a different set of factors interact to shape the adaptation strategy.

In terms of methodology, adaptations are often modelled by constraint-based models (e.g. the Constraints and Repair Strategies (Paradis, 1988), Optimality Theory (Prince & Smolensky, 1993, 2004; Holt, 2015)) or feature-based models (e.g. SPE (Chomsky & Halle, 1968), *Featurally Underspecified Lexicon* model (Lahiri, 2018)). Constraint-based models focus on phonological processes, while feature-based models look at representations. Section 2.2 introduces the methodology for this study in details.

1.4 Research goals and thesis structure

This study investigates Sino-Japanese from a loanword adaptation perspective. It aims to contribute empirical data to the loanwords adaptation literature and shed light on the phonetic vs phonology theoretical debate. According to Paradis and LaCharité's (2011) methodological guideline on loanword-adaptation-study design, in order to achieve a result that best reflects the real adaptation pattern, it is important to (1) focus on direct borrowings, (2) have a broad statistical basis, (3) distinguish adaptation processes and native processes, and (4) consider the social and historical context at the time of the borrowings. Among the three periods of historical language contact, the second period is the most direct and extensive. The first period of contact was mediated through the Korean peninsula so the borrowings were not direct. The last wave of contact was less systematic and the borrowings were based on more than one variety of Chinese. This thesis investigates the adaptation of Sino-Japanese *kan-on,* the substrata that result from the second wave of language contact. The source language is Chang'an Late Middle Chinese (Chang'an LMC) and the borrowing language is Early Middle Japanese (EMJ). The sociolinguistic background at the time of borrowing has also been well-studied.

Although there is a wealth of literature on the historical phonology of Chinese and Japanese, it remains difficult to ascertain the precise sound patterns of the source language, borrowing language, and adapted forms at the time of borrowing due to the absence of acoustic evidence. To conduct a rigorous analysis of loanword adaptation, we scale down the research question to the less controversial and more reliable aspects of historical phonology in Chinese and Japanese. Compared to vowels, consonant reconstruction is less contentious. This study focuses on consonants and investigates the segmental adaptation of Sino-Japanese *kan-on* initials and the phonotactic adaptation of Sino-Japanese *kan-on* codas.[4]

The empirical research consists of two corpus analyses and a psycholinguistic experimental study. In order to have a broad statistical basis, a corpus of 2136 *kanji* is assembled. Each *kanji* is paired with a Chang'an LMC reading and a historical *kan-on* reading. The first corpus analysis examines the adaptation of LMC initial consonants in EMJ. Both languages allow syllable onsets so the adaptation is at the segmental level. No phonotactic related structural change is triggered. However, the initial consonant inventory of the source language Chang'an LMC is much bigger than that of the borrowing language EMJ. The research question is how the large number of phonemic contracts and phonetic variations in LMC initials are adapted into EMJ which has a smaller consonant inventory. The overall data shows a large number of mergers and a consistent preservation of PLACE of articulation. While some data can be explained by both the phonetic and phonological theories, the adaptation of LMC voiced aspirates and the labiodental approximant /ʋ/ shows that the acoustic input is being processed by the EMJ native phonology.

The second corpus analysis looks at the adaptation of Chinese codas. EMJ has more restrictive constraints on syllable and word structure than Chang'an LMC. It does not allow

[4] Tonal adaptation is beyond the scope of this thesis. The Japanese adaptation of MC tones has been thoroughly studied by De Boer (2008, 2010), among others.

word-final consonants. LMC codas are adapted with vowel epenthesis in EMJ to satisfy native phonotactics. However, while the default epenthetic /u/ is inserted in the majority of cases, there is a small number of cases with epenthetic /i/. Previous studies on Modern Sino-Japanese strata (Ito & Mester, 2015; Tateishi, 1990) propose a vowel harmony theory to account for the occurrence of epenthetic /i/. However, the account is based on the Sino-Japanese phonology in Modern Japanese. In other words, only the adapted forms are studied and the source form at the time of adaptation was not considered. The current corpus analysis investigates the following research questions: (1) whether the data from the corpus supports the vowel harmony theory in the Sino-Japanese literature (2) if not, what conditions the quality of the epenthetic vowel from a loanword adaptation perspective. The analysis reveals an epenthetic vowel harmony that is different from the vowel harmony theory in the Sino-Japanese literature. The quality of the epenthetic vowel is influenced by the number of distinct segments and the final glide in the input nucleus.

Based on the results of the corpus analyses on coda adaptation, a follow-up psycholinguistic experimental study is conducted to further investigate the vowel epenthesis patten observed in Sino-Japanese *kan-on*. The experimental study explores (1) whether we can test historical adaptation pattern on Modern Japanese speakers, and (2) what factors influence the epenthetic vowel harmony and how those variables interact. It consists of two behavioural tasks: a forced-choice task and an XAB task. Testing historical data in the modern language enables us to verify findings from corpus data and also see if there has been a shift in the native phonology. The result shows that the epenthetic vowel harmony is influenced by the interaction of two variables: (1) the contraction of the input nucleus and (2) the final segment in the input nucleus. Dorsal codas do not have an influence on the epenthetic vowel harmony.

This thesis is organised as follows. Chapter 2 provides the necessary linguistic and extralinguistic background on Sino-Japanese for this adaptation study. The chapter starts with an introduction to the historical language contacts and substrata of Sino-Japanese, then discusses the distinctive feature framework that serves as the foundation for the phonological analyses in this thesis. This is followed by the phonological analyses of the source and borrowing languages. Chapter 3 investigates the adaptation of Chang'an LMC initial and coda consonants in EMJ through two corpus analyses. The chapter starts with a critical analysis of an early corpus study by Heffernan (2007). It then presents the methodology and empirical data from the current corpus study, along with discussions of the adaptation strategies employed in Sino-Japanese *kan-on*. Chapter 4 further explores coda adaptation and vowel epenthesis through an experimental study. The chapter discusses the experimental design in details and presents the statistical analysis. Chapter 5 provides a summary of the findings from the corpus and experimental studies, discusses how these empirical findings align with the phonetic vs phonology theoretical debate in the loanword adaptation literature, and identifies possible directions for further investigation in this field.

Chapter 2 Background – Sino-Japanese sociolinguistics and phonology

The focus of the thesis is on the adaptation of Sino-Japanese *kan-on* and this chapter introduces the linguistic background of Sino-Japanese. Section 2.1 discusses the sociolinguistic aspects of the historical language contacts and introduces the formation of the three substrata of Sino-Japanese. Before presenting the phonological analyses of historical Chinese and Japanese, Section 2.2 introduces the feature theory that the analyses are based on. Section 2.3 introduces the periodisation of Chinese, the historical background of the Middle Chinese (MC) period and presents a phonological analysis of Chang'an Late Middle Chinese (Chang'an LMC), the source language of *kan-on*. Section 2.4 discusses the phonology of Japanese, the borrowing language, at different linguistic periods. It is important to understand the overall historical phonology of the borrowing language and the sociolinguistic background of the time the adaptation took place. However, instead of taking a philological approach, the section focuses on the phonological analysis of the synchronic stages at each historical period and introduces main diachronic changes that connect the periods where relevant.

2.1 Historical language contact

2.1.1 Overview

An overview of the three periods of historical language contact between Chinese and Japanese is shown in Table 1. It presents the linguistic periods of Chinese and Japanese, the overlapping political periods in both countries, and the Sino-Japanese substrata for each period of language contact. As can be seen from the table, the first period of contact (shaded in green) took place during the Pre-Old Japanese (Pre-OJ) period when Japan was in its Yamato period. China was in its Eastern Jin to Sui Dynasty and the language spoken was Early Middle Chinese (EMC).

The Jinling (also called ‘Wu’) variety of EMC in the Northern and Southern Dynasties spoken in the area of present-day Nanjing came into indirect contact with the Japanese society through Korean. The first substratum of Sino-Japanese, *go-on*, is based on the Chinese pronunciation norm introduced during this first period of language contact. Because this period of language contact between Japanese and Chinese was indirect, and it took time for *go-on* to become widely adopted in Japanese society as a Chinese pronunciation norm, the period during which the source Chinese variety was spoken in China does not coincide with the period in which *go-on* was used in Japan. *Go-on* was widely used during the following Old Japanese (OJ) period. The OJ and the first half of Early Middle Japanese (EMJ) periods saw the second period of contact (shaded in blue). The variety of Chinese that Japan was in contact with was the LMC spoken in Chang’an. Chang’an LMC is the source language of *kan-on,* the second substratum of Sino-Japanese. Nara and early Heian Japan were in extensive contact with Tang China. During the second half of the EMJ period, direct contact with China stopped but the fossilised *kan-on*, and also *go-on* in certain fields, were still in frequent use in Japan. The third period of contact (shaded in yellow) happened during the Late Middle Japanese (LMJ) period when Japan was in its Kamakura, Muromachi and (Azuchi)-Momoyama period. Chinese evolved into Early Modern Chinese (EModC) around this time and China was in the Southern Song Dynasty to late Ming dynasty. *To-on,* the third substratum of Sino-Japanese was based on a cumulative mixture of varieties of EModC spoken throughout the four centuries. The periodisation of Chinese and Japanese are discussed in details in Section 2.3.1 and 2.4.1 respectively.

Table 1 The periodisation of Japanese and Chinese and the three periods of language contact. The colours are used to differentiate the periods.

Time period (CE)	Japanese linguistic period		Japanese historical periods		Chinese linguistic period			Chinese historical periods		Language contact period	Sino-Japanese pronunciation
401-500	Pre-Old Japanese (Pre-OJ)	- 700	Yamato	250 - 700	Middle Chinese (MC)	Early Middle Chinese (EMC)	ca. 400 - 618	Eastern Jin	317 - 420	1st contact 5th to early 7th centuries	*go-on*
501-600								Northern and Southern Dynasties	420–589		
601-700								Sui	581 - 618		
701-800	Old Japanese (OJ)	700 - 800	Nara	712 - 794		Late Middle Chinese (LMC)	ca. 618 - 1150	Tang	618 - 907	2nd contact mid 7th to late 9th centuries	*kan-on*; (*go-on* was also in use, especially during the Old Japanese period)
801-900	Early Middle Japanese (EMJ)	800 - 1200	Heian	794 - 1185							
901-1000								Five Dynasties	907 - 960		fossilised *kan-on* & *go-on*
1001-1100								Northern and Southern Song	960 - 1279		
1100- 1200											
1201-1300	Late Middle Japanese (LMJ)	1200 - 1600	Kamakura	1185 - 1333	Early Modern Chinese (EModC)		ca. 1151-1911			3rd contact late 12th to 16th centuries	*to-on*
1301-1400			Muromachi	1333 - 1573				Yuan	1271 - 1368		
1401-1500								Ming	1368 - 1644		
1501-1600			(Azuchi)-Momoyama	1573–1603							
1601-1700	Modern Japanese	1600 -	Edo	1603 - 1868				Qing	1644 - 1911		
1701-1800											
1801-1900			Meiji	1868 - 1912							
1901-2000			Taicho	1912 - 1926	Modern Chinese		ca. 1911 -		1911 CE -		
			Showa	1926 - 1989							
2001-2100			Heisei	1989 -							

2.1.2 The first period of contact and *go-on*

Japanese society's initial large scale contact with the Chinese language and texts is generally considered to have taken place before the Nara period, around 5th to early 7th century CE, contemporary with the Northern and Southern Dynasties to Sui Dynasty in China (420 – 618 CE). Japan's two oldest chronicles of classical Japanese history, the *Kojiki* 古事記 (712 CE; written in Chinese) and *Nihon Shoki* 日本書紀 (720 CE; written in Japanese), record the semi-legendary scholar Wani 王仁 who was sent by the king of Paekche 百済 to Japan during the reign of the Emperor Ōjin 應神 (270 – 310 CE) and introduced the Chinese language to Japan through two classics: Confucius' *Lunyu* 论语 and *Qianziwen* 千字文, a textbook for literary language. The specific details of the legend are controversial as *Qianziwen* was compiled by Zhou Xingsi (470-521 CE) during the Northern and Southern Dynasties in China, which was after the reign of the Emperor Ōjin 應神 (270 – 310 CE).

However, what is important from this semi-legendary historical record is that the contact between the Chinese language and Japan at the initial stage was mainly indirect and mediated through the Korean peninsula, mostly from the kingdom of Paekche, and Chinese classical literature and language texts were of great importance during that period (Endo, 2015). It has been documented that some intellectuals, traders and fishermen mainly from the kingdom of Paekche but also from China travelled to Japan during the pre-Nara period with their varieties of spoken Chinese. Monks and nuns from Paekche taught Chinese classics, and introduced Buddhism during the 6th century, and later expounded Buddhist sutras and commentaries. See Section 2.3.2 for details of the Chinese historical background and its contact with Korean.

The pronunciation for speaking the foreign language Chinese and reading Chinese texts in Japan that is based on this variety of Chinese is often referred to as *go-on* ('Wu pronunciation'). The name *go-on* is usually interpreted as indicating that this Chinese variety was mainly based on the Jinling dialect, also called 'Wu pronunciation 吴音', spoken in south-east China (Li & Yu, 2018), although there is no historical documentation to prove its exact origin. Sino-Japanese /ɡo/ in *go-on* is etymologically related to EMC 吴 'Wu' /ŋɔ/ (Pulleyblank, 1991: 325) at the time of the borrowing.

During this first period, the language contact was indirect through a variety of ways, and not as systematic as the second period. It has been argued that the Chinese language learned in Japan reflects a cumulative and multi-tiered mixture of varieties of Chinese of the EMC period, filtered through some variety of Sino-Korean (probably late Sino-Paekche) (Endo, 2015; Frellesvig, 2010).[5] *Go-on* was primarily used during the Nara period (Schmidt, 2009). In *Kojiki*, there are many Japanese poems written using the technique of *ongana* 音仮名, i.e. utilising a Chinese word of similar pronunciation to the target Japanese vocabulary to represent that Japanese word. The phonological system reflected by these poems corresponds to *go-on*. Some materials (e.g. *Suiko-chō ibun*) found from the Nara period also reflect characteristics of Old Chinese (OC) (e.g. Endo, 2015; Miyake, 2003). This is because some varieties of Chinese that have entered Japan were filtered through Korea, where OC was preserved even until China was already in its MC era. There are also considerable variations within *go-on*. Different Buddhist schools and sects had their own fixed conventions for reading and reciting texts, especially sutras (Frellesvig, 2010: 275). These pronunciation conventions were preserved by oral transmission and they gradually became distant from the original Chinese varieties. It

[5] As this study is focused on the adaptation of Sino-Japanese *kan-on*, the influence of Sino-Korean on Sino-Japanese *go-on* is beyond the scope of this thesis.

should be noted that *go-on* during this period refers to the pronunciation non-native Chinese taught and learned in Japan. Sino-Japanese, the nativized pronunciation of *kanji*, was not established until the EMJ period.

The loanwords borrowed from Chinese, i.e. Chinese words that are fully integrated into the Japanese vocabulary, during the timespan of this first period are not thought to be many. The topics that these early loans cover range from items in daily life (e.g. kuni 郡 'county', kinu 絹 'silk', kama 坩 'porcelain container', rure 琉璃 'coloured glaze'; mitsu 蜜 ミツ "honey"), plants and animals (e.g. zoo 象 ゾウ "elephant"; moke 木瓜モケ"papaya" , uma 馬 'horse', and ume 梅 'plum'), to terms in Buddhism (e.g. 経文 キョウモン "sutra"; 功徳 クドク "merit"， ke 気'spirit', saga 性, 祥 'charsteristics, good omen') (Li & Yu, 2018; Kamei, 1954; Frellesvig, 2010). Compared to the large number of loanwords which have entered Japanese since OJ onwards, however, the small number of early loanwords from Chinese is insignificant.

2.1.3 The second period of contact and *kan-on*

In the following OJ period, while the *go-on* reading of *kanji* became widely used (Schmidt, 2009), the second period of contact had also begun. Between 630 – 838 CE, during the Nara period and early Heian period, Japan sent a large number of envoys and students to visit and study in China. China was in its early Tang period, a golden age of cultural advancement, and Chinese was in the LMC period. This extensive direct contact with Tang dynasty resulted in massive intellectual, cultural, political and social influence from Tang China on Japanese society, as well as heavy Chinese influence on the Japanese language. The students and envoys brought gold as gifts to the Tang emperors and exchanged it for a large number of books and documents on Buddhist sutras and Confucian classics.

The Japanese visitors acquired contemporary Chinese as spoken in the Tang capital Chang'an in north-western China, the region around present-day Xi'an. Due to the large land area of China and the rapid change of dynasties, the variety spoken in Tang China differs considerably from the source variety of *go-on*. This variety of Chinese learned in Japan during the second contact period is was referred to as as *kan-on* 漢音 'Han pronunciation' and became the new Chinese pronunciation norm for reading of *kanji* and texts from the EMJ period. The Japanese word /kan/ in *kan-on* is the adaptation of LMC /xan/ 漢 'han'. Between 792 and 806, several imperial decrees announced that *kan-on* was the Chinese pronunciation norm to be used in study and reading of Chinese classics, and practical communication, guaranteeing the status of *kan-on* in civil service exams, and official and public recitations of Buddhist sutras (Frellesvig, 2010: 275). As a result, *kan-on* was the main pronunciation used during the Heian period (794 – 1185 CE), especially in reading Confucian classics (Endo, 2015), while *go-on* was still commonly used in reading Buddhist sutra. *Nihon Shoki* (720 CE), the second oldest chronicle of classical Japanese history, was published only 8 years after *Koshiki* (712 CE), the oldest chronicle of classical Japanese history, but it reflects the phonology of Chang'an LMC, the variety of Chinese that *kan-on* was based on.

This second historical contact between Japan and China is direct and the most extensive one of the three periods. During the Nara period, the large influence of cultural, religious, and political knowledge from China led to the rise of bilingualism. Most Japanese educated elite and court nobilities became bilingual and sent their children to study in China (Schmidt, 2009). Chinese was associated with prestige and taught in formal institutions by native instructors (Loveday, 1996). This is similar to the beginning of the Norman Conquest when the language of the court in England was French. Note the introduction of expensive food items related to animals: *pork, beef, venison,* are all French but the names of the animals, which were used by the farming community, remained in Germanic: *pig, cow, deer*. In parallel, Sinitic borrowings in Japanese during the Nara period included terms associated with Buddhism and government, e.g. '官' /kan/ from the Chinese '官' /guan/, meaning government official. These terms were integrated into Japanese as loanwords and still carry a sense of formality and erudition, much like the French-derived terms in English related to law and cuisine. In both cases, the language of the elite was distinct from the vernacular, marking a clear sociolinguistic stratification.

During the Heian period, there was a reduction in bilingualism as a consequence of the gradual nativization of Chinese writing and reading systems in Japan (Heffernan, 2007). The Japanese syllabary scripts *hiragana* and *katakana* were developed during EMJ. The formation of the Sino-Japanese strata, a pronunciation norm for the vocalisation of Chinese words in Japanese, made it easier to integrate Chinese loanwords into everyday speech, leading to an influx of a large number of Chinese loanwords into Japanese. Most of the Modern Japanese Sino-Japanese loanwords are in *kan-on*. However, lots of these loans were not introduced for the first time to the Japanese language during the Heian period but were in the Japanese language already and later changed to *kan-on* pronunciation.

The envoy travels to the Tang Dynasty ceased in 894 CE due to the unstable social status in China towards the end of the Tang Dynasty, leading to the fossilisation of pronunciation and meaning of Chinese in the late 9th century and 10th century in Japan. In order to maintain the correct standards of *kan-on*, efforts were put into learning Chinese rhyme tables and pronunciation guides, making the pronunciations of individual characters an independent object of study (Frellesvig, 2010). As a result, the pronunciation and meaning from Chang'an MC was well preserved (although there were later changes which influenced the entire Japanese phonological system) in Japan (Endo, 2015), but similar to the older *go-on, kan-on* became increasingly different from Chinese spoken in the contemporary China. The majority of Sino-Japanese vocabulary in Modern Japanese reflects meanings in MC, which did not all descend into Modern Chinese. For example, the kanji 湯 [to:] means 'hot water' in MC and the meaning is preserved in Modern Japanese. In Modern Chinese, the general meaning for 湯 [t^haŋ] (LMC /t^haŋ/) is 'soup'. The MC meaning only survives in certain proverbs, e.g. 赴汤蹈火 (go-hot water-dance-fire) 'do something for someone no matter how difficult'.

A rather limited number of loanwords entered the Japanese language during the OJ period because Chinese was still spoken as a foreign language and the nativized Sino-Japanese system was not yet established. Cases of borrowings include *kau* 香 'fragrance', *kuu* 功 'accomplishment, merit', *syauzi* 生死 'living and dying' (Frellesvig, 2010). As a lot of literature was logographically written during this period, whether a given character was intended to represent Sino-Japanese loanwords or logographically written native words is sometimes unclear. The phonological shape of the written words cannot be easily determined.

The earliest direct evidence of the beginnings of a large-scale adoption of loanwords was found from the Heian period during EMJ. Most of these loanwords derive from *go-on*, reflecting that *go-on* was still in use despite the establishment of *kan-on*. Many words in *kan-on* were not integrated into the Japanese lexicon as loanwords yet, but in Modern Japanese, most *kanji* that has a *go-on* reading also has a *kan-on* reading. The genres of the Sino-Japanese loanwords at the EMJ period include Buddhism, politics, philosophy, life, positions and ranks. In comparison to OJ, there was a striking increase in the number and variety of everyday Sino-Japanese vocabulary in EMJ, including emotional and expressive vocabulary, which is the evidence of the integration of a significant number of Sino-Japanese loanwords into everyday language, at least in the elite classes (Frellesvig, 2010).

2.1.4 The third period of contact and *to-on*

From the late 12th to 16th century, during the LMJ period, court struggles in Japan and civil war in China significantly impeded cultural exchange, resulting in a long period of little contact with only a few exceptional cases of Buddhist monks travelling to China and trading between Japan and China during its Song, Yuan, and Ming dynasties. Chinese was still considered a prestige language, but the lack of language contact resulted in a gradual decline in the level of oral fluency of Chinese at the Japanese court.

Japanese monks of Zen Buddhism brought back religious materials and read them in a contemporary variety of Chinese spoken in southern China during the Song and Yuan Dynasties, leading to the establishment of a new pronunciation norm, *to-on* ('Tang pronunciation') , within some Zen sects, which later gave rise to the nativized Sino-Japanese *to-on* strata.[6] Chinese was used to recite the Buddhist scriptures, and this helped the spreading of a ritualistic version of the Chinese language from the nobility to the general populace (Loveday, 1996: 31). However, contacts between Japanese fishermen and traders with their Chinese counterparts also gave rise to loanwords based on other varieties of Chinese. Therefore, different from the previous two substrata of Sino-Japanese, *to-on* is not based on a complete pronunciation system, but a compilation of competing ways of pronouncing Chinese, representing different varieties of Chinese with different phonetics and phonological categories.

Due to the extensive language contact in the previous periods, the majority of the Sino-Japanese loanwords entered LMJ are based on *go-on* and *kan-on* pronunciations (Frellesvig, 2010). A small number of loanwords entered Japanese through *to-on* during the third contact period and most of them are related to Zen Buddhism, (e.g. kankin 看経

[6] Note that 'Tang' here for *to-on* does not refer to the Tang dynasty in China, but used in the sense of '(real) Chinese' (Frellesvig, 2010).

‘read sutra silently’, fushin 普請 ‘construction’, osho 和尚 ‘monk’), or about items in daily life (e.g. isu 椅子 ‘chair’, bin 瓶 ‘bottle’) (Endo, 2015).

2.1.5 Sociolinguistic analysis

Loveday (1996) proposes a typology for the classification of different types of language contact, and posits a chronology of Chinese language contact settings in Japan based on the history of contact between Japanese society and the Chinese language. Table 2 shows the linguistics periods of the source and borrowing languages, the overlapping political periods in Japan, the resulting Sino-Japanese substrata, and the sociolinguistic settings in Japan proposed by Loveday (1996) during these three contact periods.

Table 2 Chronology of Chinese language contact settings in Japan (Loveday 1996: 30-36)

<table>
<tr><th>Japanese linguistic period</th><th>Japanese political period</th><th>Chinese linguistic period</th><th>Language contact period</th><th>Sino-Japanese substrata</th><th>Sociolinguistic settings</th></tr>
<tr><td>Pre-Old Japanese (Pre-OJ) -700</td><td>Yamato 250-700</td><td>Early Middle Chinese (EMC) ca. 400 - 618</td><td>1st contact, 5th to early 7th centuries</td><td>go-on</td><td>Distant non-bilingual, evidence of borrowing</td></tr>
<tr><td>Old Japanese (OJ) 700-800</td><td>Nara 712 - 794</td><td rowspan="4">Late Middle Chinese (LMC) ca. 618 - 1150</td><td rowspan="4">2nd contact, mid 7th to late 9th centuries</td><td rowspan="4">kan-on</td><td rowspan="3">Diglossic bilingual</td></tr>
<tr><td rowspan="3">Early Middle Japanese (EMJ) 800-1200</td><td>Early Heian 794-1000</td></tr>
<tr><td rowspan="2">Late Heian 1000-1185</td></tr>
<tr><td rowspan="3">Diglossic non-bilingual & institutional</td></tr>
<tr><td rowspan="2">Late Middle Japanese (LMJ) 1200-1600</td><td>Kamakura 1185-1333</td><td rowspan="2">Early Modern Chinese (EModC) ca. 1151-191</td><td rowspan="2">3rd contact, late 12th to 16th centuries</td><td rowspan="2">to-on</td></tr>
<tr><td>Muromachi 1333 - 1573</td></tr>
</table>

In the *distant non-bilingual* setting, the use of the donor language within the community is extremely limited. There is no special relation maintained between the native language community and the donor language speakers, and the acquisition of the donor language is not socially required. Contact between the native community and the donor language is mainly through media, travellers and trading. The Pre-OJ period corresponds to the *distant non-bilingual* setting. Evidence of borrowing was first found during the Yamato period, before the oldest attested OJ period. The limited language contacts were mainly in the field of agriculture, metalworking and weaving at the beginning, and also in the field of religion towards the end of the period. Chinese was not widespread in the Japanese society.

The *diglossic bilingual* setting refers to the case where there is prestige associated with the donor language and it is often used in administration or other formal matters. The donor language is often taught through formal education, and used in religion or the government. Most of the elites in the community are bilingual. The native language, on the other hand, is used in casual settings, e.g. at home or in the neighbourhood. During the Nara and early Heian periods (ca. 700–1000 CE), the language contact setting evolved considerably to a *diglossic bilingual* setting due to the massive borrowings of cultural, religious, and political knowledge from Tang China at the second period of language contact. Chinese was associated with high-prestige and was taught in formal institutions by native instructors. Bilingualism was mainly among the elite groups.

From the late Heian to Edo period (ca. 1000 – 1868 CE), the language contact setting is complex. It does not correspond to a single typological setting that Loveday (1996) proposes, but combines the features of two settings, *diglossia* and *institutional*. In the *institutional* setting, the donor language is taught in institutions like schools for political, cultural or religious reason. However, the acquisition of the donor language is not required by the community and the donor language is not used with formal functions. Learning the donor language is the end goal itself, instead of for achieving higher communication purposes. Japanese gradually adapted the Chinese writing system and nativized the Chinese reading systems from late Heian, leading to a reduction in bilingualism during the Heian period. Sino-Japanese *go-on* and *kan-on* were well established during this period, making the intake and use of words of Chinese origin more feasible. New Chinese words sounded less alien and were more easily accepted. Direct contact with China had ceased but the Chinese language was still taught in institutions and Chinese was sill the prestigious language of administration and formal matters until the Edo period. Sino-Japanese loanwords became a well-integrated part of general language and lexicon during this period.

2.2 Premises for phonological analysis

Before delving into the detailed discussion and analyses of historical Chinese and Japanese phonology, this section introduces the phonological theory that the analyses will be based on. Distinctive feature theory (Jakobson, Fant, & Halle, 1952; Chomsky & Halle, 1968) is one of the fundamental theories in phonological analysis. This study takes a feature-based approach in the analysis of loanword adaptation for the following reasons: (1) the initial consonant adaptation is at the segmental level and the focus is on the matching of representations; (2) the coda adaptation involves a vowel epenthesis process which can be explained from a feature spreading perspective – there is no complex interaction of processes that would require a constraint-based model.

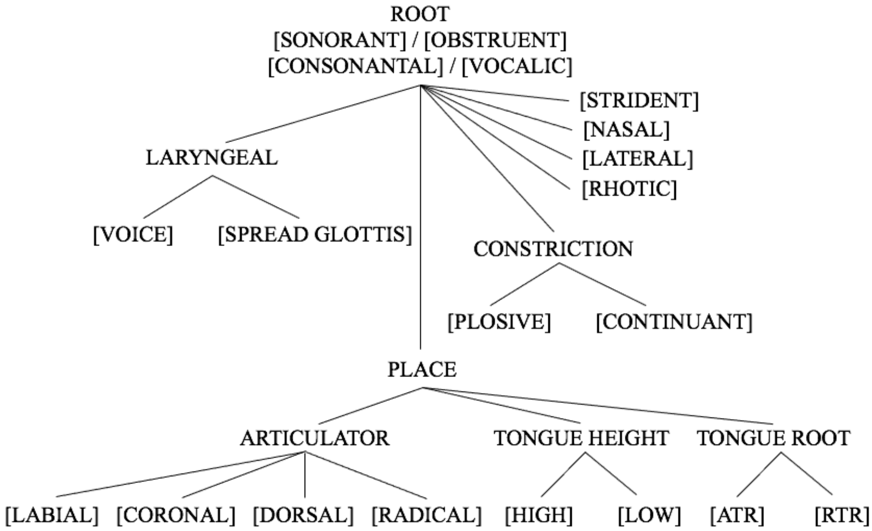
Many feature theories have been proposed. This study adapts the feature geometry from the *Featurally Underspecified Lexicon* model (FUL thereafter; Lahiri, 2018) in the discussion of Japanese and Chinese historical phonology, and the Sino-Japanese *kan-on* adaptations. FUL is inspired by the work of Jakobson et al. (1952) and Clements and Hume (1995). It is a useful descriptive model that has been tested in a large number of psycholinguistics experiments (e.g. Kotzor et al. 2015; Wynne et al. 2021), in automatic speech recognition (ASR) systems (Arora, Lahiri & Reetz, 2017) and in other loanword adaptation studies (Lahiri & Kennard, 2019; Kennard & Lahiri, 2020). Although the features in FUL have basic articulatory names, they have well defined acoustic correlates, which is helpful in our discussions of acoustic input from the source language. FUL also proposes a processing model that has clear-cut processes of matching features extracted from acoustic signal to representation.

FUL makes the following assumptions based on synchronic, diachronic, and experimental evidence (e.g. Roberts, Wetterlin, & Lahiri, 2013; Lahiri, 2018).

1. The majority of the previous feature theories propose separate place features for vowels and consonants (e.g. Sagey, 1986; Halle, 1995), or organise the place nodes for vowels and consonants on separate tiers (e.g. Clements & Hume, 1995). FUL takes the view of the landmark work by Jakobson, Fant, & Halle (1952), and assumes that vowels and consonants share PLACE features that are not represented separately. This allows discussions and pairings of, for example, [DORSAL] consonants with back vowels.
2. The feature system is hierarchical, with PLACE features being assigned first as a universal principle in language acquisition (Ghini, 2001).
3. All features are monovalent.
4. There is no dependent feature in this organisation, apart from the inherent universal dependencies, e.g. [NASAL] implies [SONORANT, VOICE], [STRIDENT] implies [OBSTRUENT]. In traditional feature organisations (e.g. Clements & Hume, 1995), there are dependent features grouped under [CORONAL]. In FUL, contrasts within coronal sounds e.g. dentals, palatals vs retroflexes, are established by a combination of [CORONAL] and TONGUE HEIGHT features.
5. [CORONAL] and [PLOSIVE] features are underspecified in the underlying phonological representation but present on the surface.

The feature organisation in FUL is shown in Figure 2.

Figure 2 Feature organisation in the Featurally Underspecified Lexicon model (Lahiri, 2018)



There are two pairs of opposing major class features under the ROOT node: [SONORANT]/[OBSTRUENT] and [CONSONANTAL]/[VOCALIC]. These features are available in all languages. The other features for manner of articulation are on the right of the feature tree: [STRIDENT], [NASAL], [LATERAL], [RHOTIC], and CONSTRICTION features [PLOSIVE] and [CONTINUANT]. The features for the voice of articulation are on the left of the feature tree under the LARYNGEAL node: [VOICE] and [SPREAD GLOTTIS]. The PLACE features at the bottom of the feature tree are organised under three nodes: ARTICULATOR, TONGUE HEIGHT and TONGUE ROOT. ARTICULATOR and TONGUE HEIGHT features characterise the horizontal and vertical dimensions of place of articulation, respectively. Only contrastive features are specified for each language.

In this thesis, FUL is employed to discuss the phonemes and phonological processes in Chinese and Japanese. The feature specifications for the phonemes and how they participate in phonological processes will be discussed in details in Sections 2.3 and 2.4.

2.3 Chinese historical phonology

2.3.1 The periodisation and varieties of Chinese

The attested history of the Chinese language is much longer than for Japanese and there are many controversies in periodisation. Different aspects of the language change at different paces, so the periodisation of Chinese is different for each field of linguistics.[7] In the field of historical phonology, the periodisation is generally based on major phonological changes shown from existing historical texts evidence that documents the pronunciation of Chinese in different eras. However, there is not yet complete agreement among Chinese phonologists on the specific stages and substages and the timespan assigned to them in Chinese historical phonology. A number of proposals have been made (e.g. Karlgren, 1915-1926; Luo, 1956; Pan, 2000) and the main differences between the proposals are centred around issues including the transition periods of phonological changes, the nature of historical evidence, and the different varieties of Chinese.

Despite the controversies, three major periods in Chinese historical phonology have been generally agreed on: Old Chinese (OC; or Archaic Chinese; Shànggǔ Hànyǔ 上古汉语), Middle Chinese (MC; or Ancient Chinese; Zhōnggǔ Hànyǔ 中古汉语) and Early Modern Chinese (EModC; Jìndài Hànyǔ 近代汉语) (Handel, 2014: 577). Middle Chinese (MC) can be further divided into Early Middle Chinese (EMC) and Late Middle Chinese (LMC) (e.g. Pulleyblank, 1984; Miyake, 2003). Table 3 shows the major linguistics periods, their timespans (a reasonable compromise between different proposals), and the relevant political periods (cf. Dong, 2014; Ting, 1996; Handel, 2014). The OC period is roughly from 12th century BCE to 3rd century CE; the MC period is roughly from 4th to early 12th centuries CE,

[7] For the periodisation of the historical syntax of Chinese, see Feng (2014).

with EMC from 4^{th} to early 7^{th} centuries and LMC from early 7^{th} to 12^{th} centuries; and the EModC period is roughly from 13^{th} to early 20^{th} centuries CE. There is hardly any written evidence from the prehistoric period preceding OC (or Proto-Chinese). The period of Modern Chinese starts from the early 20^{th} century CE.

Table 3 Periodisation of the Chinese language

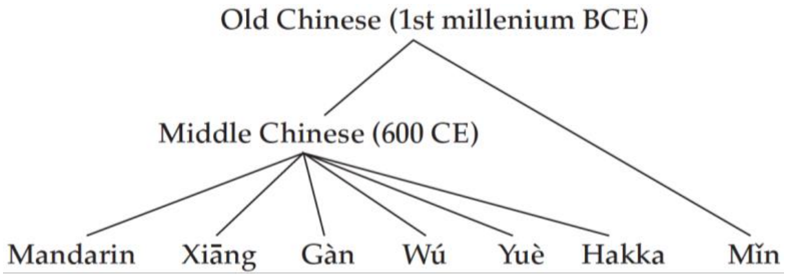
Linguistic period	Timespan	Historical periods	
Old Chinese (OC)	12^{th} century BCE to 3^{rd} century CE	Late Shang	12th – 11th centuries BCE
		Western Zhou	11th century – 771 BCE
		Spring and Autumn period	770 – 476 BCE
		Warring States period	475 – 221 BCE
		Qin	221 – 207 BCE
		Western and Eastern Han	206 BCE – 220 CE
		Three Kingdoms	220 – 265 CE
		Western Jin	265 – 316 CE
Early Middle Chinese (EMC)	4^{th} to early 7^{th} centuries CE	Eastern Jin	317 – 420 CE
		Northern and Southern Dynasties	420 – 589 CE
		Sui	581 – 618 CE
Late Middle Chinese (LMC)	Early 7^{th} to 12^{th} centuries	Tang	618 – 907 CE
		Five Dynasties	907 – 960 CE
		Northern and Southern Song	960 – 1279 CE
Early Modern Chinese (EModC)	13^{th} to early 20^{th} centuries CE	Yuan	1271 – 1368 CE
		Ming	1368 – 1644 CE
		Qing	1644 – 1911 CE

Although there is a consensus over the three historical linguistics periods, there are disagreements on the specific time ranges assigned to these periods. The main issues of the transition periods are regarding (a) whether the Three Kingdoms, Western and Eastern Jin and the first half of Northern and Southern Dynasties (220 – early 6^{th} century CE) fall within the period of MC or OC; and (b) whether the Northern and Southern Song Dynasties (960 – 1279 CE) belong to MC or EModC (Pan & Zhang, 2015). These controversies are due to the nature of the available historical evidence. For example, the primary written evidence associated with the MC period is the rhyme dictionary (a character dictionary arranged by pronunciation) *Qièyùn* (切韻) compiled in the early Sui Dynasty in 601 CE by Lù Fǎyán (陸法言), and the rhyme table (a type of phonological chart) *Yùnjìng* (韻鏡) published in the

Song Dynasty in 1161 CE. MC is defined by some scholars as the language of the latter half of the Northern and Southern Dynasties until the mid-Song dynasty, while others extend it back in time to the Eastern Jin Dynasty, or bring it forward to the end of the Song dynasty (e.g. Handel, 2014). The controversies surrounding the specific transition time of the periods do not have significant influence on the discussion of Sino-Japanese *kan-on* because *kan-on* is based on the direct contact with Tang Chang'an LMC. We adopt the periodisation shown in Table 3 for the discussion in this study.

The traditional view of the Chinese language family is shown in Figure 3 (Handel 2014: 578). OC is the ancestor of MC and Modern Chinese Min, and MC descends into the other six major Modern Chinese dialect groups: Mandarin, Xiang, Gan, Wu, Yue and Hakka (Yuan, 1989, Handel 2014). Modern Standard Chinese (or Putonghua, 'common speech'), the official common spoken language in present-day China, is based on the Mandarin dialect spoken in Beijing. It should be mentioned that Chinese dialectal diversity did not only emerge after the MC period. Written records show that there were already dialect differences in the time of the Spring and Autumn period (770 – 476 BCE) (Dong, 2014). However, the differences between varieties were not as great as they are now and this recognised dialectal diversity in the MC and OC period has generally not played a role in periodisation (Handel, 2014). In each historical period, there was a common spoken language, and the reconstructed OC and MC refer to the common spoken language in their relevant historical period. It is also important to note that MC is not a direct continuation of OC as will be discussed in the following section. This is similar to that of Old and Middle English. What may be termed an Old English 'standard' is based on the West Saxon dialect. Middle English, known for its significant diversity and absence of a standardized form, evolved not solely from West Saxon but through the amalgamation of various dialects, notably Anglian and Kentish. These dialects, particularly the Anglian Old English varieties, played a pivotal role in shaping the Midlands varieties of Middle English, which eventually influenced the standard form that emerged in the early Modern English period.

Figure 3 The traditional view of the Chinese language family from Handel (2014: 578)



2.3.2 Historical background of Middle Chinese

As discussed in Section 2.1, the MC period has the most influence on the formation of Sino-Japanese. MC refers to the common spoken variety used in Eastern Jin (317 – 420 CE), Northern and Southern Dynasties (420 – 589 CE), Sui (581 – 618 CE), Tang (618 – 907 CE), Five Dynasties (907 – 960 CE), and Northern and Southern Song (960 – 1127 CE). Traditionally, the transitional period between OC and MC is considered to be from the Three Kingdoms to Northern and Southern Dynasties when there were civil war and political divisions in China (Dong, 2014). The phonology of OC gradually evolved into a more complex system, and by Sui Dynasty, MC was formed. [8]

There was an important shift of the common spoken language of China during the Eastern Jin dynasty. Due to the turmoil during Western Jin, many Han people who spoke the common language form based on the Luoyang variety migrated to the south, carrying their Han culture and tradition. The capital of the succeeding Eastern Jin moved to Jinling, present-day Nanjing, in south-east China. Before Eastern Jin, the local dialect in Jinling was the dialect of Wu. Luoyang common speech and Wu dialect gradually combined and formed

[8] Tonogenesis: It is believed that OC was a toneless language and tones arose in EMC after the loss of various finals. There are four tones in MC, level tone (平 píng), rising tone (上 shǎng), departing tone (去 qù), and entering tone (入 rù). See Sagart (1999) for a discussion of the origin of MC tones.

the new standard variety *Jinlingyayin* ('Jinling elegant sound'), also called the Wu language. The Southern Dynasties continued using the Jinling common form, while the Northern Dynasties were ruled by different ethnic groups speaking different languages in the Central Plain area.

The Kingdom of Paekche had contact with Eastern Jin and the Southern Dynasties, and sent envoys to learn about the Chinese cultural and technology (Best, 2006). Buddhism introduced from China had a strong influence on the culture and art in Paekche. It is likely that the pronunciation varieties carried to Paekche were based on the *Jinling* common spoken form in south-east China. This Chinese variety was then filtered through the language in Paekche, introduced to Japan, and together with the Chinese variety that entered Japan through some small scale direct contacts, formed Sino-Japanese *go-on*.

When Sui reunified China, the capital moved to Chang'an, another city in the Central Plain area. Sui was ruled by Han people again. The Han civilisation were mainly preserved in the south around Jinling, so Sui combined the old Central Plain Luoyang literary pronunciation that was used in Northern Dynasties, with the Jinling common spoken form used in the Southern Dynasties and developed a new Chang'an common spoken form. The Chinese rhyme dictionary *Qieyun*, the primary source of EMC phonology, was published in 601 CE during Sui Dynasty, and established a new national standard language norm.

Sui established the Imperial Examination system in 605 CE (which was adopted in the following dynasties until the early twentieth century) as a way of selecting qualified scholars to serve as administrative officials in the imperial government (Dong, 2014). The system emphasised the importance of Confucius' classics, reinforced the use of the established standard language and gave rise to the compilation of official dictionaries which aimed to set the correct pronunciation for the composition of essays and poetry.

The subsequent Tang China was a dynasty of cultural prosperity. The capital of Tang was still at Chang'an and the common spoken norm was carried on from Sui Dynasty. The poetry written during the Tang Dynasty has always been considered as a peak in Chinese literary achievement. Tang poetry makes use of rhyme and it is a valuable source for the phonology of MC. Japan had its most extensive direct contact with China during this period which led to significant Chinese influence on the Japanese language, literature and religious study. During the later period of the Tang Dynasty, the common language form – which was originally based largely on the Jinling norm – shifted to a form that had more influence from the local Chang'an dialect.

During the Northern Song Dynasty, rhyme tables (*yuntu* 韵图), a special type of written source that shows the language phonology, emerged. The most famous rhyme table, *Yunjing* (韵镜) 'Mirror of Rhymes' shows significant differences in the main phonological features from *Qieyun*. It represents the sound system around the end of the Tang Dynasty and in the Northern Song Dynasty. Pullyblank (1984) has termed the language reflected in *Yunjing* LMC. *Yunjing* was introduced into Japan during the 13th century and since then became an important source for the pronunciation of Sino-Japanese as it was believed to reflect the pronunciation that *kan-on* was based on. During the Edo period (1603 – 1868 CE), philologists studied *Yunjing* for the purpose of establishing the norm in dictionaries for Sino-Japanese words and kanji (Frellesvig, 2010).

2.3.3 The reconstruction of Chinese historical phonology

The reconstruction of Chinese historical phonology has not been an easy field of study due to the opaque logographic orthography of Chinese. The writing system did not change significantly over the centuries, so it is difficult to extract information about the phonological systems of the underlying language or the pronunciations of individual lexical items from written texts, despite the abundant textural record. For example, Figure 4 shows the orthography of the Chinese characters 人 'human' (a) and 天 'sky' (b) at different stages in history. The structure of the characters have not undergone much change since the oracle bone script (the first column) which was used around 1500 BCE to 1000 BCE. There is, therefore, little evidence of the sound system at earlier periods from scripts. A large number of Chinese characters have radicals that provide phonetic information. For example, 路 'road' [l^{w}u:] and 客 'guest' [k^{h}ɤ:] both have the phonetic component 各 'each' [kɤ:]. This could indicate that the two characters were once pronounced in a more similar fashion further back in history. However, the phonetic components do not give information on the exact nature of the similarity, e.g. whether they are similar in the rhyme, onset, or tones. The non-phonographic writing system of Chinese has made historical textual analysis less helpful in the reconstruction of Chinese historical phonology (Handel, 2014).

Figure 4 The orthography of the Chinese characters 人 'human' (a) and 天 'sky' (b) at different stages in history.

The previous Section (2.3.2) introduced the specialised rhyme dictionaries and rhyme tables. The reconstruction of the sound systems of historical Chinese is largely based on the analysis of these specialised materials of each period in which the word initials (onsets) and finals (rhymes) are documented. EMC phonology is basically the phonological system represented by the rhyme dictionary *Qieyun* 切韵 (601 CE), and the LMC phonology mainly corresponds to the phonological system represented by the rhyme table *Yunjing* 韵镜 (ca. North Song). Those materials provide invaluable information about which onsets and which rhymes are homophonous. However, they do not in themselves give us enough information about the nature of these onsets and rhymes. For the reconstruction of the exact sounds, phonologists also adopted the Comparative method and drawn upon data from (1) descriptions by early missionaries (e.g. Matteo Ricci), (2) loans in other languages, e.g. Korean and Vietnamese, (3) transcriptions in Sanskrit-derived scripts, and (4) modern varieties of Chinese.

Sino-Japanese *kan-on* is based on the pronunciation of early Tang Dynasty which postdates the reconstructed EMC (Sui dynasty) and predates the reconstructed LMC (Late Tang and Northern Song dynasties). Despite the lack of exact phonology of the Chinese base forms at the specific time of the borrowing, the reconstructed LMC is believed among Japanese and Chinese scholars to be the closest to the Chinese variety at the time of the borrowings.

A number of Chinese historical phonology reconstructions have been proposed (e.g. Pulleyblank, 1984, 1991; Baxter, 1992; Miyake, 2003; Luo, 1956) since the pioneering work of Karlgren (1915–1926; 1957). The reconstructions of Chang'an LMC in this study are mainly based on Pulleyblank (1984, 1991) for the following reasons: (1) many scholars have discussed MC as a whole (e.g. Karlgren, 1957, 'Ancient Chinese'; Baxter, 1992) whereas Pulleyblank distinguished EMC and LMC; (2) I agree with Miyake (2003) that between the two available LMC proposals of Pulleyblank (1984, 1991) and Coblin (1994), Coblin's (1994) method which has radically deviated from Karlgren's traditional approach is too data-centred, with little theoretical evidence; (3) Pulleyblank (1991) provides a lexicon of the reconstructed pronunciation of LMC with IPA transcription which is extremely helpful for the adaptation study. Modifications to Pulleyblank's reconstructions have been made where indicated with reference to other reconstruction works.

2.3.4 Chang’an Late Middle Chinese

2.3.4.1 Consonants

Table 4 shows the reconstructed consonants phonemic inventory of Chang’an LMC. There are overall 36 consonants, with 28 obstruents and 8 sonorants.

Table 4 Consonant inventory of LMC (adapted from Pulleyblank, 1991: 10-12)

Consonants	Bilabial	Labio-dental	Labio-velar	Dental	Retroflex	Palatal	Velar	Glottal
Plosive	p p^h pɦ			t t^h tɦ	ʈ ʈ^h ʈɦ		k k^h kɦ	ʔ
Fricative		f fɦ		s sɦ	ʂ ʂɦ ʐ		x xɦ	
Affricate				ts ts^h tsɦ	tʂ tʂ^h tʂɦ			
Nasal	m			n	ɳ		ŋ	
Approximant		ʋ	w			j		
Lateral				l				

The consonants /pɦ tɦ ʈɦ kɦ tsɦ tʂɦ fɦ sɦ ʂɦ xɦ/ which are described as ‘muddy’ in the Chinese rhyme tables are in the diachronic process of devoicing. They derive from EMC fully voiced consonants /b d ɖ g dz dʐ z ʐ ɣ/ (Baxter, 1992) and later become devoiced to voiceless aspirated or unaspirated consonants (depending on the tone and dialect) in most modern varieties of Chinese (e.g. Mandarin). In a few other modern varieties including Wu, these ‘muddy’ initial consonants are preserved in the present-day language (see more details on this below).

Pulleyblank (1991: 6) describes these consonants as ‘having voiceless onset with voiced aspiration or murmur at their release, spreading through the following syllable’, and he adopts the /Cɦ/ symbol for these ‘muddy’ consonants from the description of the Wu variety of Chinese by Chao (1928). The symbol /Cɦ/ has been agreed upon in other Chinese historical linguistic studies, including Baxter (1992) and Miyake (2003). Pulleyblank (1991) also suggests the symbols of a voiced consonant with aspiration, e.g. /b^h d^h g^h/, as alternatives. Conventionally, voiced aspirates like those found in Indo-Aryan languages are represented with a voiced consonant and a superscript voiced glottal fricative, e.g. / b^ɦ d^ɦ g^ɦ/

(Ladefoged & Maddieson, 1996). The superscript ʱ marks a breathy-voiced release of obstruents[9]. The LMC 'muddy' consonants were used to transcribe voiced aspirates in Sanskrit, and the Chinese nasals, which were pronounced as prenasalized voiced obstruents in the Tang standard dialect (see detailed discussions on the nasals below), were used to transcribe the Sanskrit plain voiced stops (Pulleyblank, 1984). This preservation of the aspiration contrast for voiced obstruents in Sanskrit shows that LMC speakers could perceive the voicing and aspiration in voiced aspirates in Sanskrit, and likely to have produced the 'muddy' consonants in LMC with some form of voicing and aspiration. However, in the Tibetan transcription of northwestern LMC initials (Luo 1933), the voiced aspirates were inconsistently adapted as either the voiced (e.g. /g/), voiceless non-aspirated (e.g. /k/) or voiceless aspirated (e.g. /k^h/) consonants, indicating that the Tibetans perceived aspiration, voiced and unvoiced sounds. If LMC 'muddy' consonants are the same as the voiced aspirates in Indo-Aryan languages, we would not expect them to be transcribed as the voiceless /k/. In addition, Pullyblank's description of those sounds in Chinese as 'having voiceless onset with voiced aspiration or murmur at their release' does not completely match with Indo-Aryan voiced aspirates. A search in the UCLA Phonological Segment Inventory Database (UPSID; Maddieson & Precoda, 1990) shows that two languages have voiceless breathy sounds: the Changzhou Wu dialect of Chinese and Javanese. We are interested in the Changzhou Wu dialect here as those voiceless breathy sounds derived from the 'muddy' consonants in LMC. Changzhou voiceless breathy sounds are described as voiceless obstruents with breathy release, which aligns with Pullyblank's description. The Changzhou dialect has four voiceless breathy sounds: voiceless dental/alveolar plosive with breathy release, voiceless dental/alveolar sibilant affricate with breathy release, voiceless velar

[9] The IPA uses the two dots diacritic '◌̤' for breathy voice. However, this seems to be more commonly used on vowels than consonants.

plosive with breathy release and voiceless bilabial plosive with breathy release. Voiceless breathy fricatives are cross-linguistically rare. There are no voiceless breathy fricatives in the Changzhou dialect, nor in UPSID. Based on the above discussion and for the clarification of notation, this thesis adopts the widely used /Cɦ/ symbol in historical Chinese phonology to represent LMC 'muddy' initials (or voiceless obstruents with breathy release) to be consistent with the literature, even though it is not a common notation according to the IPA. The notation does not influence feature specification or Sino-Japanese adaptation, as we will see below and in later chapters.

The plosives are at five places of articulation: bilabial /p p^h pɦ/, dental /t t^h tɦ/, retroflex /ʈ ʈ^h ʈɦ/, velar /k k^h kɦ/ and glottal /ʔ/ (Pulleyblank, 1984; Baxter, 1992). Apart from the glottal stop, the other plosives show a three-way laryngeal contrast: voiceless, voiceless aspirated and voiceless with breathy release. Fricatives are in voiceless and voiceless with breathy release pairs at labio-dental /f fɦ/, dental /s sɦ/, and velar /x xɦ/ places of articulation. At the retroflex place, apart from the pair /ʂ ʂɦ/, there is an extra voiced /ʐ/, which is discussed in details below. The labio-dentals /f fɦ/ in LMC derives from the labial stops /p p^h b/ in EMC (Baxter, 1992: 48) through labiodentalisation - when the labial stops are followed by the high back vowel /u/, they become labiodentalised, e.g. 法 'law' EMC /puap/ > LMC /fa:p/. Affricates /ts ts^h tsɦ tʂ tʂ^h tʂɦ/ are all coronals with the same three-way laryngeal distinction as the plosives of the same places. In Early Middle Chinese, the retroflex fricative and affricate sibilants /ʂ tʂ tʂ^h/ and the alveolo-palatal fricative and affricate sibilants /ɕ tɕ tɕ^h/ are all underlying phonemes (Baxter, 1992). In Late Middle Chinese, as a result of diachronic change, the alveolo-palatals [ɕ tɕ tɕ^h] became the surface allophones of /ʂ tʂ tʂ^h/ respectively before high front vowels /i y/ (Pulleyblank, 1984; Baxter, 1992: 53).[10]

[10] A question that arises is: since the retroflexes are already [CORONAL, HIGH], what caused them to become the alveolo-palatals before high front vowels /i y/ which are also [CORONAL, HIGH]? Two phonological changes between Early and Late Middle Chinese are essential for the discussion of the allophonic rule. The high coronal

The retroflex plosives and nasals /ʈ ʈʰ ɖ ɳ/ are transcribed as /tr trʰ dr nr/ by Pulleyblank (1984) and Baxter (1992). However, Pulleyblank (1991: 7) notes that these are single segments instead of 'biphonematic' clusters like in Southern Vietnamese and English, and Baxter (1992: 50) also mentions that the /r/ is simply a mark of retroflexion and not intended as a separate segment. Luo (1956) finds that these sounds are regularly used to transcribe the Sanskrit retroflex stops. I adopt the retroflex stops symbols /ʈ ʈʰ ɖ ɳ/ in this study.

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vowels /i y/ in Late Middle Chinese are derived from the Early Middle Chinese non-coronal high vowels /ɨ u/ respectively through a high vowel fronting rule as shown below:

High vowel fronting rule

a. V [HIGH] + [CORONAL] → V [HIGH CORONAL]

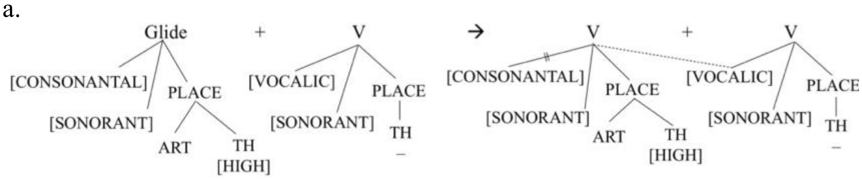
b. ɨ [HIGH] + [CORONAL] → i [HIGH CORONAL]

c. u [HIGH DORSAL LABIAL] + [CORONAL] → y [HIGH CORONAL LABIAL]

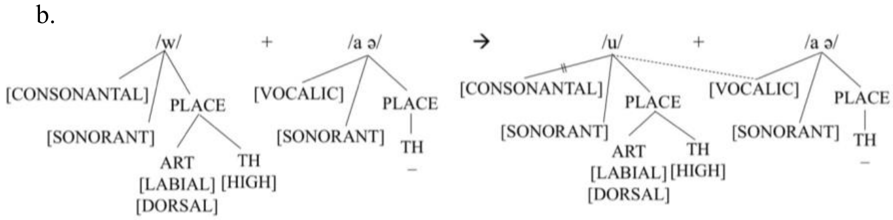
The Early Middle Chinese labial-velar glide and high coronal vowel combination /wi/ also turned into the high coronal rounded vowel /y/ in Late Middle Chinese. The Late Middle Chinese high dorsal vowel /u/ was not derived from the Early Middle Chinese high dorsal /u/, but developed through a later Glide strengthening rule (Pulleyblank, 1984: 82), as shown in the diagrams below. When the glide /w/ precedes a short non-high vowel /a/ or /ə/, it takes on the [VOCALIC] value of the vowel and becomes the high back vowel /u/.

Glide strengthening rule

a.

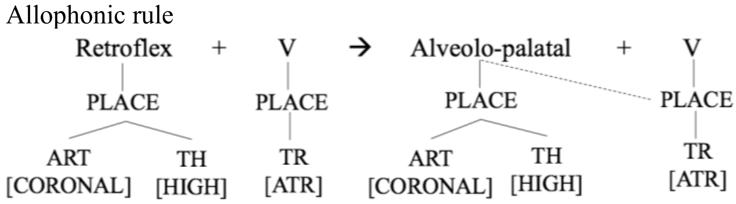


b.



Thus /i/ and /y/ pattern together in Late Middle Chinese allophonic alternation because they descended from the Early Middle Chinese high vowels /i ɨ u/ which precede the alveolo-palatals. The Early Middle Chinese high vowels are not only [HIGH], but also specified as [ATR], and this tongue root feature is taken on by the Late Middle Chinese /i y/. The later developed Late Middle Chinese high vowel /u/ does not pattern with /i y/ because it does not carry the same tongue root value as the Early Middle Chinese high vowels. The allophonic rule is shown in the diagram below. The retroflexes which are specified for tongue height [HIGH] and articulator [CORONAL] take on the tongue root feature [ATR] of the high coronal vowels and surface as alveolo-palatals.

Allophonic rule



The nasals /m n ɳ ŋ/ (Pulleyblank, 1984; Baxter, 1992) are subject to a denasalisation process in Chang'an and other northwestern varieties of LMC – they become prenasalised obstruents [^{m}b ^{n}d ^{ɳ}ɖ ^{ŋ}g] syllable initially (Coblin, 1994). In certain rimes where there are a nasal segment in the coda, e.g. /-iajŋ/, the denasalisation process is blocked, e.g. [miajŋ] (Tôdô, 1978). As no document or adaptation data from other languages suggests the existent of minimal pairs contrasting in initial nasal, prenasalised obstruents and voiced obstruents, e.g. [m mb b], Miyake (2003) analyses the nasals and prenasalised obstruents [m ^{m}b], [n ^{n}d], [ɳ ^{ɳ}ɖ], [ŋ ^{ŋ}g] as allophones of the nasal phoneme /m n ɳ ŋ/ respectively. No prenasalised variants survive in the modern varieties, and this could be either because the prenasalised variants change back to the pure nasals, or because of the influence of the Zhongyuan variety on the northwestern variety (Coblin, 1994). The bilabial nasal initial /m/ in EMC, like the oral stops, also undergoes phonemic labiodentalisation – it becomes the LMC labiodental approximant /ʋ/ when it occurs before the vowel /u/, e.g. 文 'writing; literature' EMC /mun/ > LMC /ʋjyn/.

The voiced retroflex fricative /ʐ/ derives from the palatal nasal /ɲ/ in EMC. It is reconstructed as the retroflex approximant /r/ by Pulleyblank (1984, 1991) and Todo (1978), but as a prenasalised obstruent [ɲʑ] by Miyake (2003). Pulleyblank (1991) has noted that the approximant /r/ in Chinese has more friction than the rhotic [r] of American English but it is phonologically a sonorant. Coblin (1994) shows evidence that /ɲ/ has become [nʑ] in Common Shazhou variety of LMC through the denasalisation process observed for other nasals, and suggests that this could also be the case in Late Tang Chang'an variety despite lack of direct evidence. In a similar vein, Miyake (2003) reconstructs the phonetic form [ɲʑ] based on the Tibetan (Luo, 1933) and Uighur transcriptions of northwestern LMC. In Modern Mandarin, the corresponding phoneme is analysed as the approximant /r/ in Wang (1979), and Duanmu (2000), and voiced retroflex fricative /ʐ/ in Duanmu's reanalysis (2007).

Pulleyblank and Todo's reconstruction of the rhotic approximant /r/ matches with Wang (1979) and Duanmu's (2000) analysis of Modern Mandarin. Miyake and Coblin's reconstruction of the nasalised obstruent [ɲʑ nʑ] could potentially match Duanmu's (2007) analysis as /ʐ/. However, under the nasalised obstruent assumption, [ɲʑ] or [nʑ] must have gradually lost its nasality [ʑ], phonemicised /ʑ/, changed to the retroflex place (there are no palatals in Modern Mandarin) and became /ʐ/ in Modern Mandarin. The process is very different from what the other prenasalised phonetic forms [^{m}b ^{n}d ^{n}ɖ ^{ŋ}ɡ] undergo as discussed above. Furthermore, there is no evidence suggesting that [ɲʑ] follows the same allophonic process that Miyake formalises as the other nasals. Pulleyblank (1984) argues that the palatal phonemes /ɕ ʑ tɕ tɕ^{h} dʑ/ in EMC merge with the retroflexes /ʂ ʐ tʂ tʂ^{h} dʐ/ in LMC. This diachronic change suggests that the LMC derivation of the palatal nasal /ɲ/ in EMC is likely to also have a retroflex place. To compromise between different reconstructions, this study proposes the voiced retroflex fricative /ʐ/ in LMC as the next stage of the EMC /ɲ/ and the predecessor of the Modern Mandarin /ʐ/ (Duanmu, 2007).

The glides /j w/ are not listed as initials in the rhyme tables, but in the finals (rhymes). When there is no initial consonant and /j/ is the first segment in the final, it occurs as the first and only segment in the onset. /w/ does not occur syllable-initially.

The relevant phonological features in FUL for our discussion of LMC phonemes are shown in (1).

(1) Segment classification by FUL features for LMC phonemes

- ROOT

[OBSTRUENT] / [SONORANT]: obstruents vs sonorant consonants and vowels

[STRIDENT]: fricatives with high-intensity noise

[NASAL]: nasal consonants

[LATERAL]: labial consonants

- LARYNGEAL

  [VOICE]: voicing contrasts

  [SPREAD GLOTTIS]: aspiration contrasts

- CONSTRICTION

  [CONTINUANT]: plosives vs fricatives

- PLACE

- ARTICULATOR

  [LABIAL]: labial consonants, rounded vowels

  [CORONAL]: dental and retroflex consonants, front vowels

  [DORSAL]: velar consonants, back vowels

  [RADICAL]: glottal stop

- TONGUE HEIGHT

  [HIGH]: high vowels, retroflex consonants

The feature charts for Chang'an LMC obstruent and sonorant consonants are presented in Table 5 and 6 respectively. Plosives, fricatives and affricates differ in their specification of [CONTINUANT] and [STRIDENT]. Apart from the only voiced obstruent /ʐ/, the different phonation types in the rest of the obstruents contrast in their specification for the laryngeal features [VOICE] and [SPREAD GLOTTIS]. Within coronals, retroflexes and dentals contrast in tongue height, with retroflex being specified for [HIGH] and dentals not specified for tongue height. This feature specification can be explained from a diachronic perspective. Plain dental stops in OC develop into retroflex stops in EMC when they precede */r/ or */rj/ ([CORONAL, HIGH]), and into alveolo-palatal sibilants when they precede */j/ ([CORONAL, HIGH]). Alveolo-palatal and retroflex sibilants merge in LMC with retroflexes being the underlying form and alveolo-palatal surfacing before high front vowel /i y/. It would be unreasonable to assume the plain dentals in OC are specified for [LOW] because (1) there is no three-way coronal contrast in OJ so TONGUE HEIGH feature is not needed, and (2) if dentals were specified as [LOW] there is no logical process for them to develop into retroflexes and alveolo-palatals because neither /r/ nor /j/ are [LOW]. Therefore we assume in LMC that retroflexes are [HIGH] and dentals are underspecified for TONGUE HEIGH.

Table 5 Feature chart for LMC obstruents

LMC Obstruents Phonemes		p	pʰ	pɦ	f	fɦ	t	tʰ	tɦ	s	sɦ	ts	tsʰ	tsɦ	ʈ	ʈʰ	ʈɦ	ʂ	ʂɦ	ʐ	tʂ	tʂʰ	tʂɦ	k	kʰ	kɦ	x	xɦ	ʔ
PLACE	ARTICULATOR & TONGUE HEIGHT	[LABIAL]					[CORONAL]								[CORONAL, HIGH]									[DORSAL]					[RADICAL]
ROOT	[OBSTRUENT]	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
	[STRIDENT]									✓	✓	✓	✓	✓				✓	✓	✓	✓	✓	✓						
CONSTRICTION	[CONTINUANT]				✓	✓				✓	✓							✓	✓	✓							✓	✓	
LARYNGEAL	[VOICE]			✓		✓			✓		✓			✓			✓		✓	✓			✓			✓		✓	
	[SPREAD GLOTTIS]		✓	✓		✓		✓	✓		✓		✓	✓		✓	✓		✓				✓		✓	✓		✓	

Table 6 Feature chart for LMC sonorants

LMC Sonorant Phonemes			m	n	ɳ	ŋ	ʋ	l	j	w
ROOT		[SONORANT]	✓	✓	✓	✓	✓	✓	✓	✓
		[NASAL]	✓	✓	✓	✓				
		[LATERAL]						✓		✓
PLACE	ARTICULATOR	[LABIAL]	✓				✓			
		[CORONAL]		✓	✓			✓	✓	
		[DORSAL]				✓				✓
	TONGUE HEIGHT	[HIGH]			✓				✓	✓

2.3.4.2 Vowels

The vowel inventory in LMC is shown in Table 7 (adapted from Pulleyblank, 1991: 10-12). LMC has five vowel phonemes /u a i ə y/, and they can be distinguished by the features shown in Table 8. Vowel height is represented by the tongue height feature [HIGH LOW]. Modern Standard Chinese has the same five vowel phonemes (Duanmu, 2007). The mid and low vowels have several surface variants and there are disagreements on what these variations are and their precise transcription. For example, Xu (1980: 184) propose five variants for the mid vowel /ə/: [o E ɤ e ə], and five variants for the low vowel /a/: [A ɑ a æ ɐ]. Due to these surface variations, the mid and low vowels are not specified for ARTICULATOR features (i.e. front/back). The high front rounded vowel /y/ is in Modern Standard Chinese words like 铝 /ly/ 'aluminum' and 女 /ny/ 'female'.

Table 7 Vowel inventory of LMC (adapted from Pulleyblank, 1991: 10-12)

Vowels	Front		Central	Back	
	unrounded	rounded		unrounded	rounded
High	i	y			u
Non-High			ə	a	

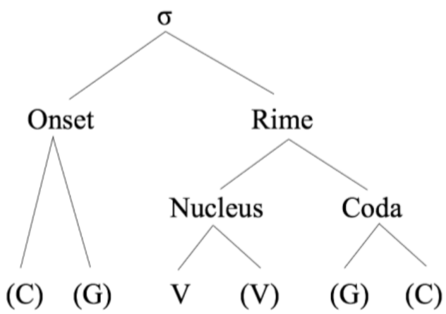
Table 8 Features for LMC vowels

LMC Vowel Phonemes			i	y	a	ə	u
ROOT		[SONORANT]	✓	✓	✓	✓	✓
PLACE	ARTICULATOR	[LABIAL]		✓			✓
		[CORONAL]	✓	✓			
		[DORSAL]					✓
	TONGUE HEIGHT	[HIGH]	✓	✓			✓
		[LOW]			✓		

2.3.4.3 Syllable and word structure

All Chinese characters (and hence Japanese *kanji*) are monosyllabic. The structure of a syllable in LMC is shown in Figure 5. C is the shorthand for consonant, V is the shorthand for vowel and G is the shorthand for glide in the representation of phonological rules here and henceforth. Complex onset, complex coda, and long vowels are all allowed in the language. The rhyme tables are arranged by syllable initials (columns) and finals (rows), but the initials and finals do not strictly correspond to syllable onsets and rimes. Initials are the first consonant in a syllable and 'finals' include the rime and the glide in the onset.

Figure 5 LMC syllable structure



2.4 Japanese historical phonology

2.4.1 The periodisation of Japanese

The history of the Japanese language is commonly categorised into 4 linguistic stages (e.g. Martin, 1987; Frellesvig, 2010; Miyake, 2003; cf. Hasegawa, 2014). OJ is the oldest attested period of the language. It lasts from 700 – 800 CE and overlaps with the Nara period (712 – 794 CE). The following period, Middle Japanese (MJ), is further divided into Early Middle Japanese (EMJ; 800 – 1200 CE) and Late Middle Japanese (LMJ; 1200 – 1600 CE), which overlap with the historical periods Heian (794 – 1185 CE), and Kamakura to (Azuchi)-Momayama period (1185 – 1603 CE) respectively. Modern Japanese starts from 1600 CE, roughly at the same time as the beginning of the Edo period (1603 CE). The alignment of the linguistics period with the political periods does not necessarily mean that the changes in language correlate with the changes of dynasties. However, policies of different dynasties have an effect on language contact situations so this common association of time periods with linguistic stages is useful in our discussion. Table 9 shows the linguistic periodisation of Japanese and the corresponding political periods. The following discussions will be based on this periodisation.

Table 9 Periodisation of Japanese (Frellesvig 2010: 1)

Linguistic period	Timespan	Historical periods	
Old Japanese (OJ)	700 - 800 CE	Nara	712 - 794 CE
Early Middle Japanese (EMJ)	800 - 1200 CE	Heian	794 - 1185 CE
Late Middle Japanese (LMJ)	1200 - 1600 CE	Kamakura	1185 - 1333 CE
		Muromachi	1333 - 1573 CE
		(Azuchi)-Momoyama	1573–1603 CE
Modern Japanese	1600 -	Edo	1603 - 1868 CE
		Meiji	1868 - 1912 CE
		Taicho	1912 - 1926 CE
		Showa	1926 - 1989 CE
		Heisei	1989 -

Japanese historical phonology is not as controversial as Chinese historical phonology and there is greater agreement among scholars. This could be due to its greater linguistic stability, smaller geographic area, and the later developed syllabic writing system. This study generally follows Frellesvig (2010) on Japanese phonology at each linguistic period with modifications otherwise discussed.

2.4.2 Old Japanese

2.4.2.1 Historical background and sources

Writing was introduced to Japan through Chinese classics from the Kingdom of Paekche during the fifth century. The Chinese script was adapted to represent the Japanese language. The earliest attested record of the Japanese language in written form are from inscriptions on stones and metals in the fifth century. Japanese written sources from this early stage are limited. In the sixth and seventh century, Chinese Buddhism was brought to Japan through Paekche. Studying written Chinese became increasingly important in the areas of classical literature, religion and philosophy. Writing became more widespread from the mid seventh century, and evidence came from the large number of wooden tablets discovered dating from the mid seventh to the mid eighth century. From the early eighth century, a great number of poetry and prose emerged, the content of which have been well preserved. These texts provide important evidence for Japanese history, literature and language.

Throughout the OJ period, Japanese was written by the logographic and phonographic adaptation of Chinese characters. The Chinese characters adopted in the Japanese writing system are called *kanji*, and the *kanji* used for the phonographic writing of Japanese are called *manyogona*. The phonographic use of *kanji* is valuable for the study of OJ historical phonology. While prose which was mainly written logographically provides information in aspects of OJ syntax, poetry in the eighth century was mainly recorded phonographically and enables the extensive study on the phonology and morphology of OJ. The main corpus for the study of OJ phonology is the poetry in the *Manyoshu* (a collection of poetry dating from mid fifth century to 759 CE), the *Kojiki* (the oldest chronicle of classical Japanese history, compiled in 712 CE) and the *Nihon Shoki* (the second oldest chronicle of classical Japanese history, compiled in 720 CE).

2.4.2.2 Consonants

The phonemic inventory of OJ consonant is shown in Table 10. There are overall 13 consonants, with six non-sibilant obstruents /p b t d k g/, two sibilant obstruents /s z/, two nasals /m n/, two glides /w j/ and one liquid /r/.

Table 10 The consonants of OJ

Consonants	Bilabial	Labial-velar	Alveolar	Palatal	Velar
Non-sibilant obstruents	p b/^{m}b		t d/^{n}d		k g/^{ŋ}g
Sibilants			s z/^{n}z		
Nasal	m		n		
Glide		w		j	
Liquid			r		

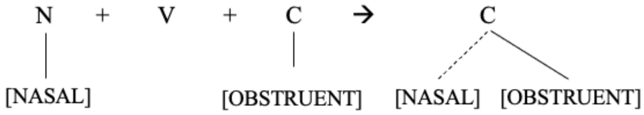
The two groups of obstruents /p t k s/ and /b d g z/ differ in voicing, nasality and distribution. /p t k s/ occur both word initially and internally – they are voiceless word initially [p t k s] and surface as voiced word internally [b d g z] (e.g. minimal pair /pata/ [pada] 'flag' vs /pada/ [pa^{n}da] 'skin') due to a word medial voicing process, represented by the rule in (2). The phonological process cease to apply from LMJ.

(2) word medial obstruent voicing

[OBSTRUENT] → [OBSTRUENT, VOICE] / [SONORANT] __ [SONORANT]

/b d g z/ are always voiced with prenasalisation [^{m}b ^{n}d ^{ŋ}g ^{n}z] in the native OJ and EMJ phonology. They spread nasality to the preceding vowel, e.g. /pada/ [pã^{n}da] 'skin'. Different from the first group /p t k s/, /b d g z/ only occur word internally in the native lexicon. Frellesvig (1991, 2010) describes prenasalisation as a phonological process and the phonemes /b d g z/ are not specified for [NASAL]. However, as /b d g z/ are always prenasalised in the native lexicon, such a phonological process would require the application context to be 'all environments'. This study assumes that the prenasalised obstruents are specified for [NASAL] and employs the symbols /^{m}b ^{n}d ^{ŋ}g ^{n}z/ from here onwards for a straightforward representation of their nasality. The process of nasality spreading can thus be understood as a spreading of the [NASAL] feature from the prenasalised obstruent to the preceding vowel. Diachronic changes also provide support for such a feature specification. The prenasalised obstruents in OJ and EMJ derive from the sporadic contractions of a nasal, an intervening vowel and an obstruent in Pre-OJ, e.g */jama-miti/ > /jama^{n}di/ 'mountain path'. The phonological process is illustrated by the autosegmental representation in Figure 6. N is used as the shorthand for nasal here. The nasal segments were deleted and the [NASAL] feature re-associated with the following obstruents.

Figure 6 Sporadic contractions of a nasal and a following obstruents



Frellesvig (2010: 35) refers to the voiceless and voiced obstruents as *tenues* and *mediae* because phonetically they are distinctive in tenseness (/p t k s/ are tense and /^{m}b ^{n}d ^{ŋ}g ^{n}z/ are lax) but not voicing. However, as the word medial voicing of /p t k s/ is due to phonological process, and the two groups /p t k s/ and /^{m}b ^{n}d ^{ŋ}g ^{n}z/ can be distinguished by nasality without referring to tenseness, here I adapt the terms prenasalised voiced obstruent for /^{m}b ^{n}d ^{ŋ}g ^{n}z/ and voiceless obstruents for /p t k s/ from Miyake (2003).

OJ allows violation of the distribution of prenasalised obstruents in loanwords. In Sino-Japanese *go-on*, the prenasalised obstruents also occur world initially through the adaptations of EMC voiced obstruent initials /b d ɖ g z ʑ ʐ ɣ/, e.g. EMC 伴 /ban/ 'companion' is adapted as /^{m}ban/ in OJ; EMC 持 /ɖi/ 'hold' is adapted as /^{n}di/ in OJ. It is unclear, however, whether word initial prenasalised obstruents are also prenasalised phonetically. Nasality spreading provides evidence for these obstruents being prenasalised in the native phonology. However, when these obstruents are in word initial position in Sino-Japanese, there is no preceding vowel. Nasality spreading could not apply, and therefore, it is hard to determine if the obstruents are still prenasalised phonetically. If they are not prenasalised in word initial position, the 'denasalisation' process would be similar to the devoicing of initial voiced obstruents in English.

The defining distinction between the obstruents /p ^{m}b t ^{n}d k ^{ŋ}g/ and /s ^{n}z/ is not continuousness but stridency, because the obstruents have surface forms that vary in manner of articulation. I therefore adapt the terms in Frellesvig (2010, 2018) and refer to the two groups as sibilants (/s ^{n}z/) and non-sibilants (/p ^{m}b t ^{n}d k ^{ŋ}g/). The labial and dorsal non-sibilants /p ^{m}b k ^{ŋ}g/ exhibit surface variations between plosives and fricatives and the manner alternations are not conditioned by phonological context. Voiceless non-sibilants /p k/ have word initial fricative variants [ɸ x], and word medial fricative variants [β ɣ] respectively. Prenasalised voiced non-sibilants /^{m}b ^{n}g/ have fricative surface forms [^{m}β ^{n}ɣ] respectively. The alternating forms in Old Japanese are sometimes in free variation and other times influenced by stylistics, with the plosives in formal speech and fricatives in casual speech (Frellesvig, 2010). The merger of /-p-/ with /-w-/ in EMJ, and syllable weakening involved in the *onbin* sound changes provide evidence for the continuousness variations. The sibilants /s ^{n}z/ have fricative and affricate surface variants and they seem to be conditioned by the following phonological context (Kobayashi, 1981; Frellesvig, 2010), as shown in Table 11.

Table 11 Surface variants of sibilants /s ^{n}z/

	s		z
	word initial	word medial	word medial
/-a -o/	[^{t}s]	[^{d}z]	[^{n}dz]
/-u/	[s] or [^{t}s]	[z] or [^{d}z]	[^{n}z] or [^{n}dz]
/-wo/	[s]	[z]	[^{n}z]
/-i -e/	[ʃ]	[ʒ]	[^{n}ʒ]

Among the five sonorant consonants, the liquid /r/ is phonetically a tap [ɾ] (the conventional symbol /r/ is adopted in this paper), and it does not occur word initially. The two nasals /m n/ occur both word initially and internally. The two glides /w j/ can occur as initials or the second element of onset. /ji wu/ are not acceptable segmental combination according to the phonotactic restriction since OJ.

The phonological features in FUL that are relevant to our discussion on Japanese phonemes are shown in (3).

(3) Segment classification by FUL features for Old, Middle and Modern Japanese phonemes

- ROOT

[OBSTRUENT] / [SONORANT]: obstruents vs sonorant consonants and vowels

[STRIDENT]: plosives vs fricatives

[NASAL]: nasal consonants and vowels

[RHOTIC]: liquid

- PLACE
  - ARTICULATOR

    [LABIAL]: labial consonants, rounded vowels

    [CORONAL]: alveolar and palatal consonants, front vowels

    [DORSAL]: velar consonants, back vowels
  - TONGUE HEIGHT

    [HIGH]: high vowels

    [LOW]: low vowels

The features for OJ consonants are shown in Table 12. The sibilants and non-sibilants contrast in [STRIDENT] and are not specified for [CONTINUANT] (Frellesvig, 2018). The voiced prenasalised obstruents and voiceless obstruents contrast in [NASAL] and are underspecified for [VOICE] ([NASAL] entails [VOICE]).

Table 12 Phonological features of OJ consonants

OJ consonant phonemes		p	^{m}b	t	^{n}d	k	^{ŋ}g	s	^{n}z	m	n	w	j	r
ROOT	[OBSTRUENT]	✓	✓	✓	✓	✓	✓	✓	✓					
	[SONORANT]									✓	✓	✓	✓	✓
	[STRIDENT]							✓	✓					
	[NASAL]		✓		✓		✓		✓	✓	✓			
	[RHOTIC]													✓
PLACE - ARTICULATOR	[LABIAL]	✓	✓							✓		✓		
	[CORONAL]			✓	✓			✓	✓		✓		✓	✓
	[DORSAL]					✓	✓					✓		

2.4.2.3 Vowels

OJ has five vowel phonemes /a i u e o/, which is the same as that of Modern Japanese. In order to understand the features of the OJ vowels, it is necessary to look at them from a diachronic perspective. Table 13 (adapted from Frellesvig, 2010: 42-50) shows how the OJ vowels derived from Proto-Japanese vowels and Pre-OJ sequences.

Table 13 Diachronic change of vowels from Proto-Japanese to OJ

Proto-Japanese	Diachronic change	Pre-Old Japanese	Diachronic change	Old Japanese	
*i	→	*i	→	i	i
*e	mid vowel raising →				
		*ɨi, *ɨj, *ui, *uj	diphthongs contraction →	wi	
*u	→	*u	→	u	u
*o	mid vowel raising →				
		*əi, *əj, *ai, *aj	diphthongs contraction →	e	e
		*ia, *iə	diphthongs contraction →	je	
*e	mid vowel raising →	*je	neutralisation →	e	
			→	je	
*ɨ	merger of central vowel →	*ə	backing of central vowel →	o	o
*ə					
*o	mid vowel raising →	*wo	neutralisation →	o	
			→	wo	
		*uo,*ua	diphthongs contraction →	wo	
*a	→	*a	→	a	a

In Old Japanese, there were almost no simple words of the structure /CoCa, CoCwo, CoCu, CaCo, CwoCo, CuCo/ (Frellesvig, 2010). This distribution shows that /Co/ does not co-occur with /Cu Cwo Ca/ in a root morpheme. In 1934, Arisaka Hideyo proposed Arisaka's Law, a morphophonemic restriction on the distribution of vowels in OJ, to account for this observed distribution. A shown in Table 13, OJ /u/ derived from Proto-Japanese (PJ) /*u *o/, OJ /wo/ derived from PJ /*o/, OJ /a/ derived from PJ /*a/, and OJ /o/ derived from PJ /*ɨ *ə/. Arisaka's Law can therefore be reinterpreted as a restriction on the co-occurrence of the Proto-Japanese vowels /*u *o *a/ and /*ɨ *ə/. This distributional pattern categorises the Proto-Japanese vowels into three groups: front vowels /*i *e/, central vowels /*ɨ *ə/ and back vowels /*u *o/. Some of the ARTICULATOR features of the OJ vowels can therefore be deduced – /i e/ are [CORONAL] and /u o a/ are [DORSAL]. Proto-Japanese /*e *o/ go through mid vowel raising to OJ /i u/ respectively in non-final positions.[11] In OJ, consonants that occur before /i/ are palatalised, e.g. /kimi/ [k^{j}ĩm^{j}ĩ] ‘lord’, showing that the [CORONAL HIGH] features of the vowel spread to the preceding consonant. The back vowel /u/ which derives from a parallel raising process is therefore also [HIGH]. Synchronically, /u/ causes the preceding consonants to be labialised, e.g. /kubi/ [k^{w}ũ^{m}b^{j}i] ‘head’ indicating that /u/ is specified for [LABIAL]. Miyake (2003: 207-211) analyses transcriptions in *Kojiki* and *Nihon Shoki*, and transliterations in other languages. He concluded that OJ /u/ is a high back rounded vowel, and it remained intact in LMJ. However, as /u/ is the only [DORSAL HIGH] vowel, [LABIAL] is not needed to establish phonemic contrast. From Modern Japanese, /u/ lost its rounding and became [ɯ]. There are two non [HIGH] back vowels /o a/, so the TONGUE HEIGHT feature [LOW] is necessary in distinguishing the vowels. OJ vowels thus have the features as shown in Table 14.

Table 14 Phonological features of OJ vowels

OJ vowel phonemes		a	i	u	e	o
ARTICULATOR	[LABIAL]			(✓)		(✓)
	[CORONAL]		✓		✓	
	[DORSAL]	✓		✓		✓
TONGUE HEIGHT	[HIGH]		✓	✓		
	[LOW]	✓				

2.4.2.4 Syllable and word structure

All OJ syllables are open short and have the syllable structure (C)(G)V. Parentheses indicate optionality. Syllables formed by a single vowel are generally in word initial position with only a few exceptions. The prenasalised voiced obstruents /^{m}b ^{n}d ^{ŋ}g ^{n}z/ and liquid /r/ cannot occur word initially. The absence of word initial liquids is typologically common in Altaic languages, a sprachbund that includes the Japonic languages. The distribution of the voiced

[11] Whether it is root final, morpheme final or word final depends on dialectal differences.

obstruents reflects their diachronic change. As there is no voiced obstruent phoneme in Proto-Japanese and the voiced obstruents in OJ are the result of contractions of a nasal and a following voiceless obstruent sequence N(V)O (as discussed in 2.3.2.2), voiced obstruents are not found word initially.

In present-day Japanese, dictionaries and text books present the syllables (in syllabary scripts) in the *gojuonzu* ('fifty-sound table') arrangement. This and the following sections present the full set of syllables for each period of Japanese in the 'fifty-sound table' format for a better understanding of the allowed syllable structures, and sound and structural changes. They are intended for easy reference and comparison. The (phonemic) syllables in OJ are shown in Table 15.

Table 15 Phonemic syllables in OJ

a	i		u	e		o	
ka	ki	kwi	ku	ke	kje	ko	kwo
^{ŋ}ga	^{ŋ}gi	^{ŋ}gwi	^{ŋ}gu	^{ŋ}ge	^{ŋ}gje	^{ŋ}go	^{ŋ}gwo
sa	si		su	se		so	swo
^{n}za	^{n}zi		^{n}zu	^{n}ze		^{n}zo	^{n}zwo
ta	ti		tu	te		to	two
^{n}da	^{n}di		^{n}du	^{n}de		^{n}do	^{n}dwo
na	ni		nu	ne		no	nwo
pa	pi	pwi	pu	pe	pje	po	
^{m}ba	^{m}bi	^{m}bwi	^{m}bu	^{m}be	^{m}bje	^{m}bo	
ma	mi	mwi	mu	me	mje	mo	mwo
ja			ju	je		jo	jwo
ra	ri		ru	re		ro	rwo
wa	wi			we		wo	

2.4.3 Early Middle Japanese

2.4.3.1 Historical background and sources

Hiragana and *katakana*, the two sets of phonographic scripts that are part of the Modern Japanese writing system, were developed during the EMJ period through the simplification and abbreviation of the shape of *manyogana* (i.e. the phonographic use of *kanji*). The two sets of scripts were created by different strategies and used to fulfil different functions in the language. *Katakana* derived from parts of *manyogana,* and was used to annotate Classical Chinese texts and to write grammatical words or endings in *kanji-kana majiribun*, a writing style that combines both logographic and phonographic writings. *Hiragana* resulted from the simplification of cursive writing of whole *manyogana* and was largely used in personal prose written by women and poetry written by both women and men. The newly developed *hiragana*, *katakana*, as well as the old *manyogana* were all in use throughout the MJ period.

The OJ tradition of extensive phonographic writing which was developed in the context of poetry was being extended by the establishment of *hiragana* in EMJ. During the tenth and eleventh century, a large amount of poetry as well as prose were written almost entirely in *hiragana.* Since the mid EMJ period, *kanji-kana majiribun* became more widespread and eventually replaced extensive *hiragana* writing in prose in the LMJ period. *Kanji-kana majiribun* is the direct ancestor of the Modern Japanese writing system. In *kanji-kana majiribun*, *kanji* were used logographically to write most lexical words and some function words, and *katakana* were used in representing some function words and endings. In Modern Japanese, however, the proportion of phonographic writing is significantly higher, but with *hiragana* replacing *katakana*. Formal and academic writing in EMJ were still largely done in Classical Chinese.

The materials for studying EMJ phonology are much more extensive than that for OJ. Prose texts written in *hiragana* are the most valuable in the study of the phonology as they were believed to reflect the contemporary language of the upper class vernacular. The genre of prose written in *hiragana* covers *monogatari* ‘stories’, *nikki* (‘diaries’), and *zuihitsu* (‘jottings’). Annotated Classical Chinese texts, dictionaries and Sanskrit studies also provide important information about the phonetics, lexicon and dating of sound change of EMJ. Poetry, which was the main source of OJ, became less valuable in the study of Japanese phonology because most poetic texts are conservative and follow the established grammar and lexicon norm. Newly formed words with long syllables and Sino-Japanese loanwords that entered the language during EMJ were not used in poetry.

2.4.3.2 The *onbin* sound change

Between the late 8th and early 10th century, the *onbin ('euphony')* sound change took place during the transition from OJ to EMJ. It is the major internal phonological structural change that differentiates OJ from Modern Japanese. It influences the syllable structure, and consonant and vowel phonemic inventories by introducing long (heavy) syllables and bound moraic phonemes into the language.

The *onbin* sound change is motivated by the ease of articulation and it turns a non-word initial CV syllable into a single vowel or consonant. The resultant vowel or consonant attaches to the preceding short syllable to form a long syllable. Japanese codas are subject to Weight-by-Position (Hayes, 1989). The vowels and consonants result from the *onbin* sound change are termed bound moraic segments as they constitute one mora and attach to the end of a syllable to form a heavy syllable. The original CV syllables that undergo the change have one of the stop phonemes /p k ^{m}b ^{ŋ}g m n/ as the onset and one of the high vowels /i u/ as the rime. However, not all syllables that meet these phonological conditions undergo the sound change. What is also irregular about *onbin* is that the same syllable can result in different forms, a bound moraic consonant and vowel (e.g. /ta**pu**two-/ 'exalted' > /ta**u**to-/ and /ta**t**to-/), and sometimes the new forms along with the old source forms coexist in use for a long period of time.

The phonemic inventory of the resulting bound moraic segments is still under debate. Traditional Japanese linguistics academia generally agrees on the four-way division of the outcomes of *onbin* changes – the high front vowel /i/, high round back vowel /u/, the nasal /N/ (i.e. a nasal coda phoneme that is not specified for PLACE) and the obstruent /O/ (i.e. an obstruent coda phoneme that is not specified for PLACE) (Okumura, 1980; Kawamoto, 1977).

A different perspective, couched within the European semiotic-structuralist theory, is given by Frellesvig (1995). He proposes that phonemic nasality distinction exists not only in consonants but also in vowels. In his analysis, the *onbin* sound change leads to the introduction of three bound moraic consonants /C O[12] N/ and four bound moraic vowels, two nasal and two oral /i u ĩ ũ/, to the Japanese phonemic inventory.

2.4.3.3 Consonants

The phonemic inventory of EMJ consonants is shown in Table 16. As in OJ, there are overall 13 consonants, with six non-sibilant obstruents /p t k ^{m}b ^{n}d ^{ŋ}g/, two sibilant obstruents /s z/, two nasals /m n/, two glides /w j/ and one liquid /r/. The only difference between the consonants of OJ and EMJ is the emergence of the bound moraic phonemes. This study follows the analysis by Frellesvig (1995). The feature specification and distribution of the moraic consonants /C N O/ are shown in Table 17. /C/ is not specified for voice, place or manner, and copies features, including nasality, from the following consonant, /N/ is a nasal consonant that copies the place of articulation from the following consonant, and /O/ is the corresponding oral bound moraic consonant that copies the feature from the following consonants. The bound moraic consonants differ in their distributions.

Table 16 The consonants of EMJ

Consonants	Bilabial	Labial-velar	Alveolar	Palatal	Velar
Non-sibilant obstruents	p ^{m}b		t ^{n}d		k ^{ŋ}g
Sibilants			s ^{n}z		
Nasal	m		n		
Glide		w		j	
Liquid			r		
Moraic	C N O				

[12] The original symbol for this bound moraic phoneme in Frellesvig (2010) is /Q/.

Table 17 The nasality specification and distribution of bound moraic consonants /C N O/

Bound moraic consonants	Nasality specification	Position
/C/	not specified	morpheme internal
/N/	[NASAL]	morpheme final, word internal
		word final
/O/	non [NASAL]	morpheme final, word internal

In morpheme internal position, the moraic consonant takes the form /C/. It remains oral in production when the following consonant is a voiceless obstruent /p t k s/ and surfaces as a nasal when the following consonant is a prenasalised voiced obstruents /^{m}b ^{n}d ^{ŋ}g ^{n}z/ or nasal /m n/. When /C/ precedes a voiceless obstruent /p t k s/, it copies the full set of features of the voiceless obstruents (e.g. /taCto-/ → ta**t**to- ‘precious’; /maCkura/ → /ma**k**kura/ 'very black'); when /C/ precedes a prenasalised voiced obstruents or a nasal / ^{m}b ^{n}d ^{ŋ}g ^{n}z m n/, it becomes a nasal by taking on the nasal feature and copying the place feature of the following consonants (e.g. /kaC^{m}basi/ → ka**m**basi ‘fragrant’; /piC^{ŋ}gasi/ → pi**ŋ**gasi ‘east’).

In morpheme final, word internal position, the moraic phonemes /O N/ are both used. /O/ only occurs before a voiceless obstruent /p t k s/ and takes on the full set of features of the following voiceless obstruents, e.g. /siO + te/ → sit-te ‘knowing’. /N/ occurs in all *onbin* environments (e.g. /naN + ^{m}besi/ → /nam-besi/ ‘copula-necessitive’), and when it occurs before a voiceless obstruents, a postnasal neutralisation rule applies – the following voiceless obstruent is neutralised into a voiced obstruents, e.g. /siN + te/ → /sin-de/ ‘dying’. The voicing of obstruents after a vowel and before a vowel or a glide in OJ continues to apply in EMJ.

In word final position, only /N/ is used. In LMJ, word final /N/ has the phonetic value [n] . It is therefore deduced that in EMJ, /N/ also realises as [n] word-finally.

The vowel nasalisation rule in OJ continues to apply in EMJ. When a vowel precedes an /N/ or a /C/ that has a following voiced obstruents or nasal, it becomes nasalised, e.g.

/puC^{n}de/ → prenasalisation of /d/ → pũnde 'brush'; /puN + te/ → postnasal neutralisation → pũnde 'stepping'.

A series of changes affecting OJ initial /p/ starts from the second half of the tenth century during EMJ when a merger of intervocalic /p/ with /w/ takes place. /p/ becomes /w/ when the following vowel environment is /a i e o/ (4a), e.g. /upe/ > /uwe/ 'top'; /api/ > /awi/ 'meeting'. When the following vowel is /u/, /p/ disappears because phonotactic constraints disallow /wu/. However, when /p/ is the onset of the second morpheme of a transparent compound, it remains /p/ (4b), e.g. /asa-pi/ 'morning sun'.

(4) a. p > w / V_ {a i e o}

b. p > ∅ / V_u

2.4.3.4 Vowels

EMJ has 7 vowel phonemes /a i ĩ u ũ e o/. The oral vowels /a i u e o/ in EMJ are directly derived from the vowels /a i u e o/ in OJ. The nasal vowels /ĩ ũ/ enter the language through the *onbin* sound change. Frellesvig (2010) adopts the capital letter notation for the bound moraic vowels /I U Ĩ Ũ/. However, since /I U Ĩ Ũ/ are fully specified for phonological features and their realisation is not conditioned by the environment like the bound moraic consonants, they are phonemically the same as /i u ĩ ũ/. This study does not employ the capital letter notation for bound moraic vowels /I U Ĩ Ũ/ but uses the normal vowel notation /i u ĩ ũ/ instead. The nasal vowels /ĩ ũ/ have the same place features as the vowels /i u/. The only differences is that /ĩ ũ/ are phonemically specified as [NASAL]. Table 18 shows the features for the bound moraic vowels. Besides the *onbin* sound change, another source of /i u/ being the second segment in a nucleus is the loss of syllable initial /w/ before /i/ and loss of /p/ before /u/, which is discussed in Section 3.3.3.5.

Table 18 Phonological features for EMJ bound moraic vowels

EMJ bound moraic vowels			i	ĩ	u	ũ
ROOT		[NASAL]		✓		✓
PLACE	ARTICULATOR	[LABIAL]			✓	✓
		[CORONAL]	✓	✓		
		[DORSAL]			✓	✓
	TONGUE HEIGHT	[HIGH]	✓	✓	✓	✓

Same as the bound moraic consonants, the nasality of the bound moraic vowels is distinctive in word final and morpheme final, word internal positions. The distribution of the vowels are shown in Table 19.

Table 19 The nasality specification and distribution of bound moraic vowels /i u ĩ ũ/

Bound moraic vowels	Nasality specification	Position
/i u/	not specified	all positions
/ĩ ũ/	[NASAL]	morpheme final, word internal; word final

In morpheme final, word internal position, same as the bound moraic nasal consonant /N/, the nasal vowels /ĩ ũ/ also trigger postnasal neutralisation, e.g. /joũ + te/ → joũ-de 'calling' vs /ou + te/ → ou-te 'pursuing'. The postnasal neutralisation rule can be generalised as a voiceless obstruent /p t k s/ becomes voiced when it occurs after any segment that is specified for [NASAL], as represented in (5).

(5) postnasal neutralisation

[OBSTRUENT] → [OBSTRUENT VOICE] / [NASAL] __

The oral bound moraic vowels /i u/ are also subject to the vowel nasalisation rule. When an oral bound moraic vowel occurs before a voiced obstruent or nasal, it surfaces as a nasalised vowel, e.g. /tui^{n}de/ → tuĩde 'sequence'. A nasalised vowel can also trigger the preceding vowel to be nasalised, e.g. /tuĩ + te/ → [tũĩ^{n}d^{j}e] 'following'. The vowel nasalisation rule can thus be generalised into (6). When a vowel precedes a segment that is specified for [NASAL], it becomes nasalised in the surface form.

(6) vowel nasalisation

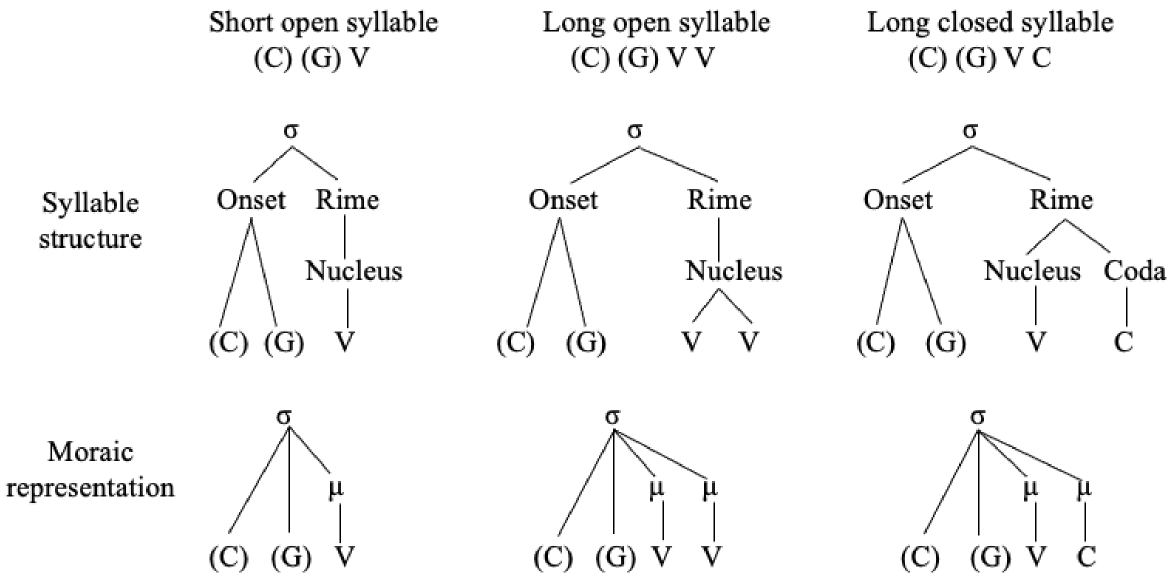
V → V [NASAL] / __ [NASAL]

The four bound moraic vowels /i u ĩ ũ/ introduce long vowels /ii uu/ and a large number of diphthongs /ai aĩ au aũ iĩ iu iũ ui uĩ uũ ei eĩ eu eũ oi oĩ ou oũ/ into the Japanese language.

2.4.3.5 Syllable and word structure

Apart from the open short syllable C(G)V that already exists in OJ, EMJ also has the long (heavy) open syllable C(G)VV and closed syllables C(G)VC. Syllable weight becomes relevant to Japanese since this period and Japanese becomes quantity sensitive. Figure 7 shows the structures of the syllables in EMJ and their moraic representations.

Figure 7 Syllable structures in EMJ



Besides the *onbin* sound change that introduces syllable coda and vowel sequence in syllable nucleus, the loss of palatal glide /j/ before /e/ around 950 CE (7a), loss of labial glide /w/ before /o/ around 1000 CE (7b) and before /i e/ in word internal position around 1100 CE (7c) also lead to changes in Japanese syllables (Frellesvig, 2010).

(7) a. j > Ø / __ e

b. w > Ø / __ o,

c. w > Ø / __ {i, e} word internal

Firstly, the OJ simple onset syllables /je wo/ are lost in EMJ, e.g. /nuje/ > /nue/ 'moutain thrush'; /awo/ > /ao/ 'blue'. As the loss of /w/ before /i o e/ takes place after intervocalic /p/ becomes /w/, the change in (7b) also influences the /w/ derived from /p/. Secondly, the OJ syllables with complex onset /Cje Cwi Cwo/ are lost, e.g. /mje/ > /me/ 'women'; /pwi/ > /pi/ 'fire'; /kwo/ > /ko/ 'child', leaving only the 6 syllables with initial glide /ja ju jo wa wi we/. The consonants in the resulting sequences /Ce Ci/ are palatalised in production. The loss of glides together with the loss of /p/ before /u/ (4b) leads to a large number of the vowel sequences /Vi Vu Ve Vo/. The vowels /i u/ are syllabified into the preceding syllable to form a heavy syllable, and the vowels /e o/ remain independent as syllable initial segments. The syllable and word initial vowels /e o/ are produced with phonetic onglides [^{j}e ^{w}o] and the onglides function as phonetic onsets (Frellesvig 2010: 208).

The influx of Sino-Japanese loanwords during the EMJ period introduces new sound combinations and distributions among which some are later integrated into the native vocabulary while others stay only in Sino-Japanese vocabulary. While the OJ syllables with complex onset /Cje Cwi Cwo/ are lost due to sound changes in EMJ, Sino-Japanese loanwords reintroduce complex onset in syllables /Cja Cjo Cju Cwa Cwe/ through the adaptation of Chinese rhymes, e.g Chinese /-yn/ → Japanese /- juN/. The syllable onset /Cj/ comes to occur in the native vocabulary in LMJ. It enters the native vocabulary through monophthongisation /iu/ > /ju:/ and /eu/ > /jo:/, e.g. /kjo:/ 'today'. Sino-Japanese vocabulary also has syllable final /t/ (different from the syllable final [t] resulted from the bound moraic consonants /C O/), and word initial voiced obstruents /^{m}b ^{n}d ^{ŋ}g ^{n}z/ and liquid /r/ which are not allowed in OJ.

Table 20 shows all syllables by the end of EMJ. The syllables /wi we/ are almost only in word initial position with a few exceptions, and /pa pi pu pe po/ are only in word initial position and after /O/.

Table 20 Syllables in EMJ

Free moras										Bound moraic phonemes			
a	i	u	e	o						-i	-ĩ	-u	-ũ
ka	ki	ku	ke	ko	kja	kju	kjo	kwa	kwe	-N	-O	-C	-t
$^{\text{ŋ}}$ga	$^{\text{ŋ}}$gi	$^{\text{ŋ}}$gu	$^{\text{ŋ}}$ge	$^{\text{ŋ}}$go	$^{\text{ŋ}}$gja	$^{\text{ŋ}}$gju	$^{\text{ŋ}}$gjo	$^{\text{ŋ}}$gwa	$^{\text{ŋ}}$gwe				
sa	si	su	se	so	sja	sju	sjo						
^{n}za	^{n}zi	^{n}zu	^{n}ze	^{n}zo	^{n}zja	^{n}zju	^{n}zjo						
ta	ti	tu	te	to	tja	tju	tjo						
^{n}da	^{n}di	^{n}du	^{n}de	^{n}do	^{n}dja	^{n}dju	^{n}djo						
na	ni	nu	ne	no	nja	nju	njo						
pa	pi	pu	pe	po	pja	pju	pjo						
^{m}ba	^{m}bi	^{m}bu	^{m}be	^{m}bo	^{m}bja	^{m}bju	^{m}bjo						
ma	mi	mu	me	mo	mja	mju	mjo						
ja		ju		jo									
ra	ri	ru	re	ro	rja	rju	rjo						
wa	wi		we										

2.4.4 Late Middle Japanese

2.4.4.1 Historical background and sources

The extensive *hiragana* writing of texts that was developed and became widespread in the EMJ period did not survive into the LMJ period. *Kanji-kana majiribun,* the writing style that combines logographic and phonographic writing, flourished in LMJ. Most of the textual evidence from this period are written in the fossilised classical norm in *kanji-kana majiribun*. The genre of the written sources includes *gunki monogatari* ('war stories'), *zuihitsu* ('jottings'), *setsuwa* ('tales, legends') and *shomono* (notes on Chinese classics or Buddhism scriptures). However, due to the high proportion of logographic writing in *kanji-kana majiribun*, these sources are not the most helpful for the study of phonology.

Around the end of the sixteenth and the beginning of the seventeenth century, a body of texts in or about the Japanese language written in alphabetic writing by the Christian missionaries emerged. Between 1549 and 1639, during the national seclusion in Japan, Jesuit missionaries performed missionary work through the production and publication of a large number of sources, including texts, grammars and dictionaries. They acquired a high proficiency in both the Japanese contemporary vernacular and the classical written form within a short time. Their dictionaries, especially the Japanese-Portuguese dictionary *Vocabulario da lingoa de Iapam* (1603-4), and texts in the contemporary vernacular written in alphabetic writing are of great importance especially in the study of phonology and lexicology.

Lots of language changes in LMJ took place by the mid sixteenth century, leaving the language at the end of LMJ reflected in the Christian sources very different from that of early LMJ. *Irop'a* (1492), a Japanese language textbook for Korean officials, provides valuable information on the dating of some phonological changes.

2.4.4.2 Consonants

One of the major changes in consonants from EMJ to LMJ is in the nasality and voicing of obstruents. The prenasalisation /^{m}- ^{n}- $^{\text{ŋ}}$- ^{n}-/ of voiced obstruents /^{m}b ^{n}d $^{\text{ŋ}}$g ^{n}z/ which was a prominent property of the language in OJ and EMJ is on its way to disappearing by the end of LMJ and eventually disappears in early Modern Japanese. The voiced obstruents lose the [NASAL] feature and stop triggering the nasalisation of the preceding vowel in production.

Due to the loss of the [NASAL] feature, the phonetic nasality of word-internal moraic consonant /C/ cannot be assigned by the following voiced obstruent. Nasality is reinterpreted as phonemic in word-internal position – when a word-internal moraic consonant occurs before a voiced obstruent or nasal /b d g z m n/, it takes on the form /N/ (8a); when a word-internal moraic consonant occurs before a voiceless obstruent /p t k s/, it takes on the form /O/ (8b). /C/ is no longer in the phonemic inventory by the end of LMJ and nasality becomes distinctive in the moraic consonants in all positions. Word final /N/ still takes on the form [n] as in EMJ.

(8) a. /C/ > /N/ / __ {b d g z m n}

e.g. /kaCbasi/ > /kaNbasi/ 'fragrant'

b. /C/ > /O/ / __ {p t k s}

e.g. /taCto-/ > /taOto-/ 'precious'

In OJ and EMJ, the obstruent voicing rule (i.e. a voiceless obstruent becomes voiced in production when it occurs after a vowel and before a vowel or glide) (9a), together with the postnasal neutralisation rule (5) (i.e. a voiceless obstruent becomes voiced in production when it occurs after a segment that is specified for [NASAL]), repeated here as (9b), guarantee word-internal obstruents, apart from those following a non-nasal bound moraic phoneme /O/, to be voiced in production. By the end of the LMJ period, both rules cease to apply, leaving voiceless obstruents occurring freely in word-internal position, e.g. /aNsin/ → /ansin/ 安身 'being safe'. However, some words are lexicalised before the loss of the rules, e.g. /naN + poku/ → /nanboku/ 'south and north'.

(9) a. obstruent voicing

[OBSTRUENT] → [OBSTRUENT VOICE] / {V, G} __ V

(or [OBSTRUENT] → [OBSTRUENT VOICE] / [SONORANT] __ [SONORANT])

b. postnasal neutralisation

[OBSTRUENT] → [OBSTRUENT VOICE] / [NASAL] __

Another major difference in consonants between the EMJ and the LMJ period is the change of /p/ > /f/, except when /p/ occurs after the moraic consonants /N O/. The diachronic change and examples are shown in (10). This sound change introduces /f/ to the phonemic inventory of LMJ.

(10) a. /p/ > /p/ / {N O} __

e.g. /aNpu/ → /anpu/ 'safety'; /maOpiru/ → /mappiru/ 'middle of the day'

b. /p/ > /f/ elsewhere

e.g. /pa/ > /fa/ ‘leaf’; /pi/ > /fi/ ‘day’

In the second half of the tenth century, LMJ /-p-/ > /-w-/ takes place, leaving /p/ in word initial position, in the onset of the second morpheme of a transparent compound or after /O/. Between then and the change of /p/ > /f/, new words with internal /p/ enter the lexicon through lexicalisation of compounds. The change of /p/ > /f/ applies to both /p/ in word initial position and internal position that is not after /N O/. The /Op/ (=/pp/) sequence which enter the language since the *onbin* sound change has been preserved into LMJ. Most of the instances of the sequence occur in Sino-Japanese words. In EMJ, the /Np/ sequence does not exist as /p/ is neutralised to /b/ due to the postnasal neutralisation rule. In LMJ, the postnasal neutralisation rule cease to apply, the /Np/ sequence becomes frequent in the language and remains uninfluenced by the /p/ > /f/ sound change. Similarly to the /Op/ sequence, most words with the /Np/ sequence are of Sino-Japanese origin.

The diachronic phonological changes in LMJ outlined above give rise to the phonemic inventory in Table 21, and the features for the obstruents and moraic phonemes in Table 22. After the prenasalisation of obstruents is lost, there is no longer a nasal vs non-nasal distinction in obstruents, and all obstruents are oral. The [NASAL] feature is no longer specified in obstruents, and the previously underspecified [VOICE] becomes the contrastive feature.

Table 21 LMJ phonemic consonant inventory

Consonants	Bilabial	Labiodental	Labial-velar	Alveolar	Palatal	Velar
Non-sibilant obstruent	p b	f		t d		k g
Sibilant				s z		
Nasal	m			n		
Glide			w		j	
Liquid				r		
Moraic	O N					

Table 22 Features for obstruents and moraic phonemes in LMJ

LMC obstruent phonemes		p	b	t	d	k	g	s	z	f	O	N
ROOT	[CONSONANTAL]	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
	[OBSTRUENT]	✓	✓	✓	✓	✓	✓	✓	✓	✓		
	[STRIDENT]							✓	✓			
	[NASAL]											✓
LARYNGEAL	[VOICE]		✓		✓		✓		✓			
PLACE - ARTICULATOR	[LABIAL]	✓	✓							✓		
	[CORONAL]			✓	✓			✓	✓	✓		
	[DORSAL]					✓	✓					

An important allophonic rule influencing the consonants is the assibilation of /t d/ when they occur before the high vowels /i u/ (11), which eventually leads to the merger of /d/ and /z/ before /i u/ in Modern Japanese (see Section 2.4.5).

(11) a. t → ts / __ u

t → tʃ / __ i

b. d → dz / __ u

d → dʒ / __ i

2.4.4.3 Vowels

In LMJ, there are five short vowels /a i u e o/ (same as in EMJ), four long vowels /ii uu oo ɔɔ/ and four diphthongs /ai ui ei oi/. The bound moraic nasal vowels /ĩ ũ/ are lost in the phonemic inventory by merging with the oral vowels /i u/ and nasality is no longer distinctive in vowels. New long vowel sequences /oo/ and /ɔɔ/ are introduced into the language through monophthongisation of the diphthongs of the shape /Vu/. The changes of each diphthong are listed in (12).

(12) Early Middle Japanese > Late Middle Japanese

/iu/	>	/juu/
/eu/	>	/joo/
/au/	>	/ɔɔ/
/ou/	>	/oo/

According to the Christian sources[13], [ɔ:] (< /au/) is a round vowel and pronounced with a phonetic onglide [^{w}ɔ:] in syllable initial position. There are different proposals for the phonemic representation of [ɔ:]. One proposal is to analyse it as a realisation of /aa/. However, this analysis cannot account for the lip rounding and the phonetic onglide of [ɔ:], since /a/ is not a round vowel. An alternative is to analyse [o:] and [ɔ:] as underlying /au/ and /ou/. However, in the first part of Modern Japanese, [ɔ:] merges with [o:], and [o:] is phonemically /oo/ in present-day Modern Japanese. The language is clearly in the process of diachronic monophthongisation and it would seem unnatural to analyse [o:] in LMJ as /ou/ and in Modern Japanese as /oo/. This study adopts the proposal of /ɔɔ/ as the underlying form of [ɔ:], but this analysis entails introducing the new vowel /ɔ/ into the phonemic inventory of Japanese. The vowel /ɔ/ only survives in the language for a short period of time until early Modern Japanese. Table 23 shows the phonological features for /ɔ/ and the other two back vowels /o a/ for comparison. The phoneme /ɔ/ only exists in the form of the long vowel /ɔɔ/.

Table 23 Phonological features of LMJ back vowels /ɔ a o/.

LMC vowel phonemes		a	ɔ	o
ARTICULATOR	[LABIAL]		✓	✓
	[CORONAL]			
	[DORSAL]	✓	✓	✓
TONGUE HEIGHT	[HIGH]			
	[LOW]	✓	✓	

As in EMJ, the front vowels /i e/ cause the preceding consonant to be palatalised (13). This is also shown by the glide /j/ in /juu/ (< /iu/) and /joo/ (< /eu/).

[13] From the middle of the sixteenth century to the middle of the nineteenth century, Jesuits carried out missionary work in Japan, created and disseminated an extensive range of materials, including grammar books and dictionaries. The books and other items made by the missionaries and their Japanese collaborators are called 'kirishitan shiryo' in Japanese, which means 'Christian materials.' Some examples of these Christian sources include 'Feiqe Monogatari' (1593), 'Esopo no Fabulas' (1593), 'Arte da Lingua de Japam' (1604-1608), and 'Dictionarium Sive Thesauri Linguae Iaponicae Compendium' (1632).

(13) C → C^j / __ {i e} ([VOCALIC CORONAL]).

2.4.4.4 Syllable and word structure

During EMJ, /w/ is lost before /i e/ in word internal position by 1100 CE. The distribution of /w/ becomes further limited through changes at later periods. During LMJ, word initial /w/ before /i e/ and word medial /w/ before /i e/ that has newly entered the language is lost by 1300 CE (14a), leaving /w/ only before /a/. The free moras /kwe/ and /gwe/ that are introduced by Sino-Japanese words in EMJ merge with /ke/ and /ge/ respectively in LMJ. After the monophthongisation of /au/ > /ɔː/, syllable initial /w/ is lost before /ɔɔ/ (14b), but retained in /kwɔː/ (< /kwau/).

(14) a. w > Ø / __ {i, e}

b. w > Ø / __ ɔː

Through the sound change of /iu/ > /juu/ and /eu/ > /joo/, the syllable onset /Cj-/ which is reintroduced to Japanese through Sino-Japanese in the EMJ period enters the native vocabulary, e.g. /kjoo/ ‘today’. The syllables /kwa/ and /gwa/ are widespread but still restricted to Sino-Japanese words, e.g. /kwasi/ ‘dessert’. Syllable final /-t/ in Sino-Japanese words in EMJ still exist but it is in the process of acquiring an epenthetic vowel.

The syllables in LMJ are shown in Table 24.

Table 24 Syllables in LMJ

Free moras																Bound moraic phonemes		
a	i	u	e	o												-i		
ka	ki	ku	ke	ko	kja		kjo	kwa	kuu	koo	kɔɔ	kjuu	kjoo	kjɔɔ	kwɔɔ	-N	-O	-t
ga	gi	gu	ge	go	gja		gjo	gwa	guu	goo	gɔɔ	gjuu	gjoo	gjɔɔ				
sa	si	su	se	so	sja	sju	sjo		suu	soo	sɔɔ	sjuu	sjoo	sjɔɔ				
za	zi	zu	ze	zo	zja	zju	zjo		zuu	zoo	zɔɔ	zjuu	zjoo	zjɔɔ				
ta	ti	tu	te	to	tja		tjo		tuu	too	tɔɔ	tjuu	tjoo	tjɔɔ				
da	di	du	de	do	dja		djo		duu	doo	dɔɔ	djuu	djoo	djɔɔ				
na	ni	nu	ne	no	nja		njo		nuu	noo	nɔɔ	njuu	njoo					
pa	pi	pu	pe	po	pja				puu	poo	pɔɔ		pjoo	pjɔɔ				
ba	bi	bu	be	bo	bja					boo	bɔɔ	bjuu	bjoo	bjɔɔ				
fa	fi	fu	fe	fo	fja		fjo		fuu	foo	fɔɔ	fjuu	fjoo	fjɔɔ				
ma	mi	mu	me	mo	mja				muu	moo	mɔɔ		mjoo	mjɔɔ				
ja		ju		jo					juu	joo	jɔɔ							
ra	ri	ru	re	ro	rja		rjo		ruu	roo	rɔɔ	rjuu	rjoo	rjɔɔ				
wa																		

2.4.5. Modern Japanese

2.4.5.1 Historical background and sources

From OJ to LMJ, the capital of Japan was in the western Kansai region, and the official language was based on the Kyoto variety. Since the Edo period, the capital of Japanese moved to Edo, present-day Tokyo, in the eastern Kanto region. Tokyo was a small castle town at the beginning of the period and it developed into a lively urban setting through immigration. The Edo period is famous for the great local dialect diversity throughout Japan. Kyoto Japanese remained the variety of high culture and prestige during the Edo period and was used as the common language form among elites and groups with high social status at the beginning of the period. The emerged Edo Japanese was largely based on the Kyoto common language form but also had influences from the contacts between the local varieties in the urban context. Edo Japanese was used by the middle and upper class in Tokyo. The differences between Edo-based and Kyoto-based Japanese slowly developed but the speakers of the two varieties continued to form a single coherent large speech community with internal variations.

The Meiji period is a period of political unification and effort was also put into the alignment of the spoken and written forms of the language, as well as the establishment of a standard national language. Written Japanese at the time involved the classical written form and did not directly reflect the contemporary vernacular. A reformation took place and by the mid 1910s the vernacular written form that shows directly the contemporary spoken language started to be adopted in public domain and helped with spreading literacy. The writing system of Modern Japanese uses a combination of *kanji*, *hiragana* and *katakana* scripts. *Kanji* is used for Sino-Japanese and native lexical words, *hiragana* is used for lexical words as well as grammatical elements, and *katakana* is primarily used for loanwords from languages apart from Chinese.

Along with the modernisation of Japan and the reformation of the written language form in the Meiji period was the standardisation of the national language. Between 1900 and 1920, a language standardisation process took place. The common language in Tokyo spoken by the educated middle and upper class was picked as the base of the national language and the normative grammar was set out through the publication of grammar books. The national language, Modern Japanese, shows relatively few differences from the Kyoto-based LMJ. Most of the features in Modern Japanese are fairly straightforwardly derived from LMJ and the rest of the small number of features reflect influences from the local eastern varieties. The language did not change much since the standardisation in the Meiji period.

There are a large number of sources for Modern Japanese, both written in the Classical and post-Classical Japanese from the Edo period, and written in the newly established written norm in Japanese scripts and alphabetic writing from the Meiji period onwards.

2.4.5.2 Consonants

The phoneme /f/ in LMJ that derives from /p/ in EMJ has delabialised and become /h/ in Modern Japanese, e.g. /fana/ > /hana/ ‘flowers’. The labio-dental phoneme /f/ thus disappears and the replacing glottal /h/ enters the phonemic inventory of Modern Japanese. The phoneme /h/ has the features [CONSONANTAL OBSTRUENT RADICAL]. When /h/ occurs before /u/, however, the phonetic realisation of /fu/ [ɸɯ] is kept.

The assibilation of /d/ before the high vowels /i u/ during late LMJ, (11b), repeated here as (15), results in the merger of the phonemes /d/ and /z/ before the high vowels /i u/. The sibilant phoneme /z/ is kept as the underlying phoneme (16a) and /zi zu/ take on the surface forms of /di du/ respectively (16b).

(15) d → dz / __ u

d → dʒ / __ i

(16) a. d > z / __ [VOCALIC CORONAL]

b. /zu/ [dzu ~ zu] ; /zi/ [dʒi]

The allophonic variations of the consonants in Modern Japanese are summarised in (17). Voiceless plosives are aspirated in production. The surface realisations of /s/ [ʃ] and /h/ [ç] are the result of palatalisation before /i j/ ([coronal high]), the surface realisations of /t/ [ts] and /z/ [dz] are the result of affrication before /u/, and the surface form of /t/ [tʃ] and /z/ [dʒ] before /i, j/ are caused by both palatalisation and affrication. The intervocalic realisation of /g/ as [ŋ], is in the process of disappearing.

(17) /p/ → [p^h]

/t/ → [t^h] / __ {e, a, o}

[ts] / __ u

[tʃ] / __ {i, j}

/k/ → [k^h]

/s/ → [s] / __ {e, a, o, u}

[ʃ] / __ {i, j}

/h/ → [h] / __ {e, a, o}

[ɸ] /__ u

[ç] / __ {i, j}

/g/ → [g] / # __

[ŋ] / V __V

/z/ → [z] / __ {e, a, o}

[z, dz] / __ u

[dʒ] / __ {i, j}

2.4.5.3 Vowels

In early Modern Japanese, the long vowel /ɔɔ/ merges with /oo/, e.g. /tɔɔto-/ > /tooto-/ 'precious'. The vowel /ɔ/ is no longer in the phonemic system, leaving the five vowels /a i u e o/ that are in the language since OJ in Modern Japanese.

The diphthong /ei/ is monophthongised as /ee/ phonemically, e.g. /sensei/ > /sensee/ 'teacher'. The other diphthongs with the shape /Vi/ (/ai oi ui/) are phonetically monophthongised in casual speech, e.g. /samui/ [sami:] 'cold', but phonemically remain diphthongs. The long vowel /aa/ exists in expressive forms and the distal adverb /aa/ 'that way'. Thus, in Modern Japanese, all five vowels occur in long vowel forms /aa ii uu ee oo/. This study adopts the bound moraic vowel /-V/ as a length phoneme to represent long vowels phonemically, e.g. /aV/ → /aa/; /oV/ → /oo/; /eV/→ /ee/.

The diphthong sequence /Vu/ that is lost through monophthongisation in LMJ is reintroduced into the language. The monophthongisation rule cease to apply to the nonpast of -w- based verbs. For example, the verb /aw-/ 'meet' has the nonpast /au/ instead of /oo/ in Modern Japanese. Loanwords from European languages also brings back the /Vu/ sequence, e.g. /mausu/ 'mouse'.

The mid vowels /e o/ are pronounced with an onglide in syllable initial position [.ʲe .ʷo] since EMJ. These phonetic onglides are lost in Modern Japanese. The palatalisation of the consonant before /e/ is also lost, leaving consonant being palatalised only before the high front vowel /i/ (as shown by the allophones in (17)).

As introduced in Section 2.4.3.3, the lip rounding of the high back vowel /u/ remained intact until LMJ. From Modern Japanese, /u/ lost the lip rounding and surfaces as [ɯ] (Miyake, 2003).

2.4.5.4 Syllable and word structure

The syllables in Modern Japanese are shown in Table 25. Some allophones are recently phonemicised through the adaptation of loanwords. These new phonemic changes are not reflected in the table. The loss of the free moras /di du/ as shown in the table is the result of the merger of /z/ and /d/ before the high vowels /i u/. The bound mora nasal /N/ is realised as a unreleased velar [ŋ] or uvular [N] nasal in word final position. The bound mora /-t/ is lost and Sino-Japanese loanwords that have a final /-t/ in LMJ acquire epenthetic vowels in Modern Japanese.

Table 25 Syllables in Modern Japanese

Free moras								Bound moraic phonemes		
a	i	u	e	o				-V	-i	-u
ka	ki	ku	ke	ko	kja	kju	kjo	-N	-O	
ga	gi	gu	ge	go	gja	gju	gjo			
sa	si	su	se	so	sja	sju	sjo			
za	zi	zu	ze	zo	zja	zju	zjo			
ta	ti	tu	te	to	tja	tju	tjo			
da			de	do						
na	ni	nu	ne	no	nja	nju	njo			
pa	pi	pu	pe	po	pja	pju	pjo			
ba	bi	bu	be	bo	bja	bju	bjo			
ha	hi	hu	he	ho	hja	hju	hjo			
ma	mi	mu	me	mo	mja	mju	mjo			
ja		ju		jo						
ra	ri	ru	re	ro	rja	rju	rjo			
wa										

The loss of the glide /w/ before /o i e/ in EMJ and early LMJ leave /w/ only before /a/ at the second half of LMJ. In Modern Japanese, /w/ is lost before /a/ in syllable internal position, as shown in (18). The free moras /kwa/ and /gwa/ that are widespread within Sino-Japanese words merge with /ka/ and /ga/, e.g. /kwaiwa/ > /kaiwa/ 'conversation'.

(18) w > Ø / C __ a

2.5 Summary

This chapter introduces the periodisation of Chinese and Japanese, the sociolinguistic settings of the three periods of language contact, and the *Featurally Underspecified Lexicon* model. It then presents phonological analyses of Chang'an LMC, OJ, MJ and Modern Japanese. The chapter provides the necessary background for the analyses and discussions in the forthcoming chapters.

Chapter 3 Corpus study

This thesis investigates the adaptation of Sino-Japanese *kan-on*. The source language is Late Middle Chinese (LMC) and the borrowing language is Early Middle Japanese (EMJ). This chapter first presents a literature review of previous corpus studies, discusses a loanword study on Sino-Japanese coda adaptation in detail, and proposes an alternative analysis. Then, it presents the current corpus study by introducing the database assembled and discussing the findings from two corpus analyses. The first analysis focuses on the segmental adaptation of Chinese initial consonants, and the second analysis examines the structural adaptation of Chinese coda consonants.

3.1 Survey of corpus studies

While there is a large body of research on the adaptation of Western loanwords in Japanese (e.g. Kubozono, 2015), there is a very limited number of studies on Sino-Japanese in the field of loanword adaptation. Most studies on Sino-Japanese either focus on the characteristics of the Sino-Japanese stratum in the Modern Japanese lexicon (e.g. Ito & Mester, 2015) or look at Sino-Japanese from philological and textual analysis perspectives (e.g. Miyake, 2003). Heffernan (2007) is one of the very few studies on Sino-Japanese that addresses the phonetics vs phonology debate in the loanword literature. His study focuses on the relation between the introduction of markedness to the phonology of the borrowing language and the sociolinguistic setting at the time of adaptation. It compares the adaptation of codas in Sino-Japanese *go-on*, *kan-on*, *to-on* and modern-day loans, with a focus on the nasal codas. His study is different from the current study in that the current corpus analysis focuses on a single synchronic stage, Sino-Japanese *kan-on,* instead of making diachronic comparisons. It also investigates both the initial and coda consonant adaptations. The corpus analysis on coda adaptation (Section 3.4) closely examines the adaptation of all consonants (as opposed to just nasals) and investigates vowel epenthesis in depth.

In the following two sections, I first review the findings and conclusion in Heffernan (2007), and then provide an alternative interpretation to account for the data observed in his study.

3.1.1 Sino-Japanese coda: Heffernan's (2007) analysis

A summary of the findings in Heffernan (2007) is shown in Table 26. What particularly interests him is the adaptation of nasal codas. All varieties of Chinese have nasal codas but they are adapted into Japanese by different strategies at different period. Heffernan attributes the different strategies in the adaptation of nasal codas to the degree of bilingualism in the speech community of the borrowing language. The higher the degree of bilingualism, the more likely a contrast in the source language is preserved.

Table 26 Summary of the adaptation of Chinese codas in Sino-Japanese in Heffernan (2007: 70). /N/ stands for a nasal phoneme that is not specified for place, i.e. bound moraic nasal.

Pre-Old Japanese						
Chinese codas	[p]	[t]	[k]	[m]	[n]	[ŋ]
Sino-Japanese adaptations	[pu] or Ø	[tu] or Ø	[ku] or Ø	[mu] or Ø	[nu] or Ø	[gu] or Ø
Old Japanese to early Early Middle Japanese						
Chinese codas	[p]	[t]	[k]	[m]	[n]	[ŋ]
Sino-Japanese adaptations	[pu]	[ti] or [tu]	[ku] or [ki]	[mu]	[N]	[ũ] or [ĩ]
Late Early Middle Japanese to Late Middle Japanese						
Chinese codas	[m]	[n]	[ŋ]			
Sino-Japanese adaptations	[N]	[N]	[N]			
Modern Japanese						
Chinese codas	[n]	[ŋ]				
Sino-Japanese adaptations	[N]	[N]				

During the Pre-Old Japanese (Pre-OJ) period, Japanese has limited contact with Chinese. Pre-OJ does not allow codas. In adapting Chinese loanwords, Pre-OJ either deletes the word-final Chinese codas, or borrows them with the addition of an epenthetic vowel nucleus. The adapted Chinese phonemes are re-syllabified as onsets of the second syllable. Pre-OJ has the phonemes /m n/, but not the velar nasal /ŋ/. The bilabial and dental nasal codas are adapted as [mu nu], and the velar nasal is adapted as the homorganic obstruent followed by a vowel [gu].

From Old Japanese (OJ) to early EMJ, Japan has extensive contact with China, resulting in a high level of bilingualism in the Japanese community, especially among the elites. All three Chinese nasal codas at this period are treated consistently differently. Early EMJ develops the phonemic bound moraic nasal /N/, i.e. a nasal coda phoneme that is underspecified for PLACE. The labial nasal is adapted in the same way as in the previous period – by the addition of an epenthetic vowel [mu], the dental nasal is adapted as the bound moraic nasal [N], and the velar nasal is adapted as the nasalised vowel [ũ] or [ĩ]. The three-way phonemic contrast of the nasals in Chinese is maintained in Japanese. Heffernan assumes that the phonemic inventory of Japanese at this period does not contain nasalised vowels, and the adaptation of Chinese velar nasals as nasalised vowels introduces markedness into the Japanese phonemic inventory. In Heffernan's analysis, the consistent preservation of the Chinese coda contrasts at this historical period is due to the high degree of bilingualism in the Japanese community. Source varieties of Chinese enjoy the prestigious status and EMJ speakers have more pressure to preserve the non-native phonemic contrasts in the source language.

As the degree of bilingualism declines from the second half of the EMJ period, the place contrasts of Chinese nasal codas are no longer preserved. All the Chinese nasal codas are adapted as the late EMJ moraic nasal [N].

Heffernan (2007) does an additional study on the adaptation of English nasal codas in Modern Japanese and finds that the three-way place contrast between the English coda phonemes /m n ŋ/ is preserved – English /m/ is adapted as [mu], /n/ is adapted as [N], and /ŋ/ is adapted as [ŋgV]. Although these repair strategies are available in Modern Japanese, the language choses to merge the Chinese phonemic contrasts between /n ŋ/, e.g. the two nasals in Chinese /ʂantuŋ/ (the name of a province) are both adapted as /N/ in Japanese /saNtoN/. The comparison of the adaptation pattern for different source languages further supports the argument that the adaptation strategy depends heavily on the social relationship between the source and borrowing languages. In modern day Japan, no special relation is maintained with the Chinese language, whereas English is taught in formal education and considered as the prestigious language.

Heffernan's (2007) analysis supports and complements the literature that addresses the relation between the rate of bilingualism and phonological adaptation (Paradis & LaCharité, 2008; Chang, 2008; Kang & Schertz, 2020). However, there are a few issues that the study does not address. Firstly, the author provides the source of the data but does not indicate the size of the corpora, or the degree of consistency for each adaptation. Secondly, in the diachronic comparison, the author discusses the phonemic inventory of different varieties of the source language Chinese but does not take into account the internal diachronic changes of the borrowing language Japanese. Only the phonemic inventory of OJ is discussed, with a brief mentioning that the addition of the bound moraic nasal /N/ in the phonemic inventory happens "at some point" in history (Heffernan, 2007: 66). Finally, in the synchronic comparison of Chinese and English loanwords in Japanese, the study does not consider the difference in the source of loanwords – whether the input is auditory or orthographic. I present below an alternative interpretation of the data pattern observed.

3.1.2 Current analysis

The current analysis proposes that the differences in adaptation strategies at different time periods are not indications of phonetic or phonological preferences conditioned by the rate of bilingualism, but rather reflections of the underlying contrasts in the native phonology. Adaptations are constrained by the phonology of the native language, and the structure of

Sino-Japanese loanwords in each substratum reflects the phonological grammar of Japanese at different historical periods.

Japanese has more contrasts in its underlying phonemic inventory in EMJ than in the earlier or later periods. As introduced in Section 2.4.3.2, the *onbin* sound change takes place during the transition from OJ to EMJ and introduces bound moraic segments into the phonemic inventory of Japanese. This sound change is significant in Japanese historical phonology as it is one of the major phonological changes that differentiates OJ and Modern Japanese. There are different views on the phonological shape of the segments resulted from the sound change. According to the traditional Japanese linguistic academia (e.g. Okumura, 1980; Kawamoto, 1977), the outcomes of *onbin* are four bound moraic segments: the high front vowel /i/, high round back vowel /u/, the nasal /N/ and the obstruent /O/. Under this view, nasal vowels are only surface variants of the oral vowels but never part of the phonemic inventory in Japanese. Frellesvig (1995) provides a different perspective that is couched within the European semiotic-structuralist theory. According to his analysis, three bound moraic consonants /C O N/ and four bound moraic vowels /i u ĩ ũ/ enters Japanese phonemic inventory through the *onbin* sound change. Based on this view, the nasal vowels /ĩ ũ/ are already phonemes in EMJ at the time of the adaptation, and Chinese loanwords do not introduce new phonemes into the native language. The *onbin* sound change took place between the late 8th and early 10th century (the transition from OJ to EMJ), during the second period of language contact between Japanese and Chinese. At the synchronic stage of the *onbin* sound change, Chinese was spoken as a foreign language and there was a high level of bilingualism. Sino-Japanese, the standard for the nativization of Chinese, was only established towards the very end of the EMJ period (Frellesvig, 2010), when there was a large number of integrated Sino-Japanese loanwords entering Japanese texts. The *onbin* sound change predates the intake of loanwords. Evidence from other languages, e.g. Swiss

German initial geminates, Bengali retroflex stops and English voiced fricatives, have shown that it is in fact difficult for loanwords to introduce brand new phonemes into another language unless it is under special circumstances (Kennard & Lahiri, 2020).

Table 27 shows a summary of the *onbin* sound change for vowel *onbin* forms according to Frellesvig's (2010) analysis. The PLACE feature of the vowel is conditioned by the onset consonant (C) or the nucleus vowel (V) of the original CV syllable. When the onset consonant is [LABIAL] /p ^{m}b m/, the resultant vowel *onbin* form is [LABIAL] /u/ or /ũ/ regardless of the PLACE of the nucleus vowel in the original syllable. When the onset consonant is [DORSAL] /^{ŋ}g k/, the resultant vowel *onbin* form takes on the same PLACE as the nucleus vowel in the original syllable. Syllables with [CORONAL] onset consonant do not give vowel *onbin* forms. This pattern is summarised in Table 28. The nasality of the *onbin* vowel is conditioned by the consonant (C) in the original CV syllable and the position of the CV syllable in the word. When C is a voiceless obstruent /p k/, the syllable gives oral *onbin* vowels in all positions; when C is a prenasalised obstruent or a nasal /^{m}b ^{ŋ}g m/, the syllable gives oral *onbin* vowels in morpheme internal positions and nasal *onbin* vowels in morpheme final and word final positions.

Table 27 The Onbin *sound change - a summary of the changes of CV syllables to bound moraic vowels (adapted from Frellesvig 2010: 195). The nasalised bound moriac vowels are marked in bold.*

Source CV syllable	Position	Bound moraic vowel
pi, pu	morpheme internal	u
	morpheme final, word internal	u
	word final	u
ku	morpheme internal	u
	morpheme final, word internal	u
	word final	u
ki	morpheme internal	i
	morpheme final, word internal	i
	word final	i
^{m}bu, ^{m}bi, mi, mu, ^{ŋ}gu	morpheme internal	u
	morpheme final, word internal	**ũ**
	word final	**ũ**
^{ŋ}gi	morpheme internal	i
	morpheme final, word internal	**ĩ**
	word final	**ĩ**

Table 28 Feature preservation in the onbin sound change. Features being kept into the onbin form are marked in bold and shaded in green.

C	V	*Onbin* V
[LABIAL]	[CORONAL]	**[LABIAL]**
[LABIAL]	[LABIAL]	**[LABIAL]**
[DORSAL]	**[CORONAL]**	**[CORONAL]**
[DORSAL]	**[LABIAL]**	**[LABIAL]**
[CORONAL]	[CORONAL]	

After the expansion of structure and contrasts in EMJ, there is a gradual reduction in forms and processes, including nasality, from the end of the period onwards. As discussed in Sections 2.4.4 and 2.4.5, the bound moraic nasal vowel phonemes /ĩ ũ/ are lost in Late Middle Japanese (LMJ), and the prenasalisation of obstruents [ᵐb ⁿd ᵑɡ ⁿz] is in the process of disappearing by the end of LMJ, and eventually disappears in early Modern Japanese. Other changes in the language include monophthongisation of /iu eu au ou/ (>/juː joː ɔː oː/), merger of the phonemes /d/ and /z/ before high vowels /i u/, and loss of consonant palatalisation before /e/.

The diachronic phonological change in Japanese is closely related to the data pattern in Heffernan (2007). During the period from OJ to EMJ when the language is adapting the three-way contrast of Chinese nasal codas /m n ŋ/, the language is also undergoing the *onbin* sound change. The instabilities of the syllables and the introduction of bound moraic phonemes at this period give the language more options in adapting foreign forms. If we assume the nasal vowels as underlying phonemes as suggested by Frellesvig, the adaptation of the Chinese [DORSAL] nasal [ŋ] as /ũ/ or /ĩ/ does not introduce new phonemes to the language. The adaptation process is similar to the *onbin* sound change of CV syllables with prenasalised dorsal obstruent [ᵑɡi ᵑɡu]. Through adaptation, the [DORSAL] consonant [ŋ] is deleted and the [NASAL] feature reassociates with the epenthetic vowel (Table 27 & 28). Whether the Chinese [ŋ] is adapted as /ũ/ or /ĩ/, and the other Chinese [DORSAL] coda [k] as [ku] or [ki] (Table 26) is discussed and analysed in details in Section 3.4 below. From LMJ onwards, the *onbin* sound change is fully concluded and the nasal vowels /ĩ ũ/ later merge with the oral vowels /i u/. LMJ has a more stable phonemic inventory, less form changes and less underlying contrasts. Therefore, it adapts all Chinese nasal codas from this period onwards as the bound moraic nasal /N/.

If we assume no underlying nasal vowels according to the Japanese linguistics analysis tradition, the adaptation pattern can still be explained by the different degrees of contrasts in the native language. The external language contact and nativization of loanwords take place simultaneously with the internal *onbin* sound change. While EMJ is in the process of developing new phonemes through the sound change, it is also more open to the introduction of new phonemes through external contact. In LMC, the loss of prenasalisation in obstruents results in the loss of nasality spreading to the preceding vowel. There is a drastic decrease of nasalised vowels in the surface phonetic. LMJ is in general reducing its phonological forms and processes, and therefore less open to accept foreign forms. All nasal codas from this period are adapted as the bound moraic /N/.

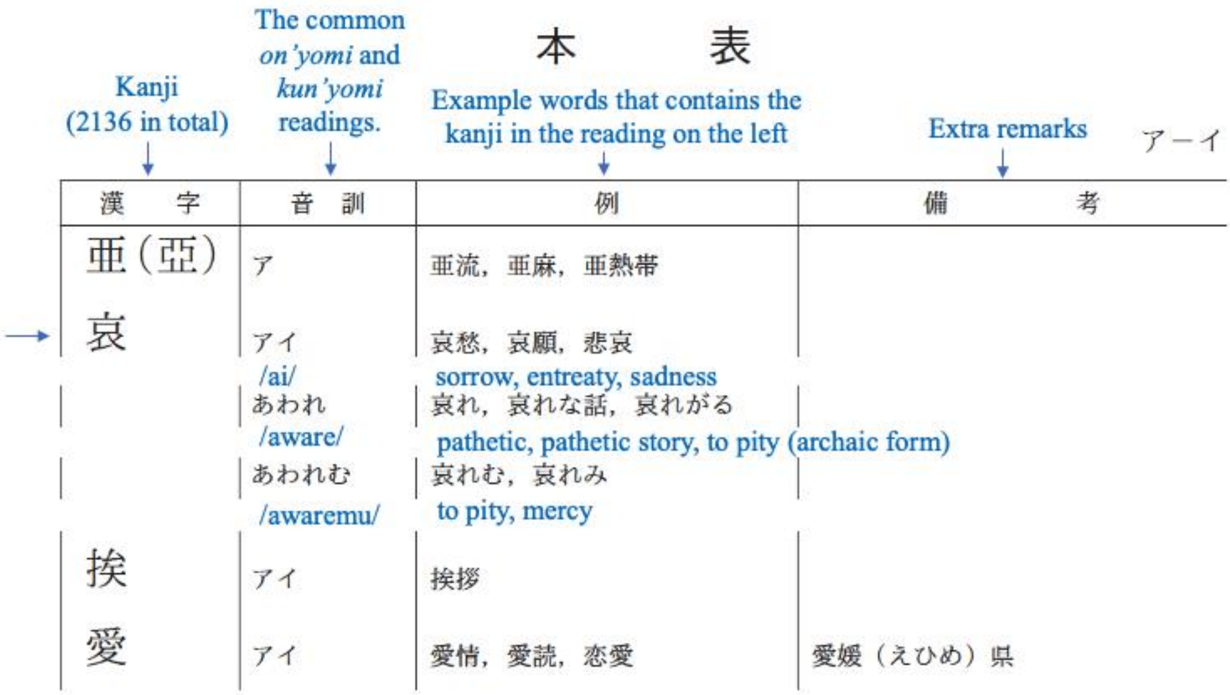
The different adaptation strategies for English and Chinese nasal codas in Modern Japanese could be a result of the differences in the media that loanwords are introduced through and the process of standardisation. Dohlus (2005) analyses the differences between the adaptation of the front rounded vowels /œ/ and /ø/ in German and French, and finds that French loanwords are used widely in the oral domain which leads to perceptual approximations, whereas German loanwords comes into Japan via the written form and education, and go through later standardisation, resulting in the preservation of more phonemic contrasts and highly conventionalised forms. In the systematic study of Western loanwords in Japanese, Irwin (2011) shows that the Modern Japanese community is mainly monolingual and English enters the language primarily through orthography. Due to its notoriously opaque spelling, English words are usually assigned dictionary pronunciations, and adaptations follow prescribed strategies in the conventionalised dictionary traditions. Chinese, in contrast, entered Japan first through the oral domain, and then the readings of kanji went through standardisation in the Edo period during early Modern Japanese. The difference between these dictionary prescribed adaptation strategies is said to be the reason for the different adapted forms of /ŋ/ in Chinese and Korean loanwords (/N/) on one hand and in Western loanwords (/Ng/) on the other.

This alternative analysis of the data in Heffernan (2007) proposes that when loanwords are introduced orally instead of orthographically, adaptations are driven by underlying phonological contrasts and phonotactics of the borrowing language. Whether a contrast in the source language is preserved depends on the phonemic contrasts and phonotactic constraints of the borrowing language (Lahiri & Kennard, 2019; Kim, 2008, 2009).

3.2 Database

A broad statistical basis is needed to study the adaptation of Sino-Japanese *kan-on.* This study assembles a kanji reading database based on the 2136 kanji from the *Jōyō-Kanji* list (see Section 1.2; the list of Chinese characters designated for everyday use issued by the Japanese Ministry of Education). The list includes kanji and their commonly used readings in Modern Japanese. The readings listed are in both *on'yomi* and *kun'yomi*, and the *on'yomi* could be from any substrata from Sino-Japanese that end up becoming the commonly used forms. An excerpt of the *Jōyō-Kanji* list is shown in Figure 8, with an annotated example for the kanji '哀'. The 2136 kanji are listed in the right column, the second column shows the common *on'yomi* and *kun'yomi* readings, the third column has the example words or phrases that contain the kanji in the reading on the left, and the last column are the extra remarks. Many Chinese characters are homographs – they have different pronunciations for different meanings. The adapted kanji therefore also has different Sino-Japanese readings for each meaning. Take the kanji ‘哀’ as an example. It has three common *on’yomi* and *kun’yomi* readings. When it is read /ai/, it can be used in words such as ‘sorrow’, ‘entreaty’, ‘sadness’; when it is read /aware/, it can be used in words and phrases such as ‘pathetic’, ‘pathetic story’, ‘to pity’; when it is read /awaremu/, it can be used in words and phrases such as ‘to pity’, ‘mercy’. The database in this study includes all different meanings and readings of the homographs. For a small number of kanji in the *Jōyō-Kanji* list, the *kan-on* reading is not in the list – it is not the most commonly used reading that survived into the modern day. The database is based on the kanji in the *Jōyō-Kanji* list instead of the readings in the list, which means some kan-on readings for the listed kanji that are not in the list are also included. Each kanji is matched with its source Chinese reading(s) and Sino-Japanese *kan-on* reading(s) in the database. The reconstructed source forms in LMC are based on Pulleyblank’s (1991) lexicon list with modification as discussed in Section 2.3.4. The *kan-on* readings of the kanji are taken from the *Shinsen Kanwa Jiten* Sino-Japanese Dictionary (Kobayashi, 2011). The web version of the dictionary can be accessed online through JapanKnowledge Lib (2023), a web archive holding an extensive collection of encyclopaedias, dictionaries, reference materials, and periodical sources in Japan. The dictionary marks out all kanji from the *Jōyō-Kanji* list, and for each kanji it includes readings in all substrata of Sino-Japanese, including historical readings. For those kanji that have both a modern day *kan-on* reading and a different historical *kan-on* reading in the dictionary (as shown in Section 1.2 Figure 1, the historical readings are in brackets), only the historical readings are included in the corpus, because the study is concerned with the readings at the time of the adaptation, rather than the modern day Sino-Japanese stratum.

Figure 8 An excerpt of the Jōyō-Kanji list 「常用漢字表」 with an annotated example for the kanji '哀' in English.



漢　字	音　訓	例	備　考
亜（亞）	ア	亜流，亜麻，亜熱帯	
哀	アイ	哀愁，哀願，悲哀	
	あわれ	哀れ，哀れな話，哀れがる	
	あわれむ	哀れむ，哀れみ	
挨	アイ	挨拶	
愛	アイ	愛情，愛読，恋愛	愛媛（えひめ）県

It has been argued that there are some discrepancies between the Sino-Japanese readings documented in dictionaries and the actual readings at the time of the borrowing. Some of the recorded readings in Sino-Japanese dictionaries (*Kanwa Jiten*) were prescribed by lexicographers through the study of Chinese phonology later in history. To prescribe the standard readings for Sino-Japanese *kan-on*, scholars studied the Chinese rhyme table, *Yunjing*. Numoto (1993) lists the differences between early uses and entries in Sino-Japanese dictionaries. However, the artificial readings mainly affect syllable rimes, especially vowels, in less frequently used kanji. The current study focuses on initial consonants and codas in frequently used kanji so prescribed readings are not expected to have a significant influence on the data, result and analyses.

Another type of Sino-Japanese reading that is listed in dictionaries, in addition to *go-on*, *kan-on* and *to-on*, is called *kan'yo-on* 'customary pronunciation'. It is believed that many actual *go-on, kan-on* and *to-on* kanji pronunciations used in history are preserved in *kan'yo-on* (Numoto, 1993). However, this database does not include any *kan'yo-on* 'customary pronunciation' for the following reasons: (1) it is unclear for each particular *kan'yo-on* which Sino-Japanese substrata or Chinese source form it is based on, (2) not every kanji has *kan'yo-on* in the dictionary, so it is not consistent, (3) there is no evidence regarding which *kan'yo-on* represents the actual pronunciation and which does not.

Two systematic corpus analyses are performed with this database. Section 3.3 presents the initials adaptation analysis and Section 3.4 discusses the data from the coda adaptation.

3.3 Initial consonant adaptation

3.3.1 Initial consonants in Chang'an Late Middle Chinese and Early Middle Japanese

The phonology of the source language Chang'an LMC and the borrowing language EMJ are discussed in Section 2.3.4 and Section 2.4.3 respectively. Both languages allow CG syllable onsets. This analysis focuses on the initial consonant C instead of the CG onset sequence because (1) in historical Chinese phonology, onset glides are listed as part of the syllable finals, and their reconstructions are also more controversial, and (2) onset glides in Sino-Japanese are not only adapted from Chinese onset glides but also nucleus vowels, which further complicates the issue.

Table 29 shows a summary of the initial consonant inventories in both languages for the ease of reference. Since both languages allow initial consonants, the adaptation of initials is expected to take place at the segmental level because the Chinese forms do not violate native Japanese phonotactics and trigger any structural change. However, comparing to LMC, EMJ has a much smaller phonemic inventory of initial consonants, and more restrictions at the word initial position – the prenasalised voiced obstruents /^{m}b ^{n}d ^{ŋ}g ^{n}z/ and liquid /r/ in Japanese cannot occur word initially in the native EMJ lexicon. The research question is how EMJ adapts the large number of LMC initials into its smaller phonemic inventory.

Which contrasts from the LMC input are kept and which ones are merged in EMJ? Are there any importations that introduce new phonemes into Japanese?

Table 29 LMC and EMJ initial consonant inventories

Consonants	LABIAL Labial	CORONAL Dental	 Retroflex	DORSAL Palatal/Velar	RADICAL Glottal
Chinese					
Plosive	p p^h pɦ	t t^h tɦ	ʈ $ʈ^h$ ʈɦ	k k^h kɦ	ʔ
Fricative	f fɦ	s sɦ	ʂ ʂɦ ʐ	x xɦ	
Affricate		ts ts^h tsɦ	tʂ $tʂ^h$ tʂɦ		
Nasal	m	n	ɳ	ŋ	
Approximant & Liquid	ʋ	l		(j)	
Japanese					
Non-sibilants	p ^{m}b	t ^{n}d		k ^{ŋ}g	
Sibilants		s ^{n}z			
Nasal	m	n			
Approximant & Liquid	w	r		j	

The analysis takes a distinctive feature-based approach. The feature charts for EMJ and LMC initials are repeated here in Tables 30, 31, 32 for the ease of reference.

Table 30 Feature chart for EMJ initials

EMJ initial consonants		p	^{m}b	t	^{n}d	k	^{ŋ}g	s	^{n}z	m	n	w	j	r
ROOT	[OBSTRUENT]	✓	✓	✓	✓	✓	✓	✓	✓					
	[SONORANT]									✓	✓	✓	✓	✓
	[STRIDENT]							✓	✓					
	[NASAL]		✓		✓		✓		✓	✓	✓			
	[RHOTIC]													✓
PLACE - ARTICULATOR	[LABIAL]	✓	✓							✓		✓		
	[CORONAL]			✓	✓			✓	✓		✓		✓	✓
	[DORSAL]					✓	✓					✓		

Table 31 Feature chart for LMC initial obstruents

LMC Obstruents Phonemes		p	pʰ	pɦ	f	fɦ	t	tʰ	tɦ	s	sɦ	ts	tsʰ	tsɦ	ʈ	ʈʰ	ʈɦ	ʂ	ʂɦ	ʐ	tʂ	tʂʰ	tʂɦ	k	kʰ	kɦ	x	xɦ	ʔ
PLACE	ARTICULATOR & TONGUE HEIGHT	[LABIAL]					[CORONAL]								[CORONAL, HIGH]									[DORSAL]					[RADICAL]
ROOT	[OBSTRUENT]	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
	[STRIDENT]									✓	✓	✓	✓	✓				✓	✓	✓	✓	✓	✓						
CONSTRICTION	[CONTINUANT]				✓	✓				✓	✓							✓	✓	✓							✓	✓	
LARYNGEAL	[VOICE]			✓		✓			✓		✓			✓			✓		✓	✓			✓			✓		✓	
	[SPREAD GLOTTIS]		✓	✓		✓		✓	✓		✓		✓	✓		✓	✓		✓				✓		✓	✓		✓	

Table 32 Feature chart for LMC initial sonorants

LMC Sonorant Phonemes			m	n	ɳ	ŋ	ʋ	l	j
ROOT		[SONORANT]	✓	✓	✓	✓	✓	✓	✓
		[NASAL]	✓	✓	✓	✓			
		[LATERAL]						✓	
PLACE	ARTICULATOR	[LABIAL]	✓				✓		
		[CORONAL]		✓	✓			✓	✓
		[DORSAL]				✓			
	TONGUE HEIGHT	[HIGH]			✓				✓

3.3.2 Statistical analysis

Descriptive statistics are presented to show the consistency of the adaptation for each LMC initial consonant. The number of occurrences for each LMC initial in the database and their adapted Sino-Japanese forms are counted. The adaptation patterns are analysed based on feature matching. The readings of kanji were introduced orally instead of orthographically. The adaptation process involves LMC speakers producing the characters in their native language and EMJ listeners adapting the acoustic input into their native phonology. All phonological features in FUL (Lahiri, 2018) have acoustic correlates. From a feature matching perspective, EMJ speakers extract features from the LMC acoustic input and matched them to the native phonemes.

Two LMC phonemes, /j/ and /ʔ/, are excluded from this analysis. The glide /j/ is not considered an initial in the rhyme tables, as discussed in Section 2.3.4.1. It becomes the first segment in a word only when there is no other initial consonant preceding it. LMC initial /j/ is adapted as glides or front vowels /j w i e/ in Sino-Japanese based on the following phonological context. The glottal stop /ʔ/ in LMC is always ignored in Sino-Japanese and adaptation starts from the segment after /ʔ/.

The statistics for the adaptation of LMC labial obstruent initials in EMJ are shown in Table 33, and the features of the source and adapted phonemes are shown in Table 34. LMC labial plosives of all phonation types – voiceless /p/, voiceless aspirated /p^h/ and voiceless with breathy release /pɦ/ – are all adapted as the EMJ voiceless labial non-sibilant /p/ (185/185 cases). LMC /p/ to EMJ /p/ is a straightforward feature match. EMJ does not have aspiration contrast so the [SPREAD GLOTTIS] feature is ignored in the matching of LMC /p^h/ to EMJ /p/. What is less obvious is the matching between LMC voiceless with breathy release /pɦ/ and EMJ voiceless /p/. LMC /pɦ/ is [VOICE, SPREAD GLOTTIS] whereas EMJ /p/

is neither [VOICE] nor [SPREAD GLOTTIS]. However, the only other EMJ labial non-sibilant /ᵐb/, despite being voiced, is specified for [NASAL]. The prenasalisation of voiced obstruents /ᵐb ⁿd ᵑg ⁿz/ is a prominent property in EMJ. EMJ non-sibilants do not contrast in [VOICE] but [NASAL]. The nasality feature of /ᵐb/ block the voicing matching with LMC /pɦ/. EMJ /p/ ends up being the only candidate for the adaptation of LMC /pɦ/. The adaptation data shown in the rest of this Section below further confirms the consistency of the LMC /Cɦ/ to EMJ voiceless consonant matching pattern.

Table 33 The adaptation of LMC initial labial obstruents in EMJ

Chinese	Cases	Japanese	Cases
/p/	82	/p/	82
/pʰ/	36	/p/	36
/pɦ/	67	/p/	67
/f/	62	/p/	62
/fɦ/	45	/p/	45

Table 34 Features for LMC labial obstruent initials and EMJ /p/

Feature	Phonemes	Chinese					Japanese
		p	pʰ	pɦ	f	fɦ	p
ROOT							
	[OBSTRUENT]	✓	✓	✓	✓	✓	✓
CON							
	[CONTINUANT]				✓	✓	
LAR							
	[VOICE]			✓		✓	
	[SPREAD GLOTTIS]		✓	✓		✓	
PLACE							
ART							
	[LABIAL]	✓	✓	✓	✓	✓	✓

EMJ does not have labial fricative phonemes and it adapted LMC labial fricatives /f fɦ/ as the [LABIAL] non-sibilant /p/ (107/107 cases, Table 34). The [CONTINUANT] feature, like the [SPREAD GLOTTIS] feature, is not required to establish phonemic contrast in EMJ, and therefore being ignored in feature mapping.

Table 35 shows the result for the adaptation of LMC initial coronal obstruents in EMJ. LMC initials have a dental (left) and retroflex (right) contrast within coronals. The retroflexes are specified for tongue height feature [HIGH] while the dentals are not.

Table 35 The adaptation of LMC initial coronal obstruents (dental - left, retroflex - right) in EMJ

Chinese	Cases	Japanese	Cases
/t/	66	/t/	66
/tʰ/	55	/t/	54
		/s/	1
/tɦ/	102	/t/	101
		/d/	1
/s/	106	/s/	106
/sɦ/	42	/s/	42
/ts/	87	/s/	87
/tsʰ/	54	/s/	54
/tsɦ/	61	/s/	61

Chinese	Cases	Japanese	Cases
/ʈ/	47	/t/	46
		/s/	1
/ʈʰ/	8	/t/	8
/ʈɦ/	61	/t/	60
		/s/	1
/ʂ/	102	/s/	102
/ʂɦ/	80	/s/	79
		/ⁿz/	1
/ʐ/	35	/ⁿz/	35
/tʂ/	111	/s/	111
/tʂʰ/	52	/s/	51
		/t/	1
/tʂɦ/	9	/s/	9

There is no contrast within EMJ coronal non-sibilants. Both LMC dentals /t tʰ tɦ/ and retroflexes /ʈ ʈʰ ʈɦ/ of all voicing types are adapted as EMJ voiceless dental /t/ (335/339 cases). According to FUL (Lahiri, 2018), a mapping between the ARTICULATOR feature [CORONAL] is established between LMC retroflexes and EMJ dentals, and the TONGUE HEIGHT feature which is non-contrastive in EMJ is ignored (Table 36).

Table 36 Features for LMC coronal plosive initials and EMJ /t/

Feature \ Phonemes		Chinese						Japanese
		t	tʰ	tɦ	ʈ	ʈʰ	ʈɦ	t
ROOT								
	[OBSTRUENT]	✓	✓	✓	✓	✓	✓	✓
LAR								
	[VOICE]			✓			✓	
	[SPREAD GLOTTIS]		✓	✓		✓	✓	
PLACE								
ART								
	[CORONAL]	✓	✓	✓	✓	✓	✓	✓
TH								
	[HIGH]				✓	✓	✓	

EMJ sibilants do not have contrast within coronal, either. Matches of the [STRIDENT] and [CORONAL] features is established and the TONGUE HEIGHT feature in LMC is ignored (Table 37). LMC voiceless and voiceless with breathy release sibilants at both retroflex /ʂ ʂɦ/ and dental places /s sɦ/ are adapted as EMJ voiceless sibilant /s/ (329/330 cases). The retroflex sibilant /ʂ/ has the alveolo-palatal surface allophone [ɕ]. This surface contrast is not kept either in adaptation. The only LMC fully voiced obstruent initial /ʐ/ is adapted as EMJ voiced prenasalised sibilant /^{n}z/ (35/35 cases). /^{n}z/ is specified for [NASAL] which entails [VOICE] according to the FUL model (See Section 2.4.2.2). As discussed in Section 2.3.4.1, the LMC voiced retroflex fricative /ʐ/ derives from EMC palatal nasal /ɲ/. Throughout the course of the diachronic change, /ʐ/ goes through the stage when it surfaces as [ɲʑ] or [nʑ]. The data seems to indicate that at the time of *kan-on* adaptation, LMC /ʐ/ still has the nasalised surface form so that EMJ speakers adapts it as the prenasalised sibilant /^{n}z/.

Table 37 Features for LMC coronal fricative initials and EMJ /s z/

Feature \ Phonemes		Chinese				Japanese	Chinese	Japanese
		s	sɦ	ʂ	ʂɦ	s	ʐ	^{n}z
ROOT								
	[OBSTRUENT]	✓	✓	✓	✓	✓	✓	✓
	[STRIDENT]	✓	✓	✓	✓	✓	✓	✓
	[NASAL]							✓
LAR								
	[VOICE]		✓		✓		✓	(✓)
	[SPREAD GLOTTIS]		✓		✓			
PLACE								
ART								
	[CORONAL]	✓	✓	✓	✓	✓	✓	✓
TH								
	[HIGH]			✓	✓		✓	

EMJ does not have underlying affricate phonemes, but the sibilants have affricate surface variations when the following vowel is /-a -o -u/ (Section 2.4.2.2). LMC has affricates that have two-way contrasts in PLACE and three-way contrasts in LARYNGEAL (Table 38). All LMC affricate initials were uniformly adapted as EMJ voiceless sibilant /s/ (373/374 cases). Same as for the surface variation of the retroflex sibilant /ʂ/, the alveolo-palatal surface allophones [tɕ tɕ^{h}] of the retroflex affricates /tʂ tʂ^{h}/ respectively are also ignored.

Table 38 Features for LMC coronal affricate initials and EMJ /s/

Feature \ Phonemes		Chinese						Japanese
		ts	ts^{h}	tsɦ	tʂ	tʂ^{h}	tʂɦ	s
ROOT								
	[OBSTRUENT]	✓	✓	✓	✓	✓	✓	✓
	[STRIDENT]	✓	✓	✓	✓	✓	✓	✓
LAR								
	[VOICE]			✓			✓	
	[SPREAD GLOTTIS]		✓	✓		✓	✓	
PLACE								
ART								
	[CORONAL]	✓	✓	✓	✓	✓	✓	✓
TH								
	[HIGH]				✓	✓	✓	

The adaptation of LMC dorsal obstruent initials are shown in Table 39 and the features for the relevant phonemes in LMC and EMJ are given in Table 40. The statistics show the same pattern of adaptation as for the labial initials. LMC dorsal plosives and fricatives are adapted as EMJ voiceless dorsal /k/ (592/592 cases). While there are no fricative phonemes at the dorsal place, EMJ ignores the manner feature [CONTINUANT] and adapts LMC /x xɦ/ as EMJ /k/ which is also [DORSAL].

Table 39 The adaptation of LMC initial dorsal obstruents in EMJ

Chinese	Cases	Japanese	Cases
/k/	247	/k/	247
/kʰ/	86	/k/	86
/kɦ/	58	/k/	58
/x/	71	/k/	71
/xɦ/	130	/k/	130

Table 40 Features for LMC dorsal obstruent initials and EMJ /k/

Feature \ Phonemes		Chinese					Japanese
		k	kʰ	kɦ	x	xɦ	k
ROOT							
	[OBSTRUENT]	✓	✓	✓	✓	✓	✓
	[STRIDENT]						
CON							
	[PLOSIVE]	✓	✓	✓			
	[CONTINUANT]				✓	✓	
LAR							
	[VOICE]			✓		✓	
	[SPREAD GLOTTIS]		✓	✓		✓	
PLACE							
ART							
	[LABIAL]						
	[CORONAL]						
	[DORSAL]	✓	✓	✓	✓	✓	✓

The results for the sonorant initial adaptations are shown in Table 41. The LMC nasal phonemes /m n ɳ ŋ/ that surface as prenasalised obstruents [ᵐb ⁿd ⁿɖ ᵑg] in syllable initial positions are adapted as EMJ prenasalised obstruents /ᵐb ⁿd ⁿd ᵑg/ respectively (212/214 cases).[14] The ARTICULATOR features are maintained in EMJ with a merger of the LMC

[14] As discussed in Section 2.3.4.1, certain rimes with a nasal segment in the coda block denasalisation. For example, the Chinese word 名 is /miajŋ/ and 明 is /mjiajŋ/ in LMC. The Sino-Japanese *kan-on* readings for both words are commonly believed to be /mei/. However, in the *Shinsen Kanwa Jiten* Sino-Japanese Dictionary, both kanji are given the *kan-on* /ᵐbei/, but the *kan'yo-on* (commonly used kanji reading) /mei/. This issue should be looked into further. To keep the data consistent here, all Sino-Japanese *kan-on* readings in the corpus strictly follow the *kan-on* in the *Shinsen Kanwa Jiten* Sino-Japanese Dictionary.

contrast within coronal. The nasal initial adaptation is in contrast with the nasal coda adaptation discussed in Heffernan (2007). When LMC nasals /m n/ surface as real nasals [m n] in codas, they are adapted as EMJ nasal phonemes /m n/ respectively. LMC nasal allophonic variants are mapped to different underlying phonemes in EMJ.

Table 41 The adaptation of LMC initial sonorants in EMJ

Chinese	Cases	Japanese	Cases
[^{m}b]	98	/^{m}b/	97
		/m/	1
[^{n}d]	33	/^{n}d/	33
[^{n}ɖ]	10	/^{n}d/	10
[^{ŋ}g]	73	/^{ŋ}g/	72
		/k/	1
/ʋ/	27	/^{m}b/	27
/l/	134	/r/	134

The features of the relevant phonemes in the adaptation of LMC labiodental approximant /ʋ/ and lateral /l/ are shown in Table 42. EMJ does not have approximant at the labial-dental place but has a labial-velar approximant /w/ which is [SONORANT, LABIAL, DORSAL]. However, EMJ /w/ has limited distribution synchronically and is also in the diachronic change of reduction. EMJ native phonology thus does not prefer adapting LMC /ʋ/ to EMJ /w/. EMJ extracts the [CONSONANTAL] and [LABIAL] features from the LMC acoustic signal and matches them to the same features of the phoneme /^{m}b/ (27/27 cases). The adaptation of LMC labial approximant /l/ to EMJ rhotic approximant /r/ is straightforward (134/134 cases), as shown in Table 42.

Table 42 Features for LMC /ʋ l/ and EMJ /w m ^{m}b r/

Feature \ Phonemes		Chinese	Japanese		Chinese	Japanese
		ʋ	w	^{m}b	l	r
ROOT						
	[CONSONANTAL]	✓	✓	✓	✓	✓
	[SONORANT]	✓	✓		✓	✓
	[NASAL]			✓		
	[RHOTIC]					✓
	[LATERAL]				✓	
PLACE						
ART						
	[LABIAL]	✓	✓	✓		
	[CORONAL]				✓	✓
	[DORSAL]		(✓)			

3.3.3 Discussion

The adaptation of LMC initials in EMJ is highly regular. Each LMC phoneme is matched to a single EMJ phoneme, with very few exceptions (8/2337[15] cases). Section 1.3 introduces the main theories in the loanword adaptation literature. At the two end of the continuum there are the purely phonology theory and the purely phonetic theory. The competing hypotheses are assessed by the data in this study. Table 43 shows a comparison of the predictions of the phonology theory and phonetic theory for the adaptation pattern of Sino-Japanese *kan-on* initials, and the result in this corpus analysis. The purely phonology account predicts that EMJ borrowers have access to the underlying phonemic contrasts in LMC, and the mapping between LMC and native EMJ phonemes is guided by phonological equivalent. Specifically, (1) phonological contrasts are maximally preserved, e.g. LMC /p/ should not be adapted the same way as /pɦ/ to preserve the laryngeal contrast; (2) the mapping is between the phonemes in LMC and phonemes in EMJ, instead of the surface forms in either language. Conversely, the purely perceptual theory predicts that adaptation takes place in the raw phonetics, and the LMC to EMJ mapping is based on perceptual similarity, i.e. it is a surface form mapping. Due to the lack of acoustic data, we do not have direct evidence on what the closest phonetic approximations are. Based on the historical phonology evidences, we hypothesise the closest perceptual matches as shown in Table 43 under the phonetic theory predictions. As can be seen from the Table, a lot of the time the closest phonological category is the same as the closest phonetic approximation. However, there are cases where the predictions of the two theories differ, and other cases where the corpus data differs from both theories. The subsequent sections will examine the instances where the corpus data aligns with the phonology or phonetic theories and the instances where it diverges.

[15] This number is bigger than the overall number of kanji (2136) from the official *Jōyō-Kanji* list because some kanji have more than one *kan-on* reading.

Table 43 A comparison of the predictions of the purely phonology theory, purely phonetic theory and the corpus analysis result. The shaded rows highlight the cases where there are differences among the phonology theory, phonetic theory and corpus data.

LMC initials	Phonology theory	Phonetics theory	Corpus data
/p/ [p]	/p/	[p]	/p/ [p]
/p^{h}/ [p^{h}]	/p/ or something else to preserve laryngeal contrast with LMC /p/	[p]	/p/ [p]
/pɦ/ [pɦ]	/^{m}b/, preserve laryngeal contrast with LMC /p p^{h}/	[^{m}b] or [p]	/p/ [p]
/t/ [t]	/t/	[t]	/t/ [t]
/t^{h}/ [t^{h}]	/t/ or something else to preserve laryngeal contrast with LMC /t/	[t]	/t/ [t]
/tɦ/ [tɦ]	/^{n}d/, preserve laryngeal contrast with LMC /t t^{h}/	[^{n}d] or [t]	/t/ [t]
/ʈ/ [ʈ]	/t/ or something else to preserve place contrast with LMC /t/	[t]	/t/ [t]
/ʈ^{h}/ [ʈ^{h}]	/t/ or something else to preserve laryngeal contrast with LMC /ʈ/	[t]	/t/ [t]
/ʈɦ/ [ʈɦ]	/^{n}d/ or something else to preserve place contrast with LMC /tɦ/	[^{n}d] or [t]	/t/ [t]
/k/ [k]	/k/	[k]	/k/ [k]
/k^{h}/ [k^{h}]	/k/ or something else to preserve laryngeal contrast with LMC /k/	[k]	/k/ [k]
/kɦ/ [kɦ]	/^{ŋ}g/, preserve laryngeal contrast with LMC /k k^{h}/	[^{ŋ}g] or [k]	/k/ [k]
/f/ [f]	/p/ or something else to preserve manner contrast with LMC /p/	[p]	/p/ [p]
/fɦ/ [fɦ]	/p/ or something else to preserve laryngeal contrast with LMC /f/	[^{m}b] or [p]	/p/ [p]
/s/ [s]	/s/	[s]	/s/ [s]
/sɦ/ [sɦ]	/^{n}z/, preserve laryngeal contrast with LMC /s/	[^{n}z] or [s]	/s/ [s]
/ʂ/ [ʂ]	/s/ or something else to preserve place contrast with LMC /s/	[s]	/s/ [s]
/ʂɦ/ [ʂɦ]	/s/ or something else to preserve laryngeal contrast with LMC /ʂ/	[^{n}z] or [s]	/s/ [s]
/ʐ/ [ʐ]	/^{n}z/ or something else to preserve laryngeal contrast with LMC /ʂ/	[^{n}z]	/^{n}z/ [^{n}z]
/x/ [x]	/k/ or something else to preserve manner contrast with LMC /k/	[k]	/k/ [k]
/xɦ/ [xɦ]	/^{ŋ}g/ or something else to preserve manner contrast with LMC /kɦ/	[^{ŋ}g] or [k]	/k/ [k]
/ts/ [ts]	/s/ or something else to preserve contrasts with other LMC [coronal strident]	[s]	/s/ [s]
/ts^{h}/ [ts^{h}]	/s/ or something else to preserve contrasts with other LMC [coronal strident]	[s]	/s/ [s]
/tsɦ/ [tsɦ]	/s/ or something else to preserve contrasts with other LMC [coronal strident]	[^{n}z] or [s]	/s/ [s]
/tʂ/ [tʂ]	/s/ or something else to preserve contrasts with other LMC [coronal strident]	[s]	/s/ [s]
/tʂ^{h}/ [tʂ^{h}]	/s/ or something else to preserve contrasts with other LMC [coronal strident]	[s]	/s/ [s]
/tʂɦ/ [tʂɦ]	/s/ or something else to preserve contrasts with other LMC [coronal strident]	[^{n}z] or [s]	/s/ [s]
/m/ [^{m}b]	/m/	[^{m}b]	/^{m}b/ [^{m}b]
/n/ [^{n}d]	/n/	[^{n}d]	/^{n}d/ [^{n}d]
/ɳ/ [^{n}ɖ]	/n/	[^{n}d]	/^{n}d/ [^{n}d]
/ŋ/ [^{ŋ}g]	/n/ or something else to preserve contrasts with LMC [coronal] nasals	[^{ŋ}g]	/^{ŋ}g/ [^{ŋ}g]
/ʋ/ [ʋ]	/w/	[w]	/^{m}b/[^{m}b]
/l/ [l]	/r/	[r]	/r/ [r]

3.3.3.1 PLACE matching

The most consistent pattern across the adaptation of all LMC initials is the preservation of place of articulation (2337/2337 cases). Even in the 8 cases of irregular adaptation, EMJ adapted forms match LMC source forms in terms of place of articulation. This aligns with the predictions of both the phonological theory and the perceptual theory (Table 43). From a phonological point of view, a ranking of PLACE over manner feature is observed in loanwords adaptation. Ghini (2001) proposes that PLACE features are the first to be assigned in acquisition. The same rule applies in loanword adaptation (Lahiri & Kennard, 2019). When there is no phoneme in the borrowing language that matches a phoneme in the source language for both place and manner of articulation, the borrowing language choses to keep the PLACE feature and alter or ignore the manner feature. LMC fricatives contrast with plosives and affricates in the specification of [CONTINUANT]. EMJ obstruents contrast in [STRIDENT] but not [CONTINUANT]. EMJ speakers ignores the [CONTINUANT] feature in LMC. LMC coronal fricatives and affricates /s sɦ ʂ ʂɦ ts tsʰ tsɦ tʂ tʂʰ tʂɦ/ are all [STRIDENT] but differ in [CONTINUANT]. EMJ extracts the [CORONAL, STRIDENT] features from the acoustic input and maps them all onto the [CORONAL, STRIDENT] of /s/. This matching pattern is the same as the adaptation of Portuguese and English sibilants in isolation (i.e. not clusters) in Bengali (Lahiri & Kennard, 2019). LMC /f fɦ/ and /x xɦ/ are not [STRIDENT] so EMJ matches them to its own non-sibilants of the same PLACE, /p/ and /k/ respectively. Within PLACE, ARTICULATOR features rank higher than TONGUE HEIGHT features. TONGUE HEIGHT features are only relevant to contrasts within coronals. EMJ has a three-way place contrast: [LABIAL], [CORONAL], and [DORSAL]. LMC has a four-way place contrast: [LABIAL], [CORONAL], [CORONAL, HIGH], and [DORSAL]. The ignoring of the TONGUE HEIGHT features in adaptation led to the merger of the LMC four-way contrast into a three-way one. As a result, LMC retroflexes are consistently adapted as EMJ dentals.

The above adaptations can also be explained from a perceptual point of view. EMJ segments that are phonetically the closest to LMC retroflexes and surface alveolo-palatal variations are likely to be the dentals. EMJ initials /p k/ have continuant surface free variants [ɸ x] (see Section 2.4.2.2). It is possible that EMJ speakers also perceive LMC [f fɦ] and [x xɦ] as close forms of [ɸ] and [x] respectively. EMJ sibilant /s/ has affricate and fricative surface forms [ᵗs s ʃ] (see Section 2.4.2.2). EMJ speakers could have perceived all LMC affricates and fricatives surface forms [s sɦ ʂ ʂɦ ts tsʰ tsɦ tʂ tʂʰ tʂɦ ɕ tɕ tɕʰ] as variants of the underlying sibilants in the native language. However, the difference between the phonetic forms of EMJ sibilant [ᵗs s ʃ] and LMC fricatives and affricate phonemes lies in their distribution. In word initial position, EMJ /s/ surfaces as [ᵗs] when it precedes /-a -o/, as [s ᵗs] when it precedes /-u/, as [s] when it precedes /-wo/ (before the w > ∅ / __ o change around 1000 CE) and as [ʃ] when it precedes /-i -e/. LMC fricative and affricate phonemes occur in a wide range of phonological environments and can appear in the same environments to form minimal pairs. What would be interesting to know is whether the adapted Sino-Japanese forms also follow the same surface distribution as the native EMJ sibilant phonemes. If all adapted Sino-Japanese sibilant segments pattern the same as the native sibilants (i.e. the fricative and affricate realisations are conditioned by the same environment as the native sibilants), it is likely that the adaptation is driven by a phonological matching where all LMC forms are mapped to EMJ underlying sibilant phonemes. Conversely, if Sino-Japanese forms have fricative and affricate realisations that are not conditioned by the same environment as the native sibilants, the adaptation could have been perceptually driven in nature. This is the case in the adaptation of English in Modern Japanese, where the adapted segments have different distribution than the native segments. For example, [ɸ] is a surface variant of /h/ before /u/ in the native phonology. In English loanwords, however, it is also used widely before vowels other than /u/.

3.3.3.2 Phonemic contrast preservation

There was a high level of bilingualism at the time of the adaptation (as discussed in Section 2.1.3 & 2.1.5). Usually in this type of sociolinguistic setting, we expect the borrowers to have access to the underlying phonemic contrasts in the source language. Due to the considerably larger number of phonemic contrasts in LMC than in EMJ, it is impossible to avoid merger and keep all the contrasts from the source language. However, in cases where contrasts could potentially be maintained by utilising all native phonemes, the corpus data do not show evidence for contrast preservation. In Section 1.3, we discussed the adaptation of English stops in Mandarin, where English voicing contrasts, e.g. /p b/, are adapted as aspiration contrasts in Mandarin, e.g. /p p^h/. In the case of Sino-Japanese *kan-on*, however, the three-way laryngeal contrast in LMC are merged in EMJ.

The phonemes of interest are the LMC voiceless obstruents with breathy release ('muddy voiced'). They were adapted as EMJ voiceless non-aspirated obstruents, along with LMC voiceless and voiceless aspirated obstruents. LMC voiceless breathy obstruents eventually changed to plain voiceless stops in Early Mandarin. However, given the language contact timeline, LMC voiceless breathy obstruents must not have started to change to plain voiceless stops at the time of language contact. The phonological system of LMC primarily matches the system depicted in the rhyme table *Yunjing*, published during the Song Dynasty in 1161 CE. The direct language contact between LMC and EMJ ceased in 894 CE during the end of the Tang Dynasty in China, which is more than 250 years before the publishing of *Yunjing*.

EMJ has two options to adapt LMC voiceless breathy obstruents: either as prenasalised voiced obstruents /^{m}b ^{n}d ^{ŋ}g ^{n}z/ that are nasal and voiced, or as voiceless non-aspirated obstruents /p t k s/ that are neither voiced nor aspirated. Without acoustic evidence, we cannot know with certainty which one is a better perceptual match. We use the processing system from FUL (introduced in Section 2.2) here to model the extraction of acoustic signal from the source language input and the mapping between LMC to EMJ sounds. EMJ prenasalised voiced obstruents match LMC voiceless obstruents with breathy release in [VOICE] but mismatch in [NASAL]; EMJ voiceless non-aspirated obstruents do not match or mismatch with LMC voiceless obstruents with breathy release. EMJ consistently adapts all LMC voiceless obstruents with breathy release as voiceless non-aspirated obstruents. This proves that nasality plays a prominent role in EMJ phonology, so a nasality mismatch is fatal, which leads to the adaptation of LMC voiceless obstruents with breathy release as the EMJ voiceless non-aspirated obstruents that do not mismatch in nasality. From a perceptual point of view, this could mean that EMJ speakers are more sensitive to nasality contrast than to voicing or aspiration contrast. This preference is conditioned by the native phonology.

To conclude, the merger of all laryngeal contrasts from LMC do not support the predictions of the purely phonology model. The data does not show evidence for the *Category Preservation Principle* nor the *Category Proximity Principle* (LaCharité & Paradis, 2005: 226-227). EMJ speakers do not seem to put extra effort into preserving LMC categorical contrasts. On the other hand, we do not have direct evidence to support the perceptual account, either. However, the adaptation data suggest that the contrast in the native phonology seems to be conditioning the adaptation process. This, in turn, implies that native phonology may be influencing perception—providing potential evidence for the phonology-based perception view.

3.3.3.3 Surface versus underlying forms

The most obvious difference between the predictions of the two competing theories (as shown in Table 43 above) is the adaptation of LMC nasals. The phonology theory predicts that LMC nasal phonemes /m n ɳ ŋ/ will be adapted as EMJ nasal phonemes /m n/, with /ŋ/ potentially adapted as another phoneme to preserve the place contrasts in nasals. From the perceptual perspective, the input to adaptation is the acoustic signal, so EMJ will adapt the surface phonetic variations [^{m}b ^{n}d ^{n}ɖ ^{ŋ}g] of LMC nasal phonemes /m n ɳ ŋ/ as the phonetically closest EMJ prenasalised obstruent phonemes /^{m}b ^{n}d ^{n}d ^{ŋ}g/ [^{m}b ^{n}d ^{n}d ^{ŋ}g], respectively, even though EMJ has nasal phonemes. The corpus data provide direct evidence supporting the prediction of the perceptual view and contradicting the purely phonological account. Combining this with the discussions in Section 3.3.3.2 above, we can safely conclude that the adaptation of Sino-Japanese kan-on initials does not follow a purely phonological pattern.

3.3.3.4 Native phonology

Having ruled out the purely phonology theory, the next step is to investigate whether the adaptation follows the purely perceptual view or the phonology-based perception view. Section 3.3.3.2 raises the hypothesis for the phonology-based perception theory. The question at hand is whether we can find further evidence showing the role of the native phonology.

The adaptation of LMC labiodental approximant /ʋ/ is of particular interest as it does not follow the phonology nor the perceptual theory. According to both theories, we expect LMC /ʋ/ to be adapted as the categorically and phonetically closest EMJ phoneme /w/. The corpus data shows, however, that LMC /ʋ/ ([LABIAL, SONORANT]) is adapted as EMJ [ᵐb]. Due to the restrictions on the distribution of EMJ /w/ as discussed in Section 3.3.2 above, the native phonology rules out /w/ and choses [ᵐb] ([LABIAL, OBSTRUENT]).

In conclusion, while some data of Sino-Japanese *kan-on* initials adaptation can be explained by both phoneme mapping and phonetic approximation, we found two pieces of evidence against the phonology theory and support the phonology-based perception theory, showing that perceptual similarity in EMJ is guided by the contrasts and processes in the native phonology.

3.4 Coda adaptation

3.4.1 Codas in Chang'an Late Middle Chinese and Early Middle Japanese

As introduced in Section 2.3.4.3 and 2.3.3.4, both LMC and EMJ allow syllable codas. The syllable structures in LMC and EMJ are repeated here in Figure 9 & Figure 10 for the ease of reference. LMC allows superheavy syllables, whereas EMJ allows maximum two morae.

Figure 9 LMC syllable structure

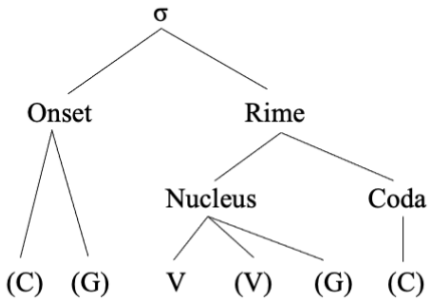
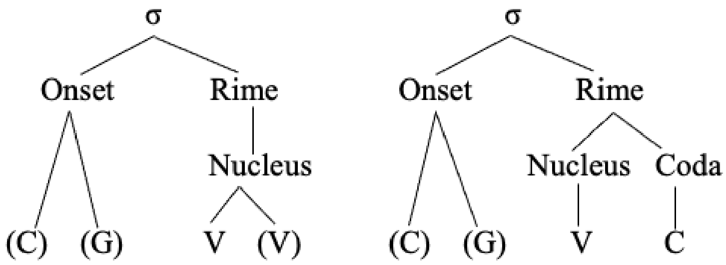


Figure 10 EMJ syllable structure



LMC has six coda consonants /p t k m n ŋ/. Apart from /ŋ/, the other five consonants /p t k m n/ are also phonemes in EMJ. However, EMJ has more strict phonotactic constraints on codas. There are three bound moraic consonants /C O N/ that can function as syllable codas. The three moraic consonants have different distributions: /C/ only occurs morpheme internally, /O/ occurs morpheme finally and word internally, and /N/ occurs morpheme finally, word internally and word finally. All LMC characters in the current corpus are monomorphemic and monosyllabic, which means that all LMC codas are morpheme final. In EMJ, each adapted LMC character (adapted as a kanji) also represents a single morpheme, so only bound moraic consonants that can occur morpheme finally (/O N/) are relevant to our discussion of the adaptation of LMC codas. Table 44 shows the morpheme final coda consonant inventories in LMC and EMJ.

Table 44 LMC and EMJ coda consonant inventories

Consonants	LABIAL Labial	CORONAL Dental	DORSAL Palatal/Velar
Chinese			
Plosive	p	t	k
Nasal	m	n	ŋ
Japanese			
Non-nasal		O	
Nasal		N	

The feature charts for LMC and EMJ codas are shown in Table 45 and Table 46 respectively. The bound moraic consonants in EMJ are not specified for PLACE. They copy the PLACE feature from the following consonant when they are not in word-final position. /O/ and /N/ differ in their nasality specification.

Table 45 Feature chart for LMC codas

LMC coda consonants		p	t	k	m	n	ŋ
ROOT	[OBSTRUENT]	✓	✓	✓			
	[SONORANT]				✓	✓	✓
	[NASAL]				✓	✓	✓
PLACE - ARTICULATOR	[LABIAL]	✓			✓		
	[CORONAL]		✓			✓	
	[DORSAL]			✓			✓

Table 46 Feature chart for EMJ codas

EMJ coda consonants		O	N
ROOT	[CONSONANTAL]	✓	✓
	[NASAL]		✓

3.4.2 Statistical analysis

3.4.2.1 Adaptation pattern

There are 1439 Chinese characters with codas in this corpus. The six LMC codas are adapted into EMJ by different strategies. The data pattern from the corpus is shown in Table 47[16]. The LMC obstruent codas [p t k] are kept in the adapted forms with the insertion of an epenthetic vowel (452 out of 459 cases). The adapted forms take on the structure

[16] Due to the use of different materials and methodology, the adaptation pattern is different from Heffernan (2007).

(C)(G)VCV. The LMC nasal codas /m n/ are adapted as EMJ bound moraic nasal /N/ (533 out of 533 cases). The adapted forms have the structure (C)(G)VN. EMJ does not have a nasal at the velar place, and LMC velar nasal /ŋ/ which is specified for [SONORANT, NASAL] is adapted as nasalised vowels[17] [SONORANT, NASAL] in EMJ (447 out of 447 cases). The adaptations have the structure (C)(G)VV.

Table 47 The adaptation of LMC coda in Sino-Japanese kan-on

LMC coda	Number of cases	Sino-Japanese adapted forms	Number of cases	Structures of adapted Sino-Japanese forms
/p/	56	/p/ + epenthetic vowel	56	(C)(G)V.**CV**
/t/	138	/t/ + epenthetic vowel	136	
/k/	265	/k/ + epenthetic vowel	260	
/m/	118	/N/	118	(C)(G)V**N**
/n/	415	/N/	415	
/ŋ/	447	nasalised vowel	447	(C)(G)V**V**

From the data pattern shown above, it can be seen that the adaptation of kanji follows EMJ word level instead of morpheme level phonotactics. Although EMJ has the bound moraic non-nasal option /O/ that can occur morpheme finally, it was not used in adaptation. Chinese characters, or Chinese morphemes, are being treated as individual words. This could be because of the morphophonology of the input language. Almost all morphemes in varieties of Chinese keep their individual phonological shapes when they combine with other morphemes to form words (Packard, 2015). There is virtually no morphophonemic alternation. Since EMJ speakers put emphasis on the vocalisation of LMC at the time of adaptation, and they adapts not only the readings of individual kanji but also Sino-Japanese compound words, they are aware of the morphophonology of Chinese. In EMJ, the only coda that is allowed in word-final position is the bound moraic nasal /N/. Epenthetic vowels are therefore inserted after all LMC obstruent codas during adaptation to follow EMJ word

[17] As discussed in Section 3.1.2, it is controversial whether the nasalised vowels are already in the phonemic inventory of EMJ or introduced by the adaptation of Chinese loanwords.

level phonotactics. EMJ choses vowel epenthesis over deletion to preserve information from the input language, following the Preservation Principle (Paradis & LaCharite, 1997).

The structures of the adapted Sino-Japanese forms presented in Table 46 suggest that LMC nuclei, irrespective of their length, are always adapted into a single vowel in EMJ. EMJ allows maximum two morae. When the LMC source form contains the nasal codas /m n ŋ/, these codas are adapted as the bound moraic nasal /N/ ((C)(G)VN) or bound moraic vowel /V/ ((C)(G)VV) which takes up one mora. LMC nucleus therefore has to be adapted into a single mora to fit all the information from the source form into one syllable. When LMC source form contains the obstruent codas /p t k/, an epenthetic vowel is inserted during adaptation. After re-syllabification, the adapted form consists of two syllables, with LMC coda adaptation and epenthetic vowel forming the second syllable ((C)(G)V.CV). In this case, the LMC nucleus vowel can be adapted into maximum two segments in EMJ because the adaptation of the LMC coda does not take up weight in the first syllable. Surprisingly, however, LMC nuclei are consistently adapted as a single vowel, leaving the first syllable light.

The quality of the epenthetic vowels inserted through the adaptation of LMC codas are shown in Table 48. When the LMC coda is the labial or coronal obstruent /p t/, the epenthetic vowel /u/ is inserted. When the LMC coda is the dorsal obstruent /k/, the epenthetic vowel is /u/ in 210/265 cases and /i/ in 50/265 cases; when the LMC coda is the dorsal nasal /ŋ/, it is adapted as /ũ/ in 334/447 cases and /ĩ/ in 113/447 cases. As LMC velar nasal /ŋ/ is adapted as a vowel itself and the pattern of adaptation is similar to the epenthetic vowel for the other dorsal coda /k/, this study expands the meaning of the term ‘epenthetic vowel’ to include the adapted vowel forms resulted from LMC /ŋ/. From the observed data pattern, it seems that vowel epenthesis applies differently after dorsal and non-dorsal consonants.

Table 48 The epenthetic vowels in Sino-Japanese kan-on

Place of LMCcoda	LMC coda	Number of cases	Sino-Japanese adapted forms	Number of cases
Labial	/p/	56	/pu/	56
Coronal	/t/	138	/tu/	136
Dorsal	/k/	265	/ku/	210
			/ki/	50
	/ŋ/	447	/ũ/	334
			/ĩ/	113

At first glance, the quality of the epenthetic vowels for the dorsal codas seems to be conditioned by the preceding vowel in the adapted Sino-Japanese *kan-on* forms. The adapted Sino-Japanese forms with epenthetic vowels have the structure $C(G)V_1(C)V_2$ (G stands for glide, parenthesis indicates optionality). The final vowel (i.e. the epenthetic vowel or the adapted vowel form for LMC coda /ŋ/) in the Sino-Japanese forms is V_2, and the first vowel (i.e. the vowel preceding the epenthetic vowel) is V_1. Table 49 shows the relationship between V_1 and V_2 in the adapted Sino-Japanese *kan-on* forms. In the current corpus, when V_1 is /e/, V_2 is /i ĩ/ (163/163 cases), e.g. 液 'liquid'/eki/; when V_1 is /i/, V_2 is /u ũ/ (29/29 cases), e.g. 竹 'bamboo' /tiku/. When V_1 is /a o u/, V_2 is always /u/. Other studies that have different databases and look at all substrata of Sino-Japanese have also found cases where the preceding vowel is /i/ and the epenthetic vowel is /i/ (e.g. Ito & Mester, 2015), e.g. 力 'power'/riki/ in Sino-Japanese *go-on*.

Table 49 LMC dorsal coda adaptation: the relationship between V1 and V2 in Sino-Japanese kan-on

V_1	LMC coda	V_2
/e/	/k/	/i/
	/ŋ/	/ĩ/
/i/	/k/	/u/ (/i/ in other studies)
	/ŋ/	/ũ/ (/ĩ/ in other studies)
/a, o, u/	/k/	/u/
	/ŋ/	/ũ/

When Sino-Japanese is studied from the perspective of a stratum of Japanese instead of loanword adaptation, the epenthetic vowel patterns for dorsal vs non-dorsal codas are explained by a vowel harmony theory (Ito & Mester, 2015; Tateishi, 1990). Japanese avoids coda consonants by inserting the default vowel /u/. When the coda is dorsal, however, the epenthetic vowel agrees with the backness of the preceding vowel in the adapted form – if V_1 is the front vowel /e/, V_2 is the front high vowel /i/. However, this backness harmony does not apply uniformly to all front vowels. When V_1 is the other front vowel /i/, V_2 alternates between /i/ and /u/. Ito & Meter (2015: 294) describe the vowel harmony for V_1=/i/ as a 'lexical option'. There is yet explanation that can perfectly account for why the harmony only holds uniformly for the specific vowel /e/ but not the other front vowel /i/ which matches both backness and height with the epenthetic vowel /i/.

3.4.2.2 Distribution analysis

The vowel harmony theory in the Sino-Japanese literature is based on a generalisation of the adapted Sino-Japanese forms. The present study investigates the pattern from a loanword adaptation perspective and examines both the source forms and adapted forms specifically for Sino-Japanese *kan-on*. Input and output are equally valuable in understanding the adaptation process and loanword phonology.

A distribution analysis of the codas in the source forms was performed. The result is shown in Table 50. It can be seen that codas of all places of articulation occur after a nucleus vowel or vowel sequence, whereas only dorsal codas occur after a glide.

Table 50 The distribution of LMC labial, coronal and dorsal codas

LMC source forms		
Contexts before coda		Coda PLACE
(C)(G)V_#	(C)(G)VV_#	LABIAL, CORONAL, DORSAL
(C)(G)V**G**_#	(C)(G)VV**G**_#	DORSAL

A follow-up distribution analysis is performed for the glides, /j w/, in the source forms. The result in Table 51 shows that the glide /j/ only occurs in VVG contexts whereas the glide /w/ occurs in all VG nuclei and one VVG context. The only phonological environment they share is after the vowel sequence /a:/. In all the instances where the glide is /w/ in the source form, the epenthetic vowel is /u/ in the adapted forms. However, this is not the case for the glide /j/. When /j/ follows the diphthongs /ia ya/ in the source forms, the epenthetic vowel is /i/ in the adapted forms; when /j/ follows /a:/, the epenthetic vowel is /i/ in 10.3% of the instances and /u/ in 89.7% of the instances. The glide in the nuclei of LMC input seems to have an influence on the quality of the epenthetic vowel in EMJ output. However, it must not be the only influencing factor, because the epenthetic vowel is not consistently /i/ when the glide is /j/.

Table 51 The distribution of LMC glide /j/ and /w/

LMC source forms					Sino-Japanese *kan-on* forms
Structure	Nucleus		Number of segments	Number of distinct segments	Epenthetic vowel (V2)
	V/VV	G			
VG	/u/	/w/	2	2	/u/ (9/9 cases)
VG	/ə/	/w/	2	2	/u/ (68/68 cases)
VG	/i/	/w/	2	2	/u/ (40/40 cases)
VG	/y/	/w/	2	2	/u/ (57/57 cases)
VVG	/a:/	/w/	3	2	/u/ (33/33 cases)
VVG	/a:/	/j/	3	2	/u/ (52/58 cases) & /i/ (6/58 cases)
VVG	/ia/	/j/	3	3	/i/ (142/143 cases)
VVG	/ya/	/j/	3	3	/i/ (15/15 cases)

Some other factors should also impact the quality of the epenthetic vowel. As the glides occur in two nucleus structures of different length, the data is coded for the number of segments in the nucleus to investigate whether the adaptation of the nucleus has an influence on the epenthetic vowel. Another consideration regards the length of the vowel. Although EMJ is weight sensitive, the only vowels that are allowed to occur as the second element in the nucleus are the high vowels /i u/. It is unclear how EMJ speakers perceive LMC acoustic input /a:/ because it is not a legal nucleus vowel sequence in EMJ. Long /a:/ also does not exist in the Sino-Japanese strata in Modern Japanese. The data is therefore also coded for the number of distinct segments in the nucleus, in case EMJ speakers do not perceive LMC long vowel sequences.

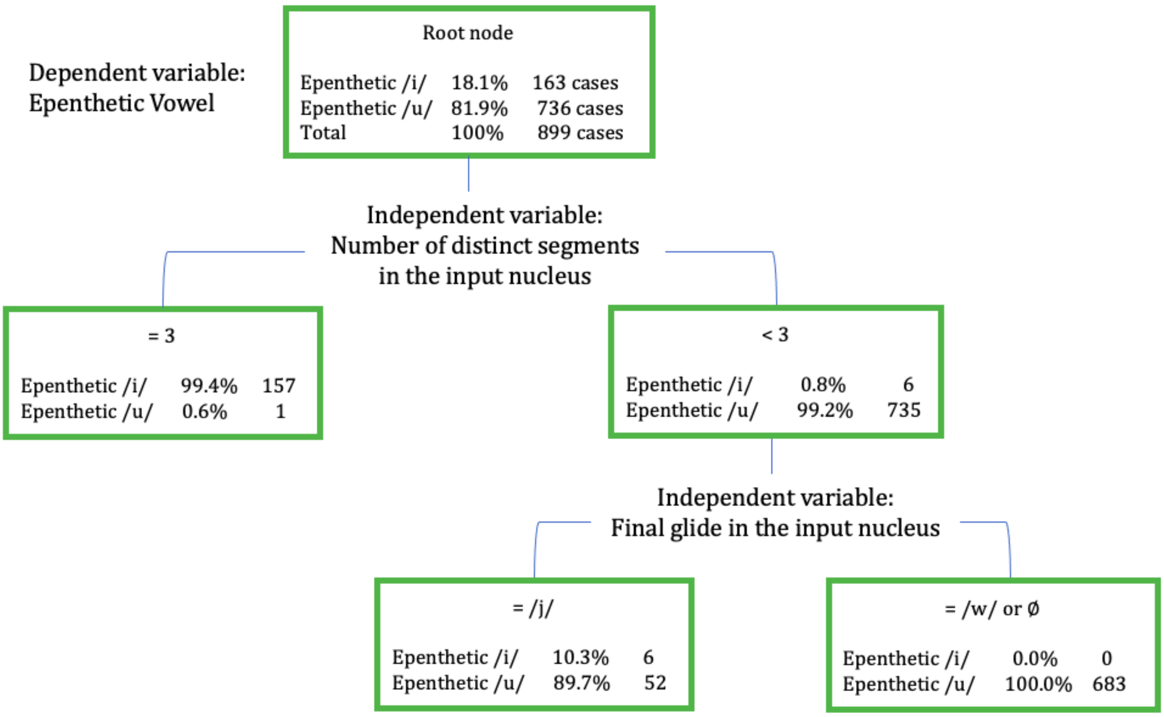
3.4.2.3 Classification analysis

A classification analysis is performed to investigate what factors influence the quality of Sino-Japanese epenthetic vowel and how those factors interact. The analysis follows Uffmann (2006) and employs the Chi-square automatic interaction detection (CHAID) technique. This decision tree method identifies the predictor variable that has the most significant interaction with the dependent variable and uses it to split the dataset up into subgroups. The algorithm is repeated on each subgroup until there is no more significant relationship between any predictor variable and the dependent variable.

In this analysis, the dependent variable is the quality of the Sino-Japanese epenthetic vowel. The predictor variables input to the algorithm are the Chinese vowel(s) V(V) (includes both single short vowel V and vowel sequences VV), the glide G before the coda, the place of articulation of the coda, the number of segments in the nucleus and the number of distinct segments in the nucleus.

The classification tree is shown in Figure 11. There are 899 data points in total as shown in the root node, of which 736 (81.9%) are epenthetic /u/, and 163 (18.1%) are epenthetic /i/. The algorithm identifies the number of distinct segments in LMC nuclei to be the best predictor variable, as shown under the root node. The root node is divided into two maximally distinct subgroups: the left group has 3 distinct segments in the input nucleus, and the right one has less than 3 distinct segments. When the number of distinct segments in the nucleus is 3, the epenthetic vowel is /i/ in 99.4% (157/158) of the cases. When the number of distinct segments in the nucleus is < 3, the epenthetic vowel is /u/ in 99.2% of the data (735/741 cases), and there are only 6 cases of epenthetic /i/. The data in the right group is further split into two subsets by the final glide in the input nucleus. All occurrences of epenthetic /i/ are in the subset where the final glide is /j/.

Figure 11 Classification tree: the independent variables for Sino-Japanese epenthetic vowel



The classification analysis shows that the quality of the epenthetic vowel is influenced by the interaction of two factors: the number of distinct segments and the final glide in the source form nucleus. When EMJ speakers perceive less than three segments in the input nucleus, the default epenthetic vowel /u/ is inserted in the majority of cases. The quality of the glide does not seem to have an influence on the choice of epenthetic vowel. When the glide is /j/, the epenthetic vowel is still /u/ almost 90% of the time. Although the classification tree shows final glide as a predictor variable, the 6 data points of epenthetic /i/ are exceptional cases and the small number is not enough as statistical evidence. When EMJ speakers perceives three segments in the input nucleus, a vowel harmony process is triggered and the epenthetic vowel matches with the input glide. Recall that for all cases where there are three distinct segments in the input nucleus, the glide is /j/. The epenthetic /i/ shares PLACE features [CORONAL, HIGH] with the input glide /j/. Due to the distribution of the glide /w/ in LMC source forms, there is no data of the structure /V_1V_2w/. According to the observed pattern for the glide /j/, the hypothesis is that when the source form has the structure /V_1V_2w/, the epenthetic vowel would be /u/ which shares PLACE features [LABIAL, HIGH] with the input glide /w/. The experimental study in Chapter 4 tests this hypothesis.

The place of articulation of the coda consonant does not interact significantly with the quality of the epenthetic vowel. Empirical studies on other languages have shown that dorsal codas participate in vowel epenthesis in a different way from labial and coronal codas (e.g. Uffmann, 2006; Rose & Demuch, 2006). However, due to the distribution of LMC codas, we do not have data where the labial and coronal codas also follow a glide like the dorsal codas. The Sino-Japanese data does not allow us to compare the adaptation of codas of different place in the same phonological context so we cannot conclude that the dorsal place has an influence on the quality of the epenthetic vowel. This is also being tested in the experimental study in the next chapter.

3.4.2.4 Epenthetic vowel analysis

The statistical analyses suggest that the quality of the Sino-Japanese *kan-on* epenthetic vowel depends on two distinct factors: the pre-coda glide and the perceived complexity of the nucleus in the source form. The two factors interact in the following ways. When there are two distinct elements in the input nucleus, regardless of whether one of the element is a glide, the default vowel /u/ is inserted in the adapted form. When there are three distinct segments in the input nucleus with the final segment being a glide, the quality of the epenthetic vowel in the adapted form is conditioned by the glide. There are two possible phonological explanations for this vowel epenthesis.

Hypothesis 1: The vowel epenthesis process consists of a segmental adaptation and a metathesis. For the segmental adaptation, when the glide in LMC is /j/ [CORONAL], it is adapted as the vowel /i/ [CORONAL] in EMJ; when the glide is /w/ [DORSAL, LABIAL], it is adapted as the vowel /u/ [DORSAL, LABIAL] in EMJ. After the segmental adaptation stage, Sino-Japanese *kan-on* forms have the structure C(G)V_1V_2C, with V_1 being the adaptation of the LMC vowel or vowel sequence and V_2 the adaptation of the glide. Because EMJ does not allow obstruent coda in word final position or superheavy syllable, after the segmental adaptation, a local metathesis applies, transposing the word-final vowel and consonant ($V_2C \rightarrow CV_2$) to make sure the newly formed loanword $C(G)V_1.CV_2$ fits into EMJ phonotactic constraints. For example, when the LMC input is /CiajC/, the first part of the nucleus /ia/ is adapted as /e/, and the final glide /j/ is adapted as the vowel /i/. A metathesis process applies to /iC/ and the output form becomes /CeCi/.

Hypothesis 2: The epenthetic vowel results from a vowel harmony process. Empirical studies on vowel harmonies in other languages have shown that 'epenthetic vowels generally match the input vowel on the left of the epenthetic site' (Rose & Demuch, 2006: 1113). In the case of Sino-Japanese, the epenthetic vowel matches to the glide on the left of the epenthetic site, because the glide is the last segment in the input nucleus. The glide spreads its PLACE features to the epenthetic vowel. The epenthetic vowels are specified for [VOCALIC, HIGH] underlyingly. When the glide is /j/, the epenthetic vowel takes on the [CORONAL] features and surfaces as /i/; when the glide is /w/, the epenthetic vowel takes on the [DORSAL, LABIAL] features and surfaces as /u/. For example, when LMC input is /CiajC/, the nucleus /iaj/ is adapted as /e/ and the final glide /j/ spreads its [CORONAL] feature to the epenthetic vowel in EMJ.

Both hypotheses can account for the alternations of epenthetic /i/ and /u/. However, they differ in their predictions in the adaptations of the nucleus vowels. Table 52 shows all EMJ input forms that have three distinct segments in the nucleus, and their corresponding Sino-Japanese *kan-on* adapted forms. According to Hypothesis 1, LMC /ia/ and /ya/ are adapted as EMJ /e/, and LMC /j/ is adapted as EMJ /i/. Hypothesis 1 predicts that /ia/ and /ya/ in LMC forms /C(G)iak, C(G)iaŋ/ and /C(G)yak, C(G)yaŋ/ respectively should also be adapted as /e/ (Table 53). Hypothesis 2 predicts that LMC /iaj/ and /yaj/ are adapted as EMJ /e/, and

EMJ epenthetic vowel /i/ is not the result of a direct segmental adaptation but a vowel harmony. According to this hypothesis, /ia/ and /ya/ in LMC forms /C(G)iak, C(G)iaŋ/ and /C(G)yak, C(G)yaŋ/ respectively are not likely to be adapted as /e/.

Table 52 LMC source forms that have the structure C(G)V1V2GC and Sino-Japanese kan-on adapted forms

LMC	Sino-Japanese *kan-on*
/C(G)**iaj**k/	/C**e**k**i**/
/C(G)**yaj**k/	/C**e**k**i**/
/C(G)**iaj**ŋ/	/C**eĩ**/
/C(G)**yaj**ŋ/	/C**eĩ**/

Table 53 Predictions of Hypothesis 1

LMC	Sino-Japanese *kan-on*
/C(G)**ia**k/	/C**e**ku/
/C(G)**ya**k/	/C**e**ku/
/C(G)**ia**ŋ/	/C**e**ũ/
/C(G)**ya**ŋ/	/C**e**ũ/

Table 54 shows the data of the adaptation of /ia/ and /ya/ in LMC forms /C(G)iak, C(G)iaŋ/ and /C(G)yaŋ/ in the current corpus and the predictions of the two hypotheses. The structure /C(G)yak/ does not exist. It can be seen from the table that /ia/ and /ya/ are adapted as /ja jo a/ when there is no following glide. The data supports Hypothesis 2 and contradicts the prediction of Hypothesis 1. The epenthetic vowels result from a vowel harmony process where the PLACE of the epenthetic vowel agrees with the pre-coda glide in the input.

Table 54 The adaptation of LMC nuclei /ia ya/ with dorsal codas

LMC	Sino-Japanese *kan-on* forms in the corpus	Hypothesis 1	Hypothesis 2
/-iak/	/-jaku/ /-joku/	/-eku/	not /-eku/
/-iaŋ/	/-jaũ/ /-joũ/	/-eũ/	not /-eũ/
/-yaŋ/	/-aũ/ /-jaũ/	/-eũ/	not /-eũ/

3.4.3 Discussion

This coda adaptation study contributes a new piece of empirical evidence to the body of literature on vowel epenthesis in loanwords. As introduced in Section 1.3, epenthesis and deletion are the two strategies languages employ to resolve structural violation. Cross-linguistically we are seeing both strategies being used in word final positions. In the case of Japanese, epenthesis is the preferred option over deletion to repair illegal codas in loanwords of all origins. One important research question in the field of vowel epenthesis is what determines the quality of the epenthetic vowel. Uffmann (2006, 2007) focuses on vowel epenthesis in loanwords and conducts a series of cross-linguistic case studies. His work shows that there are mainly three options available to determine the quality of the epenthetic vowel: vowel harmony, consonantal assimilation and default insertion. For Sino-Japanese *kan-on*, epenthetic /u/ is the result of default insertion. The question is what phonological process is responsible for epenthetic /i/. This study proposes two possible explanations to account for the epenthetic /i/ cases – (1) segmental adaptation + metathesis, and (2) vowel harmony. Further analysis supports the vowel harmony hypothesis, conforming to Uffmann's (2006, 2007) findings. EMJ speakers employ default insertion and vowel harmony strategies in the adaptation of LMC codas.

The analysis answers the questions of (1) how the two strategies interact – in what context does the language choose default insertion and in what context does it prefer vowel harmony; and (2) which segment the epenthetic vowel assimilates to, and what features it copies. When EMJ listeners perceive less than three segments in the input nucleus, vowel harmony does not apply and a default epenthetic vowel is inserted; when EMJ speakers perceive three segments in the input nucleus, a vowel harmony process is triggered and the epenthetic vowel matches with the input glide. This study introduces the influence of the complexity of the input nucleus in epenthetic vowel harmony process.

The findings explain why when the Sino-Japanese V_1 is /i/, the vowel harmony does not consistently apply to the epenthetic vowel (Sino-Japanese V_2) – a problem we mentioned earlier for the vowel harmony theory based on Sino-Japanese adapted forms. An analysis of

LMC source forms in the dataset shows that for all Sino-Japanese *kan-on* forms with V_1=/i/, there are less than three segments in the input nucleus so the default epenthetic vowel /u/ was inserted.

Due to the restricted distribution of the glides and coda consonants in the input, the current coda adaptation analysis has two limitations: (1) There is no data evidence showing that when the input nucleus is /V_1V_2w/, the vowel harmony applies and the epenthetic vowel /u/ is inserted. The hypothesis in this analysis is based on an analogy of /V_1V_2j/ inputs. (2) It is unclear whether the place of articulation of the coda consonant also has bearings on the quality of the epenthetic vowel. Will the adaptation strategy still applies when the coda is not a dorsal consonant? A follow-up experimental study is designed to test the result of this corpus study and further explore these two issues.

Returning to the broader phonetics vs phonology theoretical debate in loanword adaptation, the findings of this corpus analysis show that perceptual account alone cannot capture the Sino-Japanese *kan-on* coda adaptation data. Modern Japanese vowel epenthesis has always been used as a strong case to support the purely perceptual perspective (Dupoux et al., 1999; Peperkamp & Dupoux, 2003; as discussed in Section 1.3). The back vowel /u/ has always been the default epenthetic vowel for loanwords in Japanese both historically and in the modern language (Kubozono, 1999). It is not only the default epenthetic vowel in Sino-Japanese, but also for western loanwords in Japanese. In Modern Japanese, the vowel /u/ is the weakest vowel. It is phonetically the shortest (Sagisaka & Tohkura, 1984) and perceptually the least salient (Dupoux et al., 1999; Shoji & Shoji, 2014). It is also prone to vowel devoicing (Fujimoto, 2015). The insertion of /u/ makes the adapted form perceptually the most similar to the source form. Historically, /u/ was a rounded vowel. Due to the lack of acoustic data, we do not know with certainty if /u/ was perceptually the best option. Nevertheless, historical data shows that /u/ is prone to weakening processes. EMJ vowel sequences that end in /u/, e.g. /au ou eu iu/, underwent monophthongisation in LMJ as shown in 2.4.4.3 (12). In contrast, diphthongs with the other bound moraic vowel /i/ resisted the process of vowel coalescence. The instability of /u/ in comparison to /i/ shows that it has always been a weak vowel in Japanese. However, it remains unclear whether the default epenthetic vowel support the perceptual or phonological view in Sino-Japanese.

What is clear from the data, however, is that Sino-Japanese *kan-on* epenthetic /i/ and nucleus adaptation cannot be explained from a purely perception perspective. If we assume EMJ epenthetic /u/ to still be the best perceptual option, we would expect the epenthetic vowel to always be the default vowel with little or no exception. However, this is not the case as shown in the data. What is also odd from a phonetic approximation point of view is the contraction of complex nucleus from the input. For inputs with the nucleus structure VVG, e.g. /iaj/, we would expect the output candidate /ja.i/ or /i.ai/, which are both valid structures in EMJ, to be perceptually more similar to the input, rather than a single vowel /e/. It cannot be argued that this contraction is due to the fact that EMJ speakers could not perceive the complex nucleus, since they chose a different epenthetic vowel based on the complexity of the nucleus. The input signal must have also been processed by the native phonology during adaptation. An analysis in terms of phonological feature spreading can more precisely account for the vowel harmony data. The current analysis corroborates Uffmann's (2006: 1107) conclusion that in vowel epenthesis, which is “a prosodic rather than segmental phenomenon,” the role of perception “seems limited”.

Sociolinguistic factors also influence the coda adaptation pattern, although it was not directly reflected from the adaptation data in this corpus study. As introduced in Section 2.1, during the second period of language contact, there was a high level of bilingualism among the elites, and LMC was the language of prestige. It was taught in formal institutes by native instructors. Speakers are more likely to exceptionally import foreign phonemes or accept new phonotactics if the source language is considered important by the native community. The Christian sources from the end of the LMJ period showed evidence of a short-lived syllable final /-t/, which reflected EMC coda /t/, e.g. the Sino-Japanese loanword for 'fever' 熱 is shown as /net/ in the Christian sources (Frellesvig, 2010). The final /-t/ existed almost exclusively in Sino-Japanese loanwords. Those codas also participate in the phonological process *renjo*– the process in which a coda consonant is replicated as the onset of a subsequent syllable containing an initial vowel or glide. There is no systematic documentation of all the Sino-Japanese monosyllabic words that had syllable final /t/, and this short-lived coda is also not reflected in the resource we used for this corpus study.

This chapter presents two corpus analyses. The first one looks at onset adaptation in Sino-Japanese *kan-on* from the segmental level, and the second one looks at coda adaptation from the structural level. The findings from both studies suggest that neither the pure perceptual nor the pure phonological theory alone can account for the adaptation of Sino-Japanese *kan-on*. Both phonetics and phonology had their roles in the process. In the next Chapter, I present the experimental study which is a follow-up study of the coda adaptation corpus study.

Chapter 4. Experimental study

This experimental study is designed to test the findings of the coda adaptation corpus study. Adaptation studies on other languages have shown that vowel harmony is usually triggered by dorsal codas (e.g. Uffmann's (2006) research on Shona, Sranan, Samoan and Kinyarwanda). The result of the corpus analysis in Section 3.4.2, however, suggests that the length of the nucleus in the source form could also be a trigger for vowel harmony. This study investigates the factors that influence vowel harmony and the quality of the epenthetic vowel in Japanese through two psycholinguistic behavioural tasks.

There have not yet been any psycholinguistic studies on Sino-Japanese. It is challenging to test historical language adaptation patterns on the modern languages. However, experimental studies would enable us to verify the historical data and also find out if there has been a shift in the native phonology. The data from the coda adaptation corpus study shows the adaptation pattern during the language contact between Early Middle Japanese (EMJ) and Late Middle Chinese (LMC). Would we be able to find the same adaptation pattern in Modern Japanese? This study aims to contribute empirical data to the loanword adaptation and the Sino-Japanese literature.

4.1 Background

Although the adaptation of Sino-Japanese *kan-on* happened centuries ago, and Japanese has gone through waves of sound changes, both segmental and structural, the phonemic inventory and phonotactics of Modern Japanese are still similar to those of EMJ. EMJ has seven vowels: /i ĩ u ũ e o a/ (Frellesvig, 2010). The two nasalised vowels /ĩ ũ/ have the same place features as /i u/. Only the high vowels /i u ĩ ũ/ can attach to open syllables to form syllables with long vowels or diphthongs. The segments that can attach to open syllables to form heavy syllables are termed bound moraic segments. In contrast, in Modern Japanese, nasality is no longer distinctive in vowels. The phonemic inventory has only the five oral vowels /i u e o a/. All five vowels can attach to open syllables to form long vowels, but similar to EMJ, only the high vowels /i u/ can attach to open syllables to form diphthongs. The high back vowel /u/ is the default epenthetic vowel in both Sino-Japanese and modern day loanwords. It was a rounded vowel in EMJ and has become phonetically unrounded in Modern Japanese. Despite the surface phonetic differences, there are no major phonological changes that make Modern Japanese /u/ significantly different from EMJ, as can be seen from the discussions of Japanese historical phonology at each period in Chapter 2. Historically, it might have been specified for [LABIAL]. However, this feature was not needed to establish contrast – the dorsal vowels differ in height, with /u/ being the only [DORSAL, HIGH]. In Modern Japanese, this remains the same. In terms of instability, as discussed in Section 3.4.3, /u/ has been unstable historically and prone to changes, i.e. subject to vowel coalescence. In Modern Japanese, /u/ is also subject to coalescence, as well as devoicing. Its status as the default epenthetic vowel in both historical Sino-Japanese loanwords and modern day loanwords is in itself a prove of the similarities.

Table 55 shows the consonant inventory of Modern Japanese. The only difference between the consonant inventory of Modern Japanese and EMJ is that EMJ does not have the glottal fricative /h/. It is derived from EMJ /p/ in certain contexts.

Table 55 The consonant inventory of Modern Japanese

Consonants	Bilabial	Labial-velar	Alveolar	Palatal	Velar	Glottal
Plosive	p b		t d		k g	
Fricative			s z			h
Nasal	m		n			
Glide		w		j		
Liquid			ɾ			

However, Modern Japanese has many allophonic variations. Some of these allophonic variations are listed in Table 56.

Table 56 Some allophonic variations in Modern Japanese

Phoneme	Allophone	Phonological context
/t/	[ts]	__ u
	[tʃ]	__ i, j
/z/	[dz]	__ u
	[dʒ]	__ i, j
/s/	[ʃ]	__ i, j
/g/	[ŋ]	V __V
/h/	[ɸ]	__ u
	[ç]	__ i, j

Based on these surface forms, Modern Japanese vowel epenthesis generally follows the rules as shown below in (19) (summarised by Kubozono, 2015: 369).

(19) a. The vowel /o/ is inserted after the dental stops [t d]. e.g. 'meat' is adapted as [mi:to]

b. The vowel /i/ is inserted after the palatoalveolar affricates [tʃ dʒ], e.g. 'peach' is adapted as [pi: tʃi], and after [k] in some archaic words, e.g. 'ink' is adapted as [iŋki][18]

c. The default vowel /u/ is inserted in all other contexts, e.g. 'map' is adapted as /mappɯ/

Both EMJ and Modern Japanese have syllable structures C(G)V, C(G)VV, C(G)VN, and C(G)VC (G stands for glide). However, *C(G)VC is not permitted as an independent word because word-final obstruent codas are not allowed.

The similarities between EMJ and Modern Japanese mentioned above make it feasible to test the findings from Sino-Japanese *kan-on* data on Modern Japanese. However, careful stimuli design is required to minimise the influence of the phonological differences.

Previous experimental studies on the perception and production of epenthetic vowels in Modern Japanese have focused on Western loanwords. For example, Mattingley, Hume, & Hall (2015) looks at whether Japanese speakers can identify which vowel occur between the

[18] Kilpatrick et al. (2021) conducted experimental studies to investigate whether native Japanese speakers perceive an illusory /i/ after /tʃ/. The illicit form [etʃpo] was assigned to the [etʃipo] category in 46% of the responses, with the default [u] still taking up more than 50%.

consonants in VCVCV forms; Shoji & Shoji (2014) conducts two orthographically based production experiments with acoustic and Roman orthographic pseudoword inputs, e.g. *gamb, *fmil; Mattingley; Mattingley, Hall & Hume (2019) carry out an orally based production experiment with Roman orthographic input of the structure ‘aCCa’. The similarity between the experimental stimuli in these studies is that the input vowel on the left of the epenthetic sites are monophthongs in the majority of cases (e.g. Dutch <doek> ‘canvas, sackcloth’ [duk] is adapted as [zukku] in Japanese), and in the rare cases diphthongs.

When the input is a monophthong or diphthong, it is straightforward for the epenthetic vowel to copy information from the input vowel. However, when the input on the left of the epenthetic site is more complex, for example a nucleus that has the structure VVV or VVG like in LMC, the adaptation is less straightforward. There have not been many vowel harmony cases with complex input nucleus in the loanword adaptation literature.

One example with complex nuclei is the adaptation of the five Standard Southern British English triphthongs, [ɔɪə] (e.g. ‘employer’), [aɪə] (e.g. ‘fire’), [eɪə] (e.g. ‘player’), [aʊə] (e.g. hour) and [əʊə] (e.g. ‘mower’), in Modern Japanese. Because these nuclei are already superheavy (contains three morae), they do not usually occur before a coda. Japanese does not allow superheavy syllables but it has syllables with initial glides /j w/. English words with the triphthongs that have a high front vowel in the middle [ɔɪə], [aɪə], [eɪə] are adapted as an open syllable followed by /ja:/, e.g. English ‘buyer’ [baɪə] is adapted as Japanese バイヤー /bai.ja:/, English ‘player’ [pleɪə] is adapted as Japanese プレイヤー /pu.rei.ja:/, and English words with the triphthongs that have a labial vowel in the middle [aʊə], [əʊə] are adapted as an open syllable followed by /wa:/ or /a:/, e.g. English ‘hour’ [aʊə] is adapted as Japanese アワー /a.wa:/, English ‘blower’ [bləʊə] is adapted as Japanese ブロアー /bu.ro.a:/. In the rare cases when the triphthongs do occur before a consonant in a word, because the triphthongs are adapted as two separate syllables in Japanese, the left of the epenthetic site for the consonant is no longer a complex VVV structure, e.g. English ‘loyal’ [lɔɪəl] is adapted as Japanese ‘ロイヤル’ /roi.ja.ru/, English ‘allowance’ [əlaʊəns] is adapted as Japanese アローワンス /a.ro:.wan.su/. It is important to note that some English triphthongs are in the process of monophthongisation. For example, in Received Pronunciation (RP), the word 'fire' which was traditionally pronounced with a triphthong [aɪə] is often being simplified to a diphthong [aɪ] or a monophthong [aː]. The consistent preservation of English triphthongs in Japanese loanwords could potentially be attributed to the influence of English orthography.

Contrary to the adaptation of English triphthongs, LMC nuclei that have a complex VVG structure are consistently adapted as one mora V or GV when they precede a coda consonant, e.g. LMC 夕 (evening, sunset) /sɦiajk/ is adapted as /seki/ in EMJ, LMC 更 (more, in addition) /kja:jŋ/ is adapted as /kaũ/ in EMJ. It is unclear whether this was due to some specific constraints that preferred contractions of LMC nuclei. It is obvious from the data, however, that EMJ speakers could perceive the complex nuclei and this is reflected in the differences of the epenthetic vowel.

4.2 Research questions

The data from the corpus study (Chapter 3) suggests that the quality of the epenthetic vowel is the result of the interaction between two factors: (1) the number of segments perceived in the nucleus of the source form, (2) the final glide. When the borrowers perceive less than 3 segments in the input nucleus, they insert the default epenthetic vowel /u/; when they perceive three segments in the input nucleus, vowel harmony applies: the place feature of the epenthetic vowel matches the input glide. EMJ adapts the complex nucleus from LMC into (G)V and the ‘information’ that does not fit in the adapted nucleus spreads to the epenthetic vowel. There are no data showing if the place of the Chinese coda has an influence on the epenthetic vowel.

This experimental study investigates what factors influence the quality of the epenthetic vowel and how those variables interact. Like the corpus study, this experimental study focuses on epenthetic vowels that are inserted in avoidance of coda consonants. Specifically, the study aims to answer the following research questions through a forced-choice test and a modified ABX test:

1. Loanword literature on Modern Japanese has shown that when speakers face words of a foreign structure, they tend to keep all details from the source form and insert the default epenthetic /u/, as opposed to deletion or contraction (Kubozono, 2015). Which epenthetic vowel will Modern Japanese speakers choose to adapt words that have the structure of LMC? If Modern Japanese speakers keep all details of the input nucleus, we would expect them to adapt the input as a few different syllables and add the default epenthetic vowel /u/ to the last syllable.
2. When given designed options (with different degrees of nucleus contraction), will Modern Japanese speakers adapt the words with the structure of LMC in the same way as EMJ speakers do? Will the quality and length of the nucleus in the input influence the quality of the epenthetic vowel in the adapted form?
3. Due to the distribution of Chinese codas, there are no items in the corpus study where the labial and coronal codas also follow a glide like the dorsal codas. This experiment tests whether the place feature of the coda consonant also has an influence on the quality of the epenthetic vowel.
4. Due to the distribution of the glide /w/ in the LMC source forms, there are no items in the corpus that have the structure V_1V_2w. According to the observed pattern for the glide /j/, we expect that when the source form has V_1V_2w, the epenthetic vowel

would be /u/, which shares place feature with the input glide /w/ (see Chapter 3). This experiment tests this hypothesis.

5. The corpus study shows that when the source nucleus has the structure /a:j/, the epenthetic vowel alternates between /i/ (10.3% of the instances) and /u/ (89.7% of the instances). A possible explanation of this alternation is that EMJ speakers have difficulties perceiving the vowel length in /a:/. This experimental study looks at whether Modern Japanese speakers could perceive the difference between /a:/ and /a/ from the input and if they adapt them differently.

4.3 Methodology

4.3.1 Experiment design

This study consists of two behavioural experimental tasks: a forced-choice task and a modified ABX task. Both tasks were designed with the software tool PsychoPy (Peirce et al., 2019). After the stimuli in both tasks were designed, two pilot studies were carried out to test the feasibility and suitability of the main experiments. The findings of the pilot studies were used to refine the main experimental design and procedure.

4.3.1.1 Forced-choice test

The forced-choice task looks at which epenthetic vowel Modern Japanese-speaking participants pick to adapt words with a structure of LMC. Before testing the historical adaptation pattern, we have to first understand what is the natural adaptation process in the modern language. We want to find out if Modern Japanese speakers prefer to keep all details from the input and insert the default epenthetic vowel as predicted by the Modern Japanese loanword literature (Research question 1).

In each trial, participants first listen to an auditory stimulus of a pseudoword that ends with a coda consonants, e.g. /kiajk/. Then, they are presented with two katakana (Japanese syllabary) characters on the screen, e.g. キ /ki/ and ク /ku/. They are asked which one of the katakana characters they will choose to write the “last sound” of the word they hear in Japanese. The Modern Japanese writing system uses a combination of the logographic kanji (each kanji represents a single syllable) and syllabic kana. It is therefore impossible to represent a single coda consonant in the written form. Katakana is one of the two Japanese syllabaries and is commonly used to write Western loanwords and Modern Chinese loanwords. Each katakana character represents a V or CV syllable (with the exception of ン which represents the bound moraic nasal /N/). Participants therefore have to naturally pick a vowel after the coda consonant they hear at the end of each stimulus. For example, if Japanese speakers hear [pik], they will have to write a k-initial syllable, like キ /ki/ or ク /ku/, to represent the last sound [k] in the stimulus.

The auditory stimuli are monosyllabic pseudowords and have the structures of LMC words. Section 4.3.2 gives details of the recording of all auditory stimuli in the pilot and main studies. Table 57 shows the structure of the stimuli. Because the focus of the experimental study is on the adaptation of the rime (i.e. nucleus, coda and the insertion of the epenthetic vowel), potential onset influences are controlled for. As shown in Table 55, coronals in Modern Japanese are subject to allophonic variations. Therefore, all stimuli in this study have the non-coronal onset [k] to avoid any potential influence of surface variations. The coda contexts included in the study are the dorsal [k] and labial [p]. All nuclei in the experiment have the same distribution – they can occur before both codas.

Table 57 Structures of stimuli for forced-choice study

<table>
<tr><th>Stimuli Structures</th><th>Onset</th><th>Nucleus</th><th>Coda</th></tr>
<tr><td>CVVC</td><td rowspan="2">k</td><td>VV</td><td rowspan="2">p k</td></tr>
<tr><td>CVVGC</td><td>VVG</td></tr>
</table>

The stimuli conditions and examples are shown in Table 58. The stimuli are coded for their nucleus length, glide, and coda place. There are overall 20 different auditory stimuli. The test follows a reverse counterbalanced design. Each auditory stimulus occurs twice in the stimuli list with the order of the katakana options swapped to prevent order effects. For example, when participants hear /kiajk/ for the first time, they are asked to choose between "キ ク"; when they hear /kiajk/ for the second time, the two options become "ク キ". Each participant has 40 trials in total, with 12 CVVjC stimuli, 12 CVVwC stimuli and 16 CVVC stimuli. The orders of the stimuli are randomised for each participant to avoid sequence effects. See Appendix A for the full stimuli list.

Table 58 Forced-choice experiment stimuli conditions and examples

Structure	Nucleus length	Glide	Coda Place	Example	Number of stimuli	Number of stimuli per participant/list
CVVGC	3	j	Dorsal	/kiajk/	3	12
			Non-dorsal	/kiajp/	3	
		w	Dorsal	/kiawk/	3	12
			Non-dorsal	/kiawp/	3	
CVVC	2	∅	Dorsal	/kaik/	4	16
			Non-dorsal	/kaip/	4	

According to the Modern Japanese literature, the expectation is that no matter the stimulus condition, participants will always choose the katakana with the epenthetic /u/. For example, for stimulus "kiajk", they will adapt it as "kja.i.ku", therefore choose "ク" /ku/ as the last "sound".

4.3.1.2 XAB test

After identifying how Modern Japanese speakers adapt foreign words, the next step is to create an experimental setting that will allow the testing of historical adaptation patterns. A XAB task is designed to investigate the historical adaptations. The XAB task is a modified ABX test. It differs from the standard paradigm in two ways:

1. In a traditional ABX study, participants are first presented with the two options and then the target stimuli. In this XAB task, the target stimuli are presented at the beginning, followed by the two options.
2. In an ABX test, X is identical with either A or B. In this XAB task, however, A and B are both different from X.

In each trial of the XAB task, participants first hear a pseudo "foreign word" that ends with a coda consonant, e.g. X = /kiajk/, then hear two Japanese ways of saying that foreign word, e.g. A = /keku/ and B= /keki/. They are asked to choose which one of the two Japanese ways (A & B) of saying that foreign word (X) is better. The A, B options follow the phonology of Sino-Japanese *kan-on.* For example, LMC /CiajC/ is adapted as /CeCi/ in Sino-Japanese *kan-on*. Modern Japanese speakers are forced to consider the only options available to them, and as such are forced to make decisions based on an EMJ adaptation strategy. The inversion of the order of X & AB is because in natural loanword adaptation scenarios, borrowers first hear the foreign word and then come up with the adapted form. The task presents the natural adaptation process in an experimental setting.

The X stimuli are the same as the stimuli in the forced-choice test. They follow the phonological structure of LMC. They are monosyllabic with an obstruent coda. The designs and examples are shown in Table 59. The conditions vary in terms of nucleus length, glide and coda place. There are 20 different X stimuli.

Table 59 XAB experiment stimuli X

X					
Structure	Nucleus length	Glide	Coda Place	Example	Number of stimuli
CVVGC	3	j	Dorsal	/kiajk/	3
			Non-dorsal	/kiajp/	3
		w	Dorsal	/kiawk/	3
			Non-dorsal	/kiawp/	3
CVVC	2	∅	Dorsal	/kaik/	4
			Non-dorsal	/kaip/	4

The conditions and examples of the A/B options stimuli are presented in Table 60. All stimuli are disyllabic. The first syllable is the adaptation of the onset and nucleus of X, and the second syllable is the adaptation of the coda of X and an epenthetic vowel. The nucleus of the first syllable (i.e. the adaptation of the input X nucleus) is either VV/GV (length = 2) or V (length = 1). The epenthetic vowel is either /i/ or /u/.

Table 60 XAB experiment stimuli A/B

A/B			
Structure	First nucleus length	Epenthetic vowel	Example
CGV.CV CVV.CV	2	i	/kjaki/
		u	/kjaku/
CV.CV	1	i	/keki/
		u	/keku/

Each X can be matched with 4 different types of A – B pairs, as shown in Table 61. The 4 types fall into two classes:

Class I: The nucleus adaptation is controlled, and the variable is the epenthetic vowel. The variable has two values, /i/ and /u/. This condition is designed to investigate when the input nucleus is contracted in the adapted form (i.e. not all information from the source nucleus can fit into the adapted nucleus), whether Modern Japanese speakers will employ the vowel harmony strategy like EMJ speakers. There are two types of A – B pairs within this condition, as shown below.

Type 1: Both A and B have a long first nucleus VV/GV: CGVCi – CGVCu, or CVVCi – CVVCu

Type 2: Both A and B have a short first nucleus V: CVCi – CVCu

A comparison between type 1 and 2 will show if the degree of nucleus contraction has an influence on the likelihood of the application of vowel harmony.

Class II: The epenthetic vowel is controlled, and the variable is the nucleus adaptation. The variable has two values, length = 1 and length = 2. This condition is designed to test if Modern Japanese speakers have a preference for the different degrees of contraction of the nucleus adaptation. There are two types of A – B pairs within this condition, as shown below.

Type 3: Both A and B have the epenthetic /u/: CGVCu or CVVCu – CVCu

Type 4: Both A and B have the epenthetic /i/: CGVCi or CVVCi – CVCi

A comparison between type 3 and 4 will show whether the different epenthetic vowels have an influence on Modern Japanese speakers' preference on the nucleus adaptation.

There are 80 XAB combinations (20 X stimuli * 4 types of AB pairs) and another 80 combinations with the AB options presented in the reversed order, making a total of 160 trials.

Table 61 X-AB matching

X		A – B pairs							
Structure	Example	Class	First nucleus	Epenthetic V	Type	Structure		Example	
CVVGC	/kiajk/	I	same	different	1	CGVCi	CGVCu	/kjaki/	/kjaku/
					2	CVCi	CVCu	/keki/	/keku/
		II	different	same	3	CGVCu	CVCu	/kjaku/	/keku/
					4	CGVCi	CVCi	/kjaki/	/keki/
CVVC	/kaik/	I	same	different	1	CVVCi	CVVCu	/kaiki/	/kaiku/
					2	CVCi	CVCu	/keki/	/keku/
		II	different	same	3	CVVCu	CVCu	/kaiku/	/keku/
					4	CVVCi	CVCi	/kaiki/	/keki/

This XAB task is more challenging for participants than the forced-choice task. In the forced-choice task, participants could adapt the pseudoword freely in their mind and they only need to choose an epenthetic vowel to complete the task. Both epenthetic vowel options exist in Modern Japanese, with one being the default option. In the XAB task, however, the AB options are not possible adaptation forms of X according to Modern Japanese phonology. Participants will consider both A and B as bad options in Modern Japanese but they will have to make the difficult decision to pick one that is better. We expect longer processing time for each trial. It is therefore important to control the duration of the experiment to be within participants' attention span and not to exhaust them too much that they will start to give random responses. The XAB paradigm also induce an inbuilt asymmetry in processing time. The mean RT for B responses is expected to be faster than that for A, because B is the option participants hear immediately before making the decision, while A responses require accessing the memory. To control the processing intensity and at the same time avoid the AB order effect, the XAB test adopts an across subjects counterbalanced design. The 160 trials are split into two lists of 80 trials, with half of the participants doing list 1 and the other half doing list 2. The two lists are designed by counterbalancing the AB order and type (a modified Latin square design). In each list, every X stimulus is matched with all 4 types of AB pairs once, with 2 in the normal order and 2 in the reversed order. See Appendix A for the full stimuli lists.

The predictions for the XAB Class I stimuli are shown in Table 62. The 'less than' symbol '<' is used to show the relation of the percentage of epenthetic /i/ and epenthetic /u/ in the responses. The number of symbols represent the degree, i.e. how much higher is the percentage of one epenthetic vowel than the other. The nucleus adaptation in the AB options is controlled, and the variable is the epenthetic vowel. The default epenthetic /u/ is predicted to be the dominant response (over 60%) across all conditions. The number of epenthetic /i/ responses is expected to vary by stimuli conditions.

<u>X = /CVVC/:</u>

Type 1 A – B pairs: will have almost only epenthetic /u/ responses because it is the natural adaptation process for Modern Japanese speakers – the nucleus is not contracted in the adapted forms so the default epenthetic /u/ will be inserted.

Type 2 A – B pairs: the nucleus is contracted by 1 segment, and we expect there to be some epenthetic /i/ when the second V in the input nucleus is /i/.

<u>X = /CVVwC/:</u>

Type 1 A– B pairs will also have mainly epenthetic /u/ responses because the glide /w/ shares the place features [DORSAL, HIGH] with the epenthetic /u/.

Type 2 A – B pairs might have a small number of epenthetic /i/ responses because firstly, the adapted nucleus in the AB options are so contracted that it might cause some processing difficulties for the participants and thus elicit higher 'error rate', and secondly the first V in the input nucleus is /i/ or /y/, and it shares the place features [CORONAL, HIGH] with the epenthetic /i/. It is an open question whether there will be more epenthetic /i/ for type 2 A – B pairs when X = /CVVC/ or when X = /CVVwC/.

X = /CVVjC/:

Type 1 A – B pairs will elicit some epenthetic /i/ because the input nucleus is contracted by 1 segment and the glide /j/ shares place features [CORONAL, HIGH] with epenthetic /i/ (similar to X = /CVVC/ type 2 A – B pairs when input second V = /i/);

Type 2 A – B pairs are predicted to elicit the most number of epenthetic /i/ of all conditions because the nucleus is contracted by 2 segments in the adapted form and the glide /j/ as well as the first V /i/ or /y/ share place features with epenthetic /i/. Whether the coda place has an influence on the quality of the epenthetic vowel is an open question, as the corpus data does not give us enough evidence to make any predictions.

Table 62 XAB Class I experiment predictions by stimuli. For the example column, all nucleus are marked in blue, epenthetic /i/ are in red and epenthetic /u/ are in purple.

X		A – B					Prediction
Structure	Example	Type	Structure		Example		
CVVC	/kaik/	1	CVVCi	CVVCu	/kaiki/	/kaiku/	/i/ <<< /u/
		2	CVCi	CVCu	/keki/	/keku/	/i/ << /u/
CVVwC	/kiawk/	1	CGVCi	CGVCu	/kjaki/	/kjaku/	/i/ << /u/
		2	CVCi	CVCu	/keki/	/keku/	/i/ << /u/
CVVjC	/kiajk/	1	CGVCi	CGVCu	/kjaki/	/kjaku/	/i/ << /u/
		2	CVCi	CVCu	/keki/	/keku/	/i/ < /u/

In terms of reaction time, we predict longer processing time for longer X and shorter AB options. Participants need more time when the input is complex or when the options deviate notably from the natural adaptation in Modern Japanese.

Each Class II A – B pair has the same epenthetic vowel but different adaptations of the nucleus. The nucleus adaptations have either two segments VV/GV (long), or one segment V (short). We expect longer adapted nuclei to be preferred over shorter ones across all conditions (> 60%) because Modern Japanese speakers prefer to keep all information from foreign words as shown in the pilot study. The percentage of short nucleus responses is predicted to vary by condition. The predicted data pattern is shown in Table 63.

<u>X = /CVVC/</u>:

Type 3 A – B pairs are expected to have the highest percentage of long nuclei, because /CVVC/ inputs are naturally adapted as /CVVCu/ in Modern Japanese. All information from the input nuclei is kept in the adapted form and the default epenthetic vowel /u/ is inserted.

Type 4 A – B pairs might have some short nuclei responses, because /CVVCi/ is an apparent violation of the default Modern Japanese vowel epenthesis patten and /CVCi/ could be a better option especially when the input nucleus /VV/ ends in /i/, e.g. /CaiC/.

<u>X = /CVVwC/</u>:

Type 3 A – B pairs are predicted to have almost all long nuclei because /CGVCu/ is the metathesised form of /CVVwC/, so it would be much more natural than /CVCu/ for native speakers.

Type 4 A – B pairs might have some short nuclei responses. The long nucleus option /CGVCi/ is nowhere close to the /CVVwC/ input/ For example, when the input is /CiawC/, the long nucleus option /CjaCi/ lost the /w/ from the input and does not have the default epenthetic vowel /u/. There are no [DORSAL, HIGH] features at all in the output. On the other hand, the short nucleus /V/ in the /CVCi/ option at least is a plausible contraction of the input nucleus. For example, the input /iaw/ has a high front vowel, a high back glide and a low vowel, and the output /e/ is a mid vowel that is in the middle of the three input segments in the vowel space. However, both short and long options are expected to be considered as very bad options by Modern Japanese speakers.

X = /CVVjC/: stimuli are predicted to have the highest percentage of short nuclei responses.

Type 3 A – B pairs, Modern Japanese speakers might feel it is unnatural to adapt a /VVj/ nucleus as /GV/ because they prefer to keep all information from the nucleus but the place features of the final glide /j/ is left out, e.g. /iaj/ is adapted into /ja/ without the input /j/. The /CVCi/ option, however, shortens the /VVj/ input into a single vowel /V/ that combines the place features of the input nuclei, e.g. /iaj/ is a combination of two high front segments and a low vowel, and the nucleus adaptation is shortened into a mid front vowel /e/. The shorter option therefore could be preferred by some speakers in this case.

Type 4 A – B pairs: The /CVCi/ option follows the adaptation pattern in EMJ. As shown in the corpus study in Chapter 3, /V_1V_2j/ nuclei were consistently adapted as /e/ in EMJ, and /V_0V_0j/ nuclei were also adapted as /e/ in some cases when followed by a coda. There is therefore a chance that Modern Japanese speakers would accept the short nucleus adaptation better for this stimuli condition.

Table 63 XAB Class II experiment prediction by stimuli. For the example column, all nuclei are marked in blue, epenthetic /i/ are in red and epenthetic /u/ are in purple.

X		A – B					Prediction
Structure	Example	Type	Structure		Example		
CVVC	/kaik/	3	CVVCu	CVCu	/kaiku/	/keku/	short <<< long
		4	CVVCi	CVCi	/kaiki/	/keki/	short << long
CVVwC	/kiawk/	3	CGVCu	CVCu	/kjaku/	/keku/	short << long
		4	CGVCi	CVCi	/kjaki/	/keki/	short << long
CVVjC	/kiajk/	3	CGVCu	CVCu	/kjaku/	/keku/	short < long
		4	CGVCi	CVCi	/kjaki/	/keki/	

In terms of reaction time, we predict longer processing time for Type 4 stimuli because /i/ is not a normal candidate for vowel epenthesis in Modern Japanese. Short nuclei responses are predicted to have longer RT than long nuclei responses because they deviate more from the Modern Japanese nucleus vowel adaptation pattern.

4.3.1.3 Pilot studies

Two pilot studies were carried out to facilitate the design of the main study. The first pilot study was designed to see how Japanese speakers would adapt foreign words in katakana. It was conducted to further the understanding of the natural adaptation process in Modern Japanese and evaluate the design of the forced-choice task. The stimuli were 50 auditory monosyllabic pseudowords following the same stimuli structure as in the main study: /kVVGk/ /kVVGp/ /kVVk/ or /kVVp/. However, more /VV/ and /VVG/ combinations were used in the pilot study than in the main study. See Appendix for the full stimuli list.

Four native Japanese speaking consultants who were based in Tokyo, Japan took part in the first pilot study. The consultants were asked to listen to each pseudoword twice and type what they heard in katakana.[19] The focus was on the way the consultants adapted the nucleus and which epenthetic vowel, if any, they chose.

The result of the first study showed that:

1. All consultants tended to keep all information from the nucleus. None of them chose to regularly contract the nucleus. For example, /uaw/ was adapted as /uwau/; /yaj/ was adapted as /joai/.
2. Consultants adapted /V_1V_2/ and /V_0V_0G/ (when it is a long vowel + glide sequence) nucleus in similar ways, but there were many more variations in the way they adapted /V_1V_2G/ nuclei. For example, /aːj/ was adapted as /ai/ by all four consultants; /ia/

[19] The stimuli were monosyllabic and only around 500-700 ms in duration. The consultants were, therefore, instructed to listen to each stimulus twice in case they did not hear the stimuli clearly the first time.

was adapted as /ja/ by three consultants and /ja:/ by one consultant; /uaj/, however, has four different adapted forms /u:wai, uwai, uai, uaiu/; similarly /auj/ was adapted as /auju, awaju, aju:, ai:/.

3. Three out of four consultants adapted all codas with the insertion of an epenthetic vowel. One consultant chose consonant deletion over vowel epenthesis in most of the cases. According to Shoji and Shoji (2014), vowel epenthesis is the dominant adaptation strategy, and consonant deletion is chosen when speakers do not perceive the input segment. In order to understand whether the deletions were due to perception or a conscious choice, we checked with the consultant about the reason he adapted the pseudowords in this way, and learned that he did hear the last consonants but thought that they were difficult to be written in katakana.
4. All epenthetic vowels inserted were the default vowel /u/ with no exception.

The result of pilot study 1 informed the design of the main study in the following ways:

1. The forced-choice paradigm is suitable for the purpose of the research. If participants were given the freedom to write down the whole adapted words like in the pilot study, there would be more variation in the adaptation strategy and choice of vowels for the input nucleus, and it would also be more time consuming. The forced-choice design controls the variables and experiment duration by giving participants only two epenthetic vowel options. Participants are forced to adapt by vowel epenthesis instead of consonant deletion. It is not of interest for this study to look at how exactly each input nucleus is adapted quality-wise in Modern Japanese, as long as structure-wise there is no contraction or reduction like that in EMJ.
2. The choice of non-coronal codas /k p/ successfully controlled the epenthetic vowel variations in Modern Japanese related to allophonic variation.

3. The codas in the main study auditory stimuli were more carefully pronounced, i.e. no devoicing and with greater acoustic amplitude, to minimise the perception influence as shown in Shoji & Shoji (2014).

The second pilot study was conducted to assess and assist the design of the XAB task. The settings were similar to that of the main XAB study. It was a small-scale and simplified version of the main study. Consultants heard a monosyllabic pseudoword of the structure CVVC or CVVGC, then they had to choose between two Japanese adaptations of that foreign word presented in written forms. The stimuli are a subset of that for the XAB task. Table 64 shows the list of stimuli. The input stimuli X were auditory and the adaptation options A/B were written in Japanese katakana script. The A/B options differ in the epenthetic vowel (/i/ vs /u/) and nucleus adaptation (/ja/ vs /e/). In each trial, an auditory input X was matched with an A – B pair, and the pairs follow the same 4 types as in the main study. There were 6 different X inputs and a total of 24 trails (6 * 4 types of A – B pair). The order of the adaptation options AB vs BA were counterbalanced across subjects. The trials were randomised for each consultant, and the trials with the same X input did not occur consecutively. Two native Japanese-speaking consultants who were based in Tokyo, Japan took part in this second pilot test.

Table 64 Pilot study 2 stimuli design

Auditory input (X)	Input structure	Adaptation options (A/B)			
kiak	CVVC	keku	keki	kjaku	kjaki
kiap	CVVC	kepu	kepi	kjapu	kjapi
kiajk	CVVGV	keku	keki	kjaku	kjaki
kiajp	CVVGV	kepu	kepi	kjapu	kjapu
kyajk	CVVGV	keku	keki	kjaku	kjaki
kyajp	CVVGV	kepu	kepi	kjapu	kjapi

The findings of the second pilot study are shown below:

1. When the A – B pairs have the same epenthetic vowel but different nucleus adaptation (see Section 4.3.1.3 A – B pair Class II Type 3 & 4), both consultants chose the longer nucleus /ja/ over the shorter /e/ as the adapted form of the input

nucleus, showing that Modern Japanese speakers have a clear preference of keeping as much details as possible from the input. This result is consistent with the Modern Japanese loanword literature (e.g. Kubozono, 2015) and the findings of the first pilot study.

2. When the A – B pairs have the same nucleus adaptation but different epenthetic vowel (see Section 4.3.1.3 A – B pair Class I Type 1 & 2), the two consultants gave different responses.

   Consultant 1: Consultant 1 was very consistent in choosing the default epenthetic vowel /u/ for all trials. Even when the input stimulus was /kiajk/ and one of the adaptation options was /kjaki/, no metathesis was elicited.

   Consultant 2: Consultant 2's responses, however, followed a pattern that is closer to the prediction of the XAB study. The results are shown in Table 65 with the responses marked by the tick symbol '✓'. For all CVVC inputs, the default epenthetic vowel /u/ was selected. Based on the natural adaptation result shown in pilot study 1, /kjaCu/ is the natural way to adapt /kiaC/ in Modern Japanese. When the nucleus is contracted from /ja/ to /e/, Consultant 2 still chose the default vowel /u/. For the superheavy syllable CVVGC inputs, however, there was 1 epenthetic /i/ for type 1 A – B pairs (both A and B have a long first nucleus, /kjaki/ vs /kjaku/), and 2 epenthetic /i/ for type 2 A – B pairs (both A and B have a short first nucleus, /keki/ vs /keku/). It seemed that Consultant 2 preferred epenthetic /i/ more for the short nucleus /e/ than for long nucleus /ja/ in the options, indicating the possibility that the choice of /e/ in the nucleus influences the choice of the epenthetic /i/. It is unclear, however, if the coda place has any influence. Within type 2 A – B pairs, when the coda in the input X was the dorsal /k/ (input /kiajk/ and /kyajk/), the consultant chose /keki/ over /keku/; when the coda in X was the non-dorsal /p/ (input

/kiajp/ and /kyajp/), the consultant chose /kepu/ over /kepi/. It seems as if a vowel harmony applies only when the coda is dorsal but not when it is non-dorsal. This is not the case for type 1 A – B pairs. The only epenthetic /i/ was chosen for the input that ends with the non-dorsal coda /p/.

Table 65 Pilot study 2 consultant 2 result. The answers are shaded in light blue.

Auditory input (X)	Input structure	Adaptation options (A/B)	
Type 1 A – B pairs (both A and B have a long first nucleus)			
kiak	CVVC	kjaku ✓	kjaki
kiap		kjapu ✓	kjapi
kiaik	CVVGC	kjaku ✓	kjaki
kiaip		kjapu ✓	kjapi
kyaik		kjaku ✓	kjaki
kyaip		kjapu	kjapi ✓
Type 2 A – B pairs (both A and B have a short first nucleus)			
kiak	CVVC	keku ✓	keki
kiap		kepu ✓	kepi
kiaik	CVVGC	keku	keki ✓
kiaip		kepu ✓	kepi
kyaik		keku	keki ✓
kyaip		kepu ✓	kepi

The result of the second pilot study suggests that it is possible to test the historical adaptation pattern with Modern Japanese speakers. Although Consultant 2's responses do not neatly follow the pattern of Sino-Japanese *kan-on*[20], they indicate that the XAB setting can elicit responses that deviate from the standard Modern Japanese default or constraints, and are closer to that of EMJ. As epenthetic /u/ is the default epenthetic vowel in Modern Japanese as shown in both pilot studies, we expect /u/ to still be the dominant answer in the main study, same as the earlier prediction for the XAB result. This pilot study verified the feasibility of the main XAB study. However, because the performance of one native Japanese speaker is not representative and, as will be discussed in Section 4.3.1.3, the XAB

[20] Given the nature of the study, which is a psycholinguistic experiment testing historical patterns, we did not expect any single Modern Japanese speaker to show the exact neat pattern of the historical adaptation.

task is challenging for Modern Japanese speakers, a broad statistical basis is needed for the main study.

4.3.2 Recording

The pilot study stimuli and forced-choice study stimuli, which are also the X stimuli in the XAB study, were recorded by a female native speaker of Standard Chinese who was trained in phonetics. Standard Chinese is a tonal language and it would be unnatural for Chinese long syllables to be toneless. All stimuli pronounced by the Chinese speaker had the falling tone as it is phonetically similar to words in non-tonal languages pronounced in isolation. In order to minimise the chance of deletion (instead of epenthesis), as informed by the pilot study, the coda consonants in the forced-choice and XAB tasks were carefully pronounced, i.e. pronounced with the same acoustic amplitude as the onset and nucleus, to make sure participants can clearly perceive them. The A, B stimuli in the XAB task were recorded by a native speaker of Modern Japanese. The recordings took place in a sound-attenuating booth in the Language and Brain laboratory at the University of Oxford with professional audio recording equipment. All stimuli were then edited in Praat (Boersma & Weenink, 2022) with the volume equalised.

4.3.3 Participants

The study recruited 30 volunteers who were native Japanese speakers aged between 18 and 50. They were born to at least one native Japanese-speaking parent. They reported normal or corrected-to-normal vision and reported no hearing or any other impairment. As the stimuli are pseudowords, participants' proficiency in other modern languages was not expected to influence the result. However, for ease of communication, all participants were expected to have basic English proficiency. Participants were recruited through departmental mailing lists, noticeboards, social networking sites and friends. They were first informed about the topic, participant criteria and general information of the experiment. Those who showed interest in participating received an email with the information sheet which had the details of the experiment, and a link to book designed time slots to participate in the experiment. On the day of the experiment, before the tasks started, participants were shown a paper copy of the information sheet again to make sure they understood what participation involved and what they were expected to do. They were then asked to sign a consent form, adhering to the University ethics policy for research.[21] After the experimental session, participants received compensation for their time and effort.

4.3.4 Experimental procedure

The experiments were carried out in the Language and Brain Laboratory at the University of Oxford. To validate the experimental design, a native Japanese speaking consultant was invited to the lab to do a test run of the study. Her feedback was used to tailor the instructions for the tasks. In the actual study, all instructions were given both orally and on the computer screen in English with examples in Japanese. Each experimental session lasted around 30-40 minutes.

For the forced-choice task, participants were told that they would hear “foreign words”, but that they were not real words from another language, so their proficiency in any other language would not influence the result. They would then see two katakana characters on the screen. They had to decide which character is the one that they would use to write the last sound of the foreign word in Japanese. The characters appeared on the two sides of the screen. Participants were asked to press the key labelled “1” to choose the character on the

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[21] This study has received ethics approval from a subcommittee of the University of Oxford Central University Research Ethics Committee (Ethics reference: R76652/RE002). See Appendix C & D for the information sheet and consent form.

left of the screen and “2” to choose the character on the right of the screen. The label “1” is on key A and the label “2” is on key L on a MacBook Air laptop ANSI keyboard. Those two keys were chosen because they are on the two ends of the keyboard and they are comfortable for the index fingers to press on. Participants were then given examples to help them further understand the task. For example, they would see the following on the screen “You hear 'map' → You have to choose whether you would use プ (マップ) or ピ (マッピ) to write the last sound in 'map'”. There was a training session which consisted of 10 trials to help participants practice. If participants were happy with the training, they could proceed to the main experiment. There were a total of 40 trials in 4 groups (10 trials per group) and a 5-second break between each group.

For the XAB task, participants were instructed that they would hear a “foreign word” and then hear two Japanese ways of saying that word. When they heard the “foreign word”, there would be an “X” on the screen. The X had no meaning other than a “foreign word is being played”. Participants were once again being reminded that the “foreign word” was not a real word in any language. When participants heard the first Japanese way of saying the word, the screen would display “1”, and when they heard the second one, the screen would display “2”. They had to decide which one of the two Japanese words sounded more natural as a Japanese form of the foreign word by pressing “1” for the first Japanese word and “2” for the second one. The two labelled keys are the same as the ones in the forced-choice task. Participants were given examples on the screen: “You hear the X word ‘cake’ in English, then hear 1 ケーキ and 2 ケーク → You have to choose between ケーキ and ケーク, which one sounds more natural as a Japanese form for the foreign word ‘cake’”. Participants then did a training session of 10 trials. The main experiment consisted of 80 trials in 5 groups (16 trials per group). Participants had an 8-second break between each group.

For both tasks, participants were instructed to give their responses as fast as they could and were told that both their reaction time and answer would be recorded. For the forced-choice test, participants had 3 seconds to give a response in each trail before it automatically moved on to the next trial. For the XAB test, they had 5 seconds for each trail. However, participants were also being reassured that it was not a test so there was no need to be stressed, and that as long as they followed their first intuition, they should be fine with the timing. The response was more important than the speed.

4.4 Results

4.4.1 Forced-choice test

4.4.1.1 Stimuli and predictions recap

For the ease of reference, the stimuli conditions and examples in the forced-choice study are repeated here in Table 66. The stimuli were designed by structure/nucleus length (CVVGC vs CVVC), glide (/j/ vs /w/ vs ∅) and coda place (dorsal vs non-dorsal). The prediction is that Modern Japanese speakers always choose the default epenthetic /u/ regardless of the structure and quality of the input nucleus.

Table 66 Forced-choice experiment stimuli conditions and examples

Structure	Nucleus length	Glide	Coda Place	Example	Number of stimuli	Number of stimuli per participant/list
CVVGC	3	j	Dorsal	/kiajk/	3	12
			Non-dorsal	/kiajp/	3	
		w	Dorsal	/kiawk/	3	12
			Non-dorsal	/kiawp/	3	
CVVC	2	∅	Dorsal	/kaik/	4	16
			Non-dorsal	/kaip/	4	

4.4.1.2 Data cleaning

There were a total of 1200 data points (40 trials * 30 participants) collected from the forced-choice test. 5 data points did not have any response recorded as the subjects did not react within the 2-second given time. Data points with RT smaller than 250 ms or more than 3 standard deviations from the mean (> 1868.77 ms) were excluded as outliers. RTs smaller than 250 ms could be the result of fast guesses or unintended presses, and RTs bigger than 3 standard deviations from the mean is beyond the normal time needed for this psychological process. In order to check if any participants have bias towards one of the response keys, the relationship between response key (Y) and participant (X) were analysed by Pearson's chi-squared test. All participants showed genuine behaviour ($\chi^2 = 2.461, p = 1.000$) and no data is excluded. After the cleaning process, 2.25% of data (27 data points) were removed, with 1173 data points remaining.

4.4.1.3 Response analysis

Table 67 shows the total number of epenthetic /i/ and /u/ responses. Participants picked the default epenthetic /u/ in almost all the cases (97.95%).

Table 67 Forced choice study result – response overview

Responses	Number of response	Percentage
Overall	1173	100.00%
Epenthetic /i/	24	2.05%
Epenthetic /u/	1149	97.95%

Pearson's chi-square tests were performed to test the relationship between the dependent variable (response) and each independent variables (nucleus length, glide and coda place). A summary of the results is shown in Table 68. The nucleus length ($p = 0.7888$) and coda place ($p = 0.3789$) do not have influence on the choice of the epenthetic vowel. The input glide has significant effect on the quality of the epenthetic vowel ($p = 0.0026$).

Table 68 Pearson's chi-square tests for forced-choice independent variables. Statistically significant results are in bold with the p-value in red.

Variable	χ^2	*p*-value
nucleus length	0.072	0.7888
glide	11.927	**0.0026***
coda place	0.774	0.3789

Table 69 is the contingency table for glide (independent variable) and epenthetic vowel (dependent variable). Out of 24 epenthetic /i/ responses, 14 were elicited by inputs with glide /j/, 9 were elicited by inputs without a glide (CVVC structure) and only 1 was elicited by inputs with glide /w/. The 14 epenthetic /i/ with input glide /j/ could be the result of [CORONAL, HIGH] vowel harmony triggered by the experimental settings. It is unclear however, whether there is any information from the input nucleus of the 9 CVVC stimuli that influences the choice of epenthetic /i/.

Table 69 Contingency table - Epenthetic vowel (Y) by Glide (X)

			EpentheticVowel		
			i	u	Total
Glide	∅	Count	9	462	471
		% within Glide	1.9%	98.1%	100.0%
		% within EpentheticVowel	37.5%	40.2%	40.2%
	j	Count	14	339	353
		% within Glide	4.0%	96.0%	100.0%
		% within EpentheticVowel	58.3%	29.5%	30.1%
	w	Count	1	348	349
		% within Glide	0.3%	99.7%	100.0%
		% within EpentheticVowel	4.2%	30.3%	29.8%
Total		Count	24	1149	1173
		% within Glide	2.0%	98.0%	100.0%
		% within EpentheticVowel	100.0%	100.0%	100.0%

The input nuclei of the 9 CVVC stimuli are summarised in Table 70. In the very rare cases when Modern Japanese speakers choose epenthetic /i/ for CVVC input, there are more (6 out of 9) input nuclei with a [CORONAL, HIGH] segment (i.e. one of the segments have [CORONAL, HIGH] features, could be the first or the second vowel), than without. If the 15 CVVGC stimuli are also considered, then 20 out of 24 (83.33%) data points have [CORONAL, HIGH] features in the input stimuli.

Table 70 CVVC nuclei of the 9 epenthetic /i/ responses

Input nucleus VV	Feature	Count
ia ya ai	[CORONAL, HIGH]	6
au	no [CORONAL, HIGH]	3

However, because the number of epenthetic /i/ is so low (less than 30), neither the statistical significant result nor the descriptive overview above have a strong predictive power. The main conclusion from the response analysis is that Modern Japanese speakers strongly prefer the default epenthetic /u/ in loanwords adaptation for any type of input nucleus. In the rare situations when they choose epenthetic /i/, there might be some influences from the high front vowel in the input nucleus.

4.4.1.4 Reaction time analysis

The distribution of the RT data is shown in Figure 12. The Shapiro–Wilk test of normality shows that the data does not follow a normal distribution (W = 0.8393, p < 0.0001).

Figure 12 Forced-choice: distribution of RT histogram

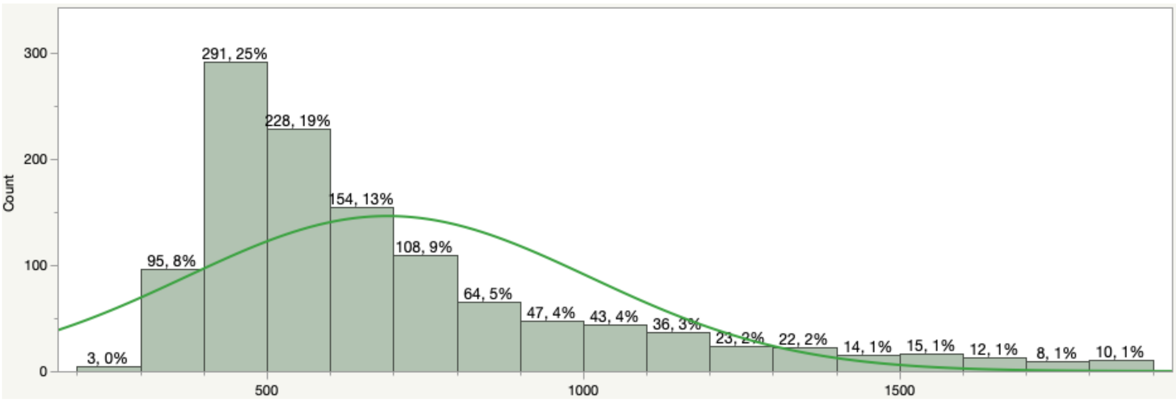


Table 71 presents an overview of the reaction time (RT) by response. The overall mean RT is 691.02 ms and the standard deviation is 319.51 ms. The mean RT for responses of epenthetic /i/ is 1018.88 ms, which is 334.71 ms more than the mean RT for responses of epenthetic /u/ (684.17 ms). The high standard deviation (480.36 ms) for RTs of epenthetic /i/ responses indicate that the data is very spread out from the mean.

Table 71 Forced choice result – RT by response

Responses	Mean RT (ms)	Standard deviation (ms)
Overall	691.02	319.51
Epenthetic /i/	1018.88	480.36
Epenthetic /u/	684.17	311.94

The nonparametric hypothesis test used in this analysis is the Wilcoxon rank-sum test (or Mann-Whitney U test).[22] The test ranks all the values from low to high, and then compare the means of the ranks. Table 72 shows the result of the Wilcoxon rank-sum test for epenthetic vowel response and RT. The RT mean rank for epenthetic /i/ responses is statistically significantly higher than the RT mean rank for epenthetic /u/ responses (U = 8301.00, Z = -3.341, $p < 0.001$).

Table 72 Forced-choice result – Wilcoxon rank-sum test for response and RT. The statistically significant variable is in bold with the p-value in red.

Variable	*U*	Z	*p*-value
Epenthetic vowel	8301.00	-3.341	**< 0.001***
		Value	Mean Rank
		epenthetic /i/	815.63
		epenthetic /u/	582.22

The independent variables (nucleus length, glide, coda place, as well as response key), were also assessed by the Wilcoxon rank-sum tests. The statistics in Table 73 shows that the RT for CVVC (nucleus length = 2) input is significantly faster than the RT for CVVGC (nucleus length = 3) input (U = 147834.00, Z = -3.9745, p = 0.002). Participants had significantly longer processing time for longer input than shorter ones.

Table 73 Forced-choice result – Wilcoxon rank-sum test for nucleus length and RT. The statistically significant variable is in bold with the p-value in red.

Variable	*U*	Z	*p*-value
nucleus length	147834.00	-3.075	**0.002***
		Value	Mean Rank
		2	549.87
		3	611.91

Among the data points with CVVGC inputs, a test was run for the glide /j/ vs /w/ (Table 74). The RT for CVVjC input and CVVwC input are not significantly different (U =

[22] The Wilcoxon rank-sum test is used to compare the differences between two independent groups. When the values of an independent variable separate the data into three or more independent groups, the Kruskal–Wallis test is used instead, as shown in the analysis of the RT data in the XAB study in Section 4.4.2.

61299.00, Z = 0.111, p = 0.911). The difference in mean rank for glide /w/ and /j/ is only 1.71.

Table 74 Forced-choice result – Wilcoxon rank-sum test for glide j vs w and RT

Variable	U	Z	p-value
glide (j vs w)	61299.00	0.111	0.911
		Value	Mean Rank
		w	350.65
		j	352.36

The place of the coda has significant influence on RT (Table 75). Participants reacted to stimuli with dorsal codas (mean rank 550.72) significantly (U = 150928.00, Z = -3.627, p < 0.001) faster than stimuli with non-dorsal codas (mean rank 622.48). This could be due to the fact that dorsal codas and the default epenthetic /u/ share the place feature [DORSAL].

Table 75 Forced-choice result – Wilcoxon rank-sum test for coda place and RT. The statistically significant variable is in bold with the p-value in red.

Variable	U	Z	p-value
coda place	150928.00	-3.627	**< 0.001***
		Value	Mean Rank
		dorsal	550.72
		non-dorsal	622.48

There is no response key induced RT bias (Table 76; U = 171934.00, Z = 0.010, p = 0.992). The mean rank for response key 1 is only 0.2 different from the mean rank for response key 2.

Table 76 Forced-choice result – Wilcoxon rank-sum test for response key and RT

Variable	U	Z	p-value
response key	171934.00	-0.10	0.992
		Value	Mean Rank
		key 1	586.90
		key 2	587.10

To conclude, the RT is significantly influenced by response, X nucleus length and coda place. Participants needed more processing time for the non-default epenthetic /i/ responses, for longer input nucleus and for non-dorsal codas.

4.4.2 XAB Test

4.4.2.1 Stimuli recap

The stimuli of the XAB task are re-presented here in Table 77 and Table 78. To recap, the X stimuli are the same as the forced-choice stimuli (designed by nucleus length/structure, glide and coda place), and each X can be matched with 4 different types of A – B pairs that fall under 2 experimental conditions:

Class I: The nucleus adaptation is controlled, and the variable is the epenthetic vowel.

Type 1: Both A and B have a long first nucleus VV/GV: CGVCi – CGVCu, or CVVCi – CVVCu

Type 2: Both A and B have a short first nucleus V: CVCi – CVCu

Class II: The epenthetic vowel is controlled, and the variable is the nucleus adaptation.

Type 3: Both A and B have the epenthetic /i/: CGVCi or CVVCi – CVCi

Type 4: Both A and B have the epenthetic /u/: CGVCu or CVVCu – CVCu

Table 77 X stimuli in the XAB task

X					
Structure	Nucleus length	Glide	Coda Place	Example	Number of stimuli
CVVGC	3	j	Dorsal	/kiajk/	3
			Non-dorsal	/kiajp/	3
		w	Dorsal	/kiawk/	3
			Non-dorsal	/kiawp/	3
CVVC	2	∅	Dorsal	/kaik/	4
			Non-dorsal	/kaip/	4

Table 78 X-AB pairs in the XAB task

X		A – B pairs							
Structure	Example	Class	First nucleus	Epenthetic V	Type	Structure		Example	
CVVGC	/kiajk/	I	same	different	1	CGVCi	CGVCu	/kjaki/	/kjaku/
					2	CVCi	CVCu	/keki/	/keku/
		II	different	same	3	CGVCi	CVCi	/kjaki/	/keki/
					4	CGVCu	CVCu	/kjaku/	/keku/
CVVC	/kaik/	I	same	different	1	CVVCi	CVVCu	/kaiki/	/kaiku/
					2	CVCi	CVCu	/keki/	/keku/
		II	different	same	3	CVVCi	CVCi	/kaiki/	/keki/
					4	CVVCu	CVCu	/kaiku/	/keku/

In each experimental trial, participants first heard a pseudoword that ends with a coda consonant, e.g. X = /kiajk/, then heard two Japanese ways of adapting that foreign word, e.g. A = /keku/ and B= /keki/. Participants had to choose which one of the two Japanese adaptations (A & B) of that foreign word (X) is better. For a detailed description of the XAB study design and procedure, please refer back to Section 4.3.1.2.

4.4.2.2 Data cleaning

There were a total of 2400 data points (80 trials * 30 participants) collected from the XAB task. 82 data points do not have responses recorded because participants did not press any key within 5 seconds. Responses with RT longer than 3 standard deviations from the mean (> 3030.21ms) were excluded as outliers (43 data points). There is no minimum RT requirement for the XAB test because RT was recorded after the second stimulus being played and in certain cases participants could have already had a strong preference or even made a decision after hearing the first stimulus. For example, if X = /kiak/ and A = /kjaku/, A is the natural way Modern Japanese speakers adapt X, so there is a chance that the participant strongly prefers or even already decides on A before B is played. A fast RT in this case does not necessarily indicate a random guess or a press in error. Participants' response key or AB stimuli order bias was assessed by Pearson's chi-squared test, and no significant effect was found ($\chi^2 = 38.499, p = 0.1116$). After the initial cleaning process, 5.21% of data (125 data points) were excluded, leaving 2275 data points in the analysis. Class I stimuli have 1132 data points and Class II stimuli have 1143 data points.

4.4.2.3 Class I stimuli

4.4.2.3.1 Predictions recap

The predictions for the XAB Class I stimuli are repeated here in Table 79. The nucleus adaptation in the AB options is controlled, and participants made decisions on the epenthetic vowel. As /u/ is the default epenthetic vowel in Modern Japanese, we expect to see /u/ as the dominant response across all conditions (> 60%). The percentage of epenthetic /i/ responses is expected to vary by stimuli conditions and the predictions are summarised in the Table below. For a detailed discussion of the predictions, see Section 4.3.1.2. In terms of reaction time, we expect longer processing time for longer X and shorter AB options.

Table 79 XAB Class I experiment predictions by stimuli. In the Example column, all nuclei are in blue, epenthetic /i/ are in red and epenthetic /u/ are in purple.

X		A – B					Prediction
Structure	Example	Type	Structure		Example		
CVVC	/kaik/	1	CVVCi	CVVCu	/kaiki/	/kaiku/	/i/ <<< /u/
		2	CVCi	CVCu	/keki/	/keku/	/i/ << /u/
CVVwC	/kiawk/	1	CGVCi	CGVCu	/kjaki/	/kjaku/	/i/ << /u/
		2	CVCi	CVCu	/keki/	/keku/	/i/ << /u/
CVVjC	/kiajk/	1	CGVCi	CGVCu	/kjaki/	/kjaku/	/i/ << /u/
		2	CVCi	CVCu	/keki/	/keku/	/i/ < /u/

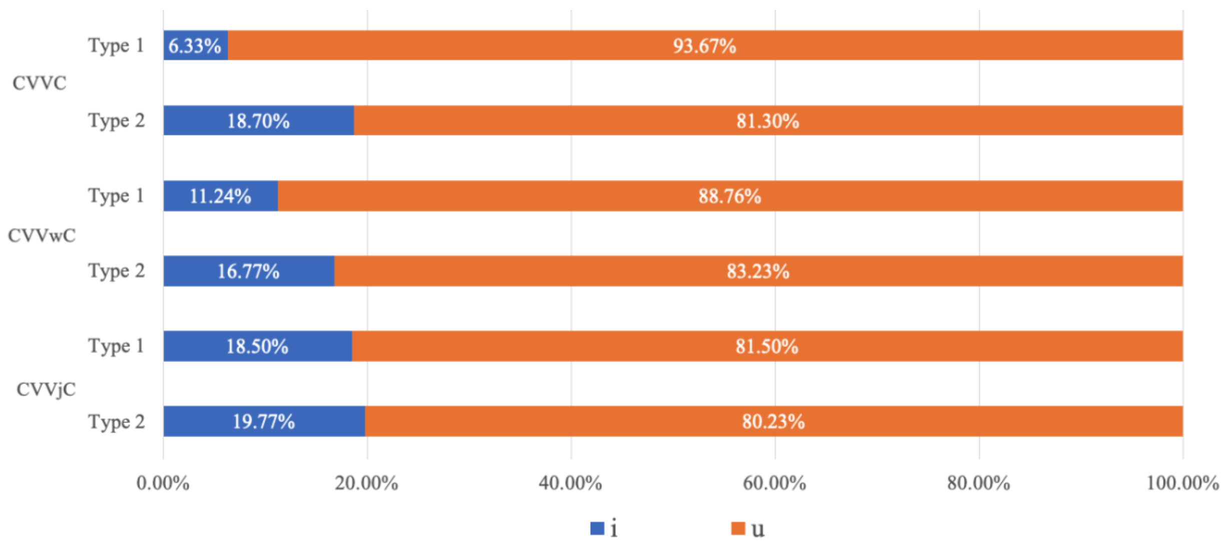
4.4.2.3.2 Response analysis

There are overall 962 epenthetic /u/ (85%) and 170 epenthetic /i/ (15%) responses. Table 80 and Figure 13 present an overview of the response pattern by stimulus condition. The numbers under the percentages are the data point counts. The general pattern aligns with the predictions. The highest percentage of epenthetic /u/ is for the condition CVVC + type 1 A – B pairs (/u/ 93.67%, /i/ 6.33%) as expected. The adapted nucleus vowel is not contracted in the AB options and the stimuli condition is close to how Modern Japanese speakers naturally adapt foreign words.

Table 80 XAB Class I result – an overview of the responses by stimuli. In the Example column, all nuclei are in blue, epenthetic /i/ are in red and epenthetic /u/ are in purple.

X		A – B					Prediction	Result	
Structure	Example	Type	Structure		Example			Epenthetic i	Epenthetic u
CVVC	/kaik/	1	CVVCi	CVVCu	/kaiki/	/kaiku/	/i/ <<< /u/	**6.33%** 14	**93.67%** 207
		2	CVCi	CVCu	/keki/	/keku/	/i/ << /u/	**18.70%** 43	**81.30%** 187
CVVwC	/kiawk/	1	CGVCi	CGVCu	/kjaki/	/kjaku/	/i/ << /u/	**11.24%** 19	**88.76%** 150
		2	CVCi	CVCu	/keki/	/keku/	/i/ << /u/	**16.77%** 28	**83.23%** 139
CVVjC	/kiajk/	1	CGVCi	CGVCu	/kjaki/	/kjaku/	/i/ << /u/	**18.50%** 32	**81.50%** 141
		2	CVCi	CVCu	/keki/	/keku/	/i/ < /u/	**19.77%** 34	**80.23%** 138

Figure 13 XAB Class I result – response by stimuli condition stacked bar



The test condition with the second highest percentage of epenthetic /u/ is the CVVwC + type 1 A – B pairs (/u/ 88.76%, /i/ 11.24%). The input nucleus is contracted by 1 segment in the adapted options. According to the findings from the corpus study, this can be explained by a vowel harmony between the glide /w/ and the epenthetic /u/. They both have the place features [DORSAL, HIGH].

The condition CVVwC + type 2 A – B pairs have more epenthetic /i/ (/i/ 16.77%, /u/ 83.23%). A close examination of the epenthetic /i/ cases shows that for 75% (21 out of 28) of them, there is a high front vowel /i/ or /y/ in X. The adapted nucleus in the AB options are contracted by 2 segments, and some participants might have taken the [CORONAL, HIGH] features from the high front vowel in the input nucleus into the epenthetic vowel because the features do not fit in the adapted nucleus. This is similar to the forced-choice study result for epenthetic /i/. In the forced-choice study, the input nucleus is not contracted in the adapted form. In the rare cases of epenthetic /i/ responses, 20 out of 24 data points have an [CORONAL, HIGH] segment (vowel or glide) in the input nucleus, among which 5 data points do not have the [CORONAL, HIGH] segment as the last segment in the input nucleus (see Section 4.4.1.3, Table 69). Combining the result of the forced-choice study and the current result of the CVVwC + type 2 A – B pairs, it seems that when the input nucleus is shortened in the adapted form, the non-final [CORONAL, HIGH] segment in the input nucleus is more likely to influence the epenthetic vowel than when there is no contraction of the input nucleus.

The two conditions CVVC + type 2 A – B pairs and CVVjC + type 1 A – B pairs have a similar percentage of epenthetic /i/, 18.70% (/u/ 81.30%) and 18.50% (/u/ 81.50%) respectively. In both conditions, the input nucleus is contracted by 1 segment in the AB options. For CVVjC + type 1 A – B pairs, the epenthetic vowel /i/ could be the result of vowel harmony. The epenthetic vowel shares place features with the input glide /j/. The epenthetic /i/ could also be due to elicited metathesis, transposing the glide and the coda, e.g. CiajC → Cia<u>Ci</u>. The epenthetic /i/ in CVVC + type 2 A – B pairs are looked into in details. There are 4 different nuclei for CVVC stimuli: /ai au ia ya/, as shown in Table 81. When the input nucleus ends in /i/, 31.03% (18/58) of the responses are epenthetic /i/; when the input nucleus does not end in /i/, only 14.53% (25/172) of the responses are epenthetic /i/. When the input nucleus is 2 segment long and contracted by 1 segment in the adapted form, there is a strong correlation between the last vowel in the input nucleus and the epenthetic vowel.

Table 81 Epenthetic /i/ responses for CVVC + type 2 A – B pairs

X nucleus	Last vowel	Epenthetic /i/
ai	i	31.03% (18/58)
au ia ya	a u	14.53% (25/172)

The highest percentage of epenthetic /i/ is elicited by the condition CVVjC + type 2 A – B pairs (/i/ 19.77%, /u/ 80.23%) as predicted (Table 79). The input nucleus is contracted by 2 segments in the adapted form. The place features of the input glide does not fit into the adapted nucleus, hence spread to the epenthetic vowel, conforming to the prediction of the corpus study. However, the percentage of epenthetic /i/ 19.77% is not considerably higher than the previously mentioned conditions CVVC + type 2 A – B pairs (18.70%) and CVVjC + type 1 A – B pairs (18.50%).

Statistical hypothesis tests were performed to assess each independent variable. Stimuli X and AB are coded for the variables as shown in Table 82. X was designed by nucleus length (2 segments CVVC vs 3 segments CVVGC), glide (glide /j/ vs glide /w/ vs no glide), and coda place (dorsal coda vs non-dorsal coda). According to the analysis of the epenthetic /i/ responses in the CVVC + type 2 A – B pairs stimuli above, it seems that the place feature of the last segment in the nucleus, whether the nucleus has 2 or 3 segments, has an influence on the quality of the epenthetic vowel. The X stimuli are, therefore, also coded for the place features of the last glide or vowel in the input nucleus. The AB options (adapted forms) were designed by type (type 1 CVVCV vs type 2 CVCV). They are also coded for the degree of contraction (no contraction, contracted by 1 segment, contracted by 2 segments).

Table 82 XAB Class I: Variables for stimuli X & AB

Stimuli	Variable	Values
X	Nucleus length	2, 3
	Glide	j, w, Ø
	Coda place	dorsal, non-dorsal
	Place features of the last segment in nucleus	[CORONAL, HIGH], non [CORONAL, HIGH]
AB	Type	1, 2
	Contraction	no, 1 segment, 2 segments

Pearson's chi-squared test (or χ^2 test) is employed to examine whether there is a statistically significant relationship between each independent variable and the response (dependent variable). It is a statistical hypothesis test used for the analysis of two categorical variables when the sample size is large. In the current analysis, all independent variables and the dependent variable are categorical and the sample size is large (1132 data points). Table 83 is the summary of the result of the Pearson's chi-square tests for all the independent variables.

Table 83 XAB Class I: Pearson's chi-square tests for all independent variables. All statistically significant variables are in bold with the p-value in red.

Variable	χ^2	*p*-value
X coda place	0.066	0.7965
X nucleus length	3.325	0.0682
X glide	6.852	**0.0325***
AB type	10.582	**0.0011***
X nucleus last segment	12.937	**0.0003***
AB contraction	16.796	**0.0002***

Coda place in the input X does not have any influence on the quality of the epenthetic vowel ($p = 0.7965$). 51.2% of epenthetic /i/ responses have dorsal coda in the input X, and 48.8% of epenthetic /i/ responses have non-dorsal coda in the input X (Table 84). The numbers are extremely close. Codas are not the trigger of epenthetic vowel harmony.

Table 84 Contingency table for response and X coda place

			Response		
			i	u	Total
X_CodaPlace	Dorsal	Count	87	482	569
		% within X_CodaPlace	15.3%	84.7%	100.0%
		% within Response	51.2%	50.1%	50.3%
	Non-Dor	Count	83	480	563
		% within X_CodaPlace	14.7%	85.3%	100.0%
		% within Response	48.8%	49.9%	49.7%
Total		Count	170	962	1132
		% within X_CodaPlace	15.0%	85.0%	100.0%
		% within Response	100.0%	100.0%	100.0%

Nucleus length in the input X also does not have significant influence on the quality of the epenthetic vowel either ($p = 0.0682$), although the data in Table 85 shows that fewer epenthetic /i/ responses were elicited by CVVC input (33.5%) than by CVVGV input (66.6%). This is different from the findings of the corpus study, which showed that vowel harmony only happened when the input nucleus has three segments.

Table 85 Contingency table for response and X nucleus length

			Response		Total
			i	u	
X_NucleusLength	2	Count	57	394	451
		% within X_NucleusLength	12.6%	87.4%	100.0%
		% within Response	33.5%	41.0%	39.8%
	3	Count	113	568	681
		% within X_NucleusLength	16.6%	83.4%	100.0%
		% within Response	66.5%	59.0%	60.2%
Total		Count	170	962	1132
		% within X_NucleusLength	15.0%	85.0%	100.0%
		% within Response	100.0%	100.0%	100.0%

The glide in X's nucleus has a significant influence on the quality of the epenthetic vowel ($p = 0.0325$). Table 86 shows that the percentage of epenthetic /i/ is the highest when the glide is /j/ (19.1%).

Table 86 Contingency table for response and X glide

			Response		Total
			i	u	
X_Glide	ø	Count	57	394	451
		% within X_Glide	12.6%	87.4%	100.0%
		% within Response	33.5%	41.0%	39.8%
	j	Count	66	279	345
		% within X_Glide	19.1%	80.9%	100.0%
		% within Response	38.8%	29.0%	30.5%
	w	Count	47	289	336
		% within X_Glide	14.0%	86.0%	100.0%
		% within Response	27.6%	30.0%	29.7%
Total		Count	170	962	1132
		% within X_Glide	15.0%	85.0%	100.0%
		% within Response	100.0%	100.0%	100.0%

However, an analysis of the last segment in the input nucleus shows an even stronger significant effect ($p = 0.0003$), indicating that it was not the nucleus glide that influences the quality of the epenthetic vowel, but any [CORONAL, HIGH] segment that is at the end of the nucleus. When the last segment is [CORONAL, HIGH], 19.7% of responses were epenthetic /i/; when the last segment is not [CORONAL, HIGH], only 11.9% of responses were epenthetic /i/ (Table 87).

Table 87 Contingency table: response and X last segment

			Response		
			i	u	Total
X_LastSegment	[CORONAL, HIGH]	Count	90	368	458
		% within X_LastSegment	19.7%	80.3%	100.0%
		% within Response	52.9%	38.3%	40.5%
	non [CORONAL, HIGH]	Count	80	594	674
		% within X_LastSegment	11.9%	88.1%	100.0%
		% within Response	47.1%	61.7%	59.5%
Total		Count	170	962	1132
		% within X_LastSegment	15.0%	85.0%	100.0%
		% within Response	100.0%	100.0%	100.0%

The AB type also influences the quality of the epenthetic vowel ($p = 0.0011$). There are significantly more epenthetic /i/ responses for type 2 CVVCV (18.5%) than for type 1 CVCV (11.5%), as shown in Table 88.

Table 88 Contingency table for response and AB options type

			Response		
			i	u	Total
AB_Type	1	Count	65	498	563
		% within AB_Type	11.5%	88.5%	100.0%
		% within Response	38.2%	51.8%	49.7%
	2	Count	105	464	569
		% within AB_Type	18.5%	81.5%	100.0%
		% within Response	61.8%	48.2%	50.3%
Total		Count	170	962	1132
		% within AB_Type	15.0%	85.0%	100.0%
		% within Response	100.0%	100.0%	100.0%

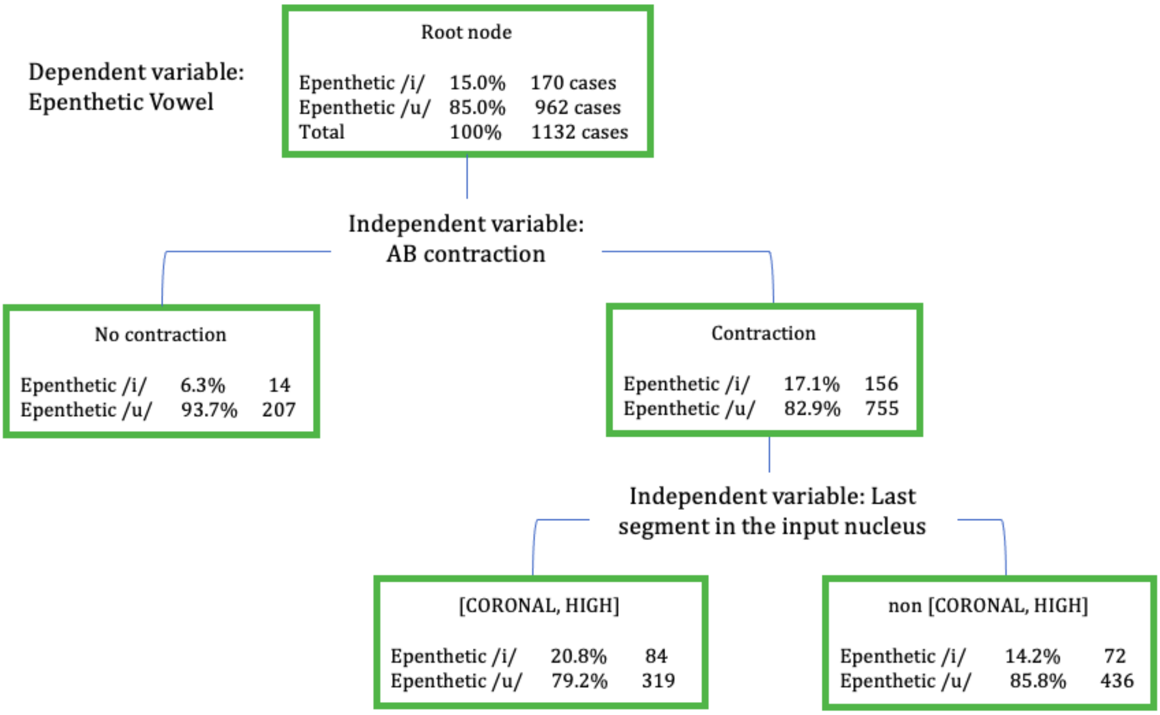
The degree of contraction for the AB options shows the highest significance effect (*p*=0.0002; Table 89). There are correlations between AB degree of contraction and AB type. When X nucleus length = 3, type 1 AB (CVVCV structure) is contract by 1 segment and type 2 AB (CVCV structure) is contracted by 2 segments. When X nucleus length = 2, type 1 AB is not contracted and type 2 AB is contracted by 1 segment. The fact that AB contraction has the highest significance effect indicates that it might have not been the AB type (structure) that is influencing the epenthetic vowel, but the degree of contraction.

Table 89 Contingency table response and AB contraction

			Response		
			i	u	Total
AB_contraction	0	Count	14	207	221
		% within AB_contraction	6.3%	93.7%	100.0%
		% within Response	8.2%	21.5%	19.5%
	1	Count	94	478	572
		% within AB_contraction	16.4%	83.6%	100.0%
		% within Response	55.3%	49.7%	50.5%
	2	Count	62	277	339
		% within AB_contraction	18.3%	81.7%	100.0%
		% within Response	36.5%	28.8%	29.9%
Total		Count	170	962	1132
		% within AB_contraction	15.0%	85.0%	100.0%
		% within Response	100.0%	100.0%	100.0%

A classification analysis using the Chi-squared Automatic Interaction Detection (CHAID) algorithm was performed to further investigate how the independent variables interact to influence the quality of the epenthetic vowel (Figure 14). The best predictor variable is AB contraction, as shown under the root node. It separates the data into two maximally distinct groups: the left group has no AB contraction, and the right group has AB contraction. When there is no contraction, the epenthetic vowel is almost always epenthetic /u/ (93.7%), conforming to the result of the forced-choice study. When the nucleus is shortened in the adapted form, there is significantly more epenthetic /i/ responses (17.1%). The way the nucleus is adapted (i.e. contracted or not) influences the quality of the epenthetic vowel. The data in the contraction group is further divided into two subgroups by the last segment in the nucleus. When the last segment in the nucleus is not [CORONAL, HIGH], there is 14.2% of epenthetic /i/; when the last segment in the nucleus has the place features [CORONAL, HIGH] (i.e. vowel /i/ or glide /j/), 20.8% of responses are epenthetic /i/. The statistically significantly high percentage of epenthetic /i/ in this subgroup is highly likely to be the result of vowel harmony, as the epenthetic /i/ also shares the same place features [CORONAL, HIGH] with the last segment in the input nucleus. The epenthetic vowel harmony is triggered by the interaction of two variables: (1) the structural adaptation of the nucleus, and (2) the features of the last segment in the input nucleus.

Figure 14 Classification analysis of Class I responses

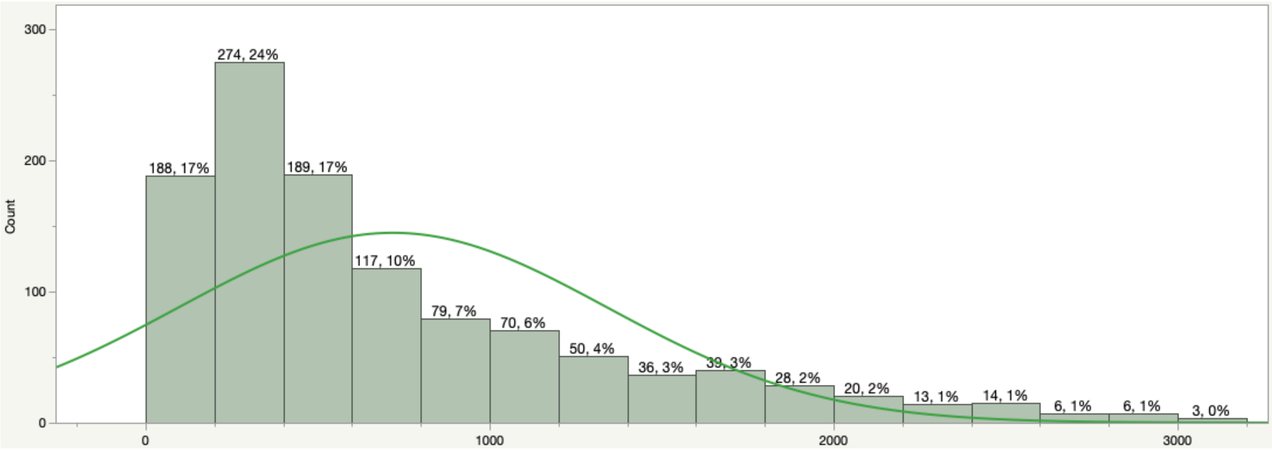


4.4.2.3.3 Reaction time analysis

The reaction time data does not follow a normal distribution (Shapiro–Wilk test, W = 0.8567, $p < 0.0001$), as shown in Figure 15. The mean RT is 719.08 ms and standard deviation is

623.38 ms. The mean is only 28.06 ms slower than the mean RT in the forced-choice study (691.02 ms). However, the standard deviation almost doubles that of the force-choice study (319.51 ms).

Figure 15 XAB Class I: distribution of RT histogram



The RT for epenthetic /i/ and /u/ responses follow different distributions so a Wilcoxon rank-sum test was performed. The result shows that the RT difference between the two responses is highly statistically significant (U = 59103.00, Z = -5.768, $p < 0.001$; Table 89). The difference in mean rank is 156.90. Participants needed considerably longer processing time to give epenthetic /i/ responses.

Table 90 XAB Class I result – Wilcoxon rank-sum test for response and RT. The statistically significant variable is in bold with the p-value in red.

Variable	*U*	Z	*p*-value
Epenthetic Vowel	59103.00	-5.768	**<0.001***
		Value	Mean Rank
		i	699.84
		u	542.94

Statistical hypothesis tests were performed to assess each independent variable. Wilcoxon rank-sum tests were used when the independent variable has two values, and Kruskal–Wallis tests were employed for independent variables of three (or more) values. Table 91 shows that none of the X input related independent variables, including nucleus length (U = 148594.00, p = 0.356), coda place (U = 157198.00, p = 0.5885), last segment

(U = 148117.00, p = 0.2486), and glide (H(2) = 1.308, p = 0.5200), have significant influence on RT.

Table 91 XAB Class I result – hypothesis tests for X independent variables and RT

Variable	*U*	Z	*p*-value
X_nucleus length	148594.00	-0.923	0.356
X_coda place	157198.00	-0.541	0.588
X_last segment	148117.00	-1.154	0.249
Variable	*H*	df	*p*-value
X_glide	1.308	2	0.520

Both AB options related variables have significant influence on RT. The RT for type 1 A – B pairs (CGVCV or CVVCV structure) is significantly faster than the RT for type 2 A – B pairs (CVCV structure; Table 92, U = 130734.00, Z = -5.351, $p < 0.001$).

Table 92 XAB Class I result – hypothesis tests for AB-type and RT. The statistically significant variable is in bold with the p-value in red.

Variable	*U*	Z	*p*-value
AB_type	130734.00	-5.351	**< 0.001***
		Value	Mean Rank
		type 1	514.23
		type 2	618.22

The Kruskal–Wallis test shows that the degree of nucleus contraction in the adapted forms (AB options) also has significant effect (H(2) = 20.218, $p < 0.001$) on participants processing time (Table 93). Post hoc Wilcoxon tests were performed to test each pair of values. All three pairs showed statistically significant results. When there is no nucleus contraction, the RT mean rank is 496.95; when the nucleus is shortened by 1 segment, the RT mean rank is 560.10; and when the nucleus is shortened by 2 segments, the mean RT is 622.64. These results are consistent with the prediction that the shorter the AB options, the longer the processing time.

Table 93 XAB Class I result – hypothesis tests for AB-contraction and RT. The statistically significant variable is in bold and p-values < 0.05 are in red.

Variable	*H*	df	*p*-value
AB_contraction	20.218	2	**< 0.001***
		Value	Mean Rank
		0	496.95
		1	560.10
		2	622.64
Values	*U*	Z	*p*-value
1 vs 0	56143.00	-2.442	0.015*
1 vs 2	86228.00	-2.794	0.005*
2 vs 0	29153.00	-4.438	< 0.001*

In summary, response, AB type and AB contraction have significant influence on RT. Participants were slower at processing epenthetic /i/ responses, AB adaptation options with shorter and more contracted nucleus, because those deviate from the norm in natural Modern Japanese loanwords adaptation.

4.4.2.4 Class II stimuli

4.4.2.4.1 Predictions recap

For the Class II A – B pairs, the quality of the epenthetic vowel is controlled and participants made decisions on the adaptations of the nucleus. The nucleus adaptations are either long (two segments VV/GV) or short (one segment V). Because Modern Japanese speakers prefer to keep all information from the foreign words, we expect longer adapted nuclei to be preferred over shorter ones across all conditions (> 60%). The number of short nucleus responses is expected to vary by condition and the predictions are repeated here in Table 94. See Section 4.3.1.2 for a detailed discussion. We predict longer RT for Type 4 stimuli because /i/ is not a preferred epenthetic vowel option in Modern Japanese. Longer nuclei responses are expected to have shorter RT than short nuclei responses because long nuclei are more natural in Modern Japanese.

Table 94 XAB Class II experiment predictions by stimuli. In the Example column, all nuclei are in blue, epenthetic /i/ are in red and epenthetic /u/ are in purple.

X		A – B					Prediction
Structure	Example	Type	Structure		Example		
CVVC	/kaik/	3	CVVCu	CVCu	/kaiku/	/keku/	short <<< long
		4	CVVCi	CVCi	/kaiki/	/keki/	short << long
CVVwC	/kiawk/	3	CGVCu	CVCu	/kjaku/	/keku/	short << long
		4	CGVCi	CVCi	/kjaki/	/keki/	short << long
CVVjC	/kiajk/	3	CGVCu	CVCu	/kjaku/	/keku/	short < long
		4	CGVCi	CVCi	/kjaki/	/keki/	

4.4.2.4.2 Response analysis

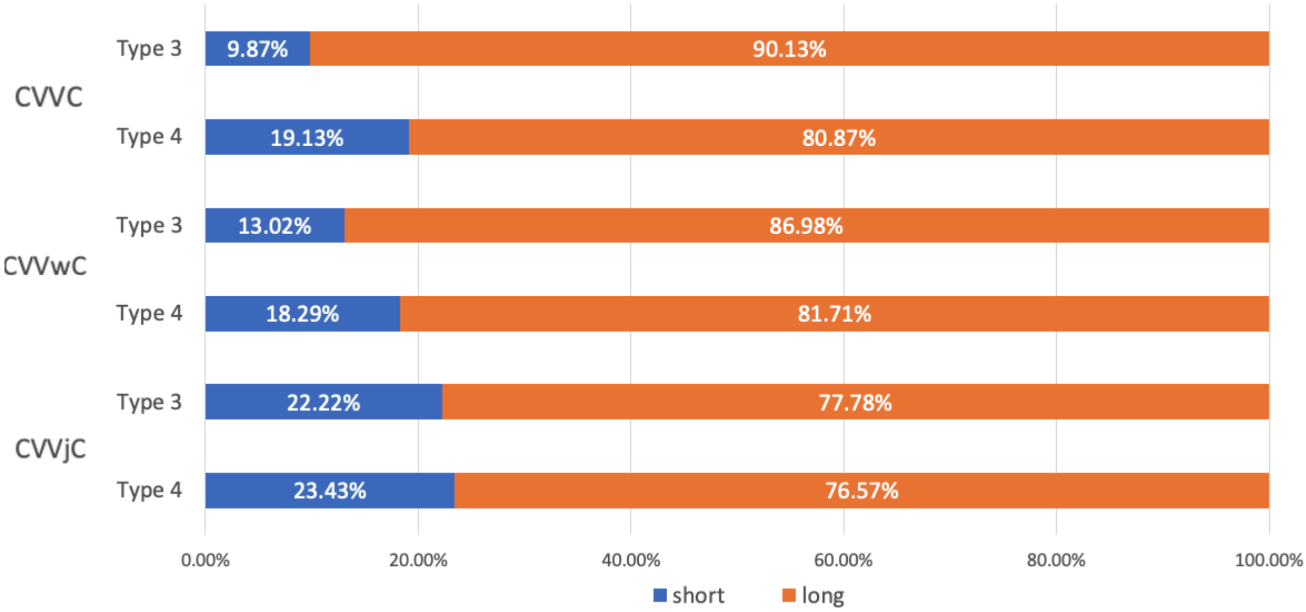
Out of 1143 data points, there are 948 (83%) responses of long nucleus adaptation (CVVCV or CGVCV) and 195 (17%) responses of short nucleus adaptation (CVCV).

Table 95 and Figure 16 show the response pattern by stimuli condition. The numbers under the percentages are the data counts. The overall pattern follows our expectations. The CVVC Type 3 stimuli elicited the highest percentage of long nucleus adaptation (90.13%) because it is the closest to the natural adaptation in Modern Japanese. The second highest percentage of long nucleus adaptation is for the CVVwC Type 3 stimuli (86.98%). The long nucleus option /CGVCu/ has the default epenthetic vowel and is a metathesis form of the input /CVVwC/. The /CVVwC/ Type 4 and /CVVC/ Type 4 stimuli both have a higher percentage of short nuclei responses (18.29% & 19.13% respectively). In both conditions, the epenthetic vowel is the non-default /i/ and the long nucleus adaptation options were not intuitively ideal. The /CVVjC/ stimuli elicited the highest percentage of short nucleus responses (Type 3 22.22% & Type 4 23.43%). /VVj/ input nuclei are better accepted as a single /V/ among Modern Japanese speakers, reflecting the adaptation pattern in EMJ.

Table 95 XAB Class II result – an overview of the responses by stimuli. In the Example column, all nuclei are in blue, epenthetic /i/ are in red and epenthetic /u/ are in purple.

X		A – B					Predictions	Result	
Structure	Example	Type	Structure		Example			long	short
CVVC	/kaik/	3	CVVCu	CVCu	/kaiku/	/keku/	short <<< long	**90.13%** 201	**9.87%** 22
		4	CVVCi	CVCi	/kaiki/	/keki/	short << long	**80.87%** 186	**19.13%** 44
CVVwC	/kiawk/	3	CGVCu	CVCu	/kjaku/	/keku/	short << long	**86.98%** 147	**13.02%** 22
		4	CGVCi	CVCi	/kjaki/	/keki/	short << long	**81.71%** 143	**18.29%** 32
CVVjC	/kiajk/	3	CGVCu	CVCu	/kjaku/	/keku/	short < long	**77.78%** 133	**22.22%** 38
		4	CGVCi	CVCi	/kjaki/	/keki/		**76.57%** 134	**23.43%** 41

Figure 16 XAB Class II result – response by stimuli condition stacked bar



Each independent variable was assessed by the Pearson's chi-square hypothesis test. The variables for stimuli X and AB are shown in Table 96. The variables for X are the same as that in Class I stimuli: nucleus length (2 segments CVVC vs 3 segments CVVGC), glide (glide /j/ vs glide /w/), coda place (dorsal coda vs non-dorsal coda), and place features of the nucleus last segment ([CORONAL, HIGH] vs non [CORONAL, HIGH]). The AB options are designed by type. Type 3 has epenthetic /u/ and type 4 has epenthetic /i/.

Table 96 XAB Class II: Variables for stimuli X & AB

Stimuli	Variable	Values
X	Nucleus length	2, 3
	Coda place	dorsal, non-dorsal
	Glide	j, w
	Place features of nucleus last segment	[CORONAL, HIGH], non [CORONAL, HIGH]
AB	Type/Epenthetic vowel	Type 3 – epenthetic /u/, Type 4 – epenthetic /i/

The test results in Table 97 shows that the X variables nucleus length ($\chi^2 = 3.290$, $p = 0.0697$) and coda place ($\chi^2 = 1.751$, $p = 0.1857$) do not have statistically significant influence on nuclei adaptation.

Table 97 XAB Class II: Pearson's chi-square tests for X nucleus length and X coda place

Variable	χ^2	*p*-value
X nucleus length	3.290	0.0697
X coda place	1.751	0.1857

Among the data with X=/CVVGC/ inputs, the quality of the glide has a significant influence on the responses ($\chi^2 = 5.782$, $p = 0.0162$; Table 98). The contingency table (Table 99) shows that when the glide is /j/ , there are 22.3% short-nucleus adaptation responses, and when the glide is /w/, there are only 15.1% short-nucleus adaptations.

Table 98 XAB Class II: Pearson's chi-square tests for X glide /j/ vs /w/. The statistically significant variable is in bold and the p-value is in red.

Variable	χ^2	*p*-value
X glide /j/ vs /w/	5.782	**0.0162***

Table 99 XAB Class II: Contingency table for response and X glide

			V1Length		
			1	2	Total
X_Glide	j	Count	77	269	346
		% within X_Glide	22.3%	77.7%	100.0%
		% within V1Length	59.7%	48.0%	50.1%
	w	Count	52	292	344
		% within X_Glide	15.1%	84.9%	100.0%
		% within V1Length	40.3%	52.0%	49.9%
Total		Count	129	561	690
		% within X_Glide	18.7%	81.3%	100.0%
		% within V1Length	100.0%	100.0%	100.0%

The place features of the last segments in X nuclei also have a statistically significant influence on the nuclei adaptation ($\chi^2 = 4.701$, $p = 0.0301$; Table 100). From the contingency table (Table 101), we can see that when input nucleus last segment is [CORONAL, HIGH], 20.0% of the responses are short adaptations; when the input nucleus last segment does not have [CORONAL, HIGH] features, only 15.1% of responses are short adaptations. The influence of nucleus last segment in the overall data follows the same pattern as the influence of glide in the CVVGC subset of data, indicating that it is not the existence of the glide that makes a difference in responses. What matters is the place features of the last segment in the input nucleus.

Table 100 XAB Class II: Pearson's chi-square tests for X nucleus last segment. The statistically significant variable is in bold and the p-value is in red.

Variable	χ^2	*p*-value
X nucleus last segment	4.701	**0.0301***

Table 101 XAB Class II: Contingency table for response and X last segment

			V1Length 1	V1Length 2	Total
X_LastSegment	[CORONAL, HIGH]	Count	92	368	460
		% within X_LastSegment	20.0%	80.0%	100.0%
		% within V1Length	47.2%	38.8%	40.2%
	non [CORONAL, HIGH]	Count	103	580	683
		% within X_LastSegment	15.1%	84.9%	100.0%
		% within V1Length	52.8%	61.2%	59.8%
Total		Count	195	948	1143
		% within X_LastSegment	17.1%	82.9%	100.0%
		% within V1Length	100.0%	100.0%	100.0%

There is a statistically significant association between the AB Type/epenthetic vowel and the nucleus adaptation ($\chi^2 = 6.372$, $p = 0.0116$; Table 102). Of all the short nuclei responses, 59% are for AB options with epenthetic /i/ and 41% are for AB options with epenthetic /u/ (Table 103). When the epenthetic vowel is /i/ (AB Type 4), 19.8% of responses are short nuclei adaptations; when the epenthetic vowel is /u/ (AB Type 3), only 14.2% of responses are short nuclei adaptations.

Table 102 XAB Class II: Pearson's chi-square tests for AB Type/Epenthetic vowel. The statistically significant variable is in bold and the p-value is in red.

Variable1	χ^2	*p*-value
AB Type/Epenthetic vowel	6.372	**0.0116***

Table 103 XAB Class II: Contingency table for response and AB type/epenthetic vowel

			V1Length		
			1	2	Total
AB_EpenV	i	Count	115	465	580
		% within AB_EpenV	19.8%	80.2%	100.0%
		% within V1Length	59.0%	49.1%	50.7%
	u	Count	80	483	563
		% within AB_EpenV	14.2%	85.8%	100.0%
		% within V1Length	41.0%	50.9%	49.3%
Total		Count	195	948	1143
		% within AB_EpenV	17.1%	82.9%	100.0%
		% within V1Length	100.0%	100.0%	100.0%

Response key bias was also tested and the result shows that the response key does not influence the nucleus adaptation (χ^2= 3.251, p = 0.0714; Table 104).

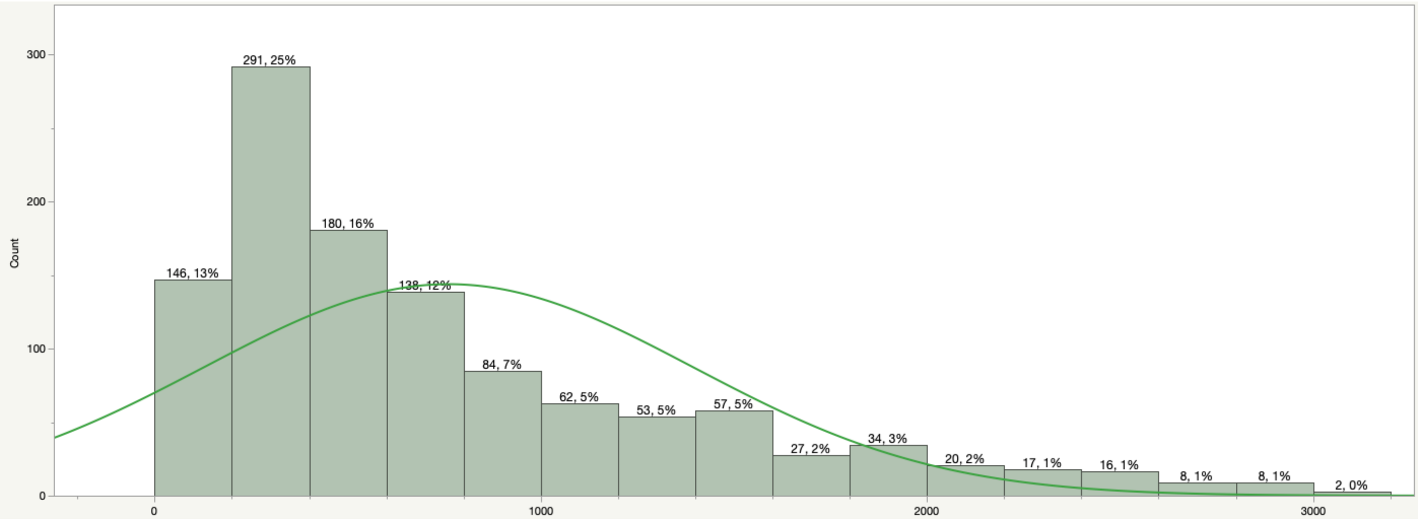
Table 104 XAB Class II: Pearson's chi-square tests for response key

Variable	χ^2	*p*-value
response key	3.251	0.0714

4.4.2.4.3 Reaction time analysis

The distribution of reaction time data is shown in Figure 17. It does not follow a normal distribution (Shapiro–Wilk test, W = 0.8641, $p < 0.0001$). The mean RT is 761.17 ms with a large standard deviation of 634.39 ms.

Figure 17 XAB Class II: distribution of RT histogram



The Wilcoxon rank-sum test shows that there is a statistically significant difference between the RT for the long and short nucleus adaptation responses (U = 69717.00, Z = -5.410, p < 0.001; Table 105). The difference in mean rank is 140.44. Participants needed longer processing time to give short nucleus adaptation responses.

Table 105 XAB Class II result – Wilcoxon rank-sum test for response. The statistically significant variable is in bold and the p-value is in red.

Variable	*U*	Z	*p*-value
Response (AB nucleus length)	69717.00	-5.410	**< 0.001***
		Value	Mean Rank
		short (1 segment)	688.48
		long (2 segments)	548.04

Table 106 shows that the independent variables X coda place (U = 157374.00, p = 0.288), last segment (U = 150102.00, p = 0.202), and glide /j/ vs /w/ (U = 57284.00, p = 0.395), do not have significant influence on the RT.

Table 106 XAB Class II result – Wilcoxon rank-sum test for X coda place, X last segment and X glide

Variable	*U*	Z	*p*-value
X coda place	157374.00	-1.063	0.288
X last segment	150102.00	-1.277	0.202
X glide /j/ vs /w/	57284.00	-0.851	0.395

The test result (Table 106) for X nucleus length shows that the RT for CVVC stimuli (mean rank 539.95) is significantly faster (U =141766.00, Z = -2.660, p = 0.008) than for CVVGC stimuli (mean rank 593.04).

Table 107 XAB Class II result – Wilcoxon rank-sum test for X nucleus length. The statistically significant variable is in bold and the p-value is in red.

Variable	*U*	Z	*p*-value
X nucleus length	141766.00	-2.660	**0.008***
		Value	Mean Rank
		2 segments CVVC	539.95
		3 segments CVVGC	593.04

The AB type or epenthetic vowel has a highly significant influence on RT (U = 135179.00, Z = 5.035, p < 0.001; Table 108). The RT mean rank for AB options with epenthetic /u/ is 522.10, which is 98.33 smaller than the mean rank for AB options with epenthetic /i/ (620.43).

Table 108 XAB Class II result – Wilcoxon rank-sum test for AB type/epenthetic vowel. The statistically significant variable is in bold and the p-value is in red.

Variable	*U*	Z	*p*-value
AB Type / epenthetic vowel	135179.00	5.035	**< 0.001***
		Value	Mean Rank
		Type 3 epenthetic /u/	522.10
		Type 4 epenthetic /i/	620.43

To conclude, the RT is significantly influenced by response (nucleus adaptation), X nucleus length and AB type (epenthetic vowel). Participants took a longer time to react to the short nucleus adaptations, epenthetic /i/ and X input with long nucleus. Similar to the RT result from the forced-choice study and the XAB Class I stimuli, the more 'unnatural' is the input or adaptation options, the longer the processing time.

4.4.3 Summary of findings

Table 109 shows a summary of the statistical tests and results.

Table 109 Summary of statistical findings. Significant results are shaded in light blue.

<table>
<tr><th rowspan="2">Paradigm</th><th rowspan="2">Stimuli</th><th rowspan="2">Dependent variable</th><th rowspan="2">Analysis</th><th colspan="2">Independent variables</th></tr>
<tr><th>Significant</th><th>Insignificant</th></tr>
<tr><td rowspan="2">Forced-choice</td><td>All</td><td>Response
(Epenthetic Vowel)</td><td>Pearson's chi-square</td><td>• glide (j vs w vs Ø)</td><td>• nucleus length
• coda place</td></tr>
<tr><td>All</td><td>Reaction time</td><td>Wilcoxon rank-sum</td><td>• epenthetic vowel (response)
• nucleus length
• coda place</td><td>• glide (j vs w)</td></tr>
<tr><td rowspan="5">XAB</td><td rowspan="3">Class I</td><td rowspan="2">Response
(Epenthetic Vowel)</td><td>Pearson's chi-squared</td><td>• X glide (j vs w vs Ø)
• X nucleus last segment
• AB type (nucleus length)
• AB contraction</td><td>• X coda place
• X nucleus length</td></tr>
<tr><td>CHAID Classification</td><td>Tree level 1: AB contraction
Three level 2: X last segment</td><td></td></tr>
<tr><td>Reaction time</td><td>Wilcoxon rank-sum
Kruskal–Wallis</td><td>• epenthetic vowel (response)
• AB type (nucleus length)
• AB contraction</td><td>• X coda place
• X nucleus length
• X nucleus last segment
• X glide (j vs w vs Ø)</td></tr>
<tr><td rowspan="2">Class II</td><td>Response
(nucleus length)</td><td>Pearson's chi-square</td><td>• glide (j vs w)
• X nucleus last segment
• AB type (epenthetic vowel)</td><td>• X coda place
• X nucleus length</td></tr>
<tr><td>Reaction time</td><td>Wilcoxon rank-sum</td><td>• AB nucleus length (response)
• X nucleus length
• AB type (epenthetic vowel)</td><td>• X coda place
• X last segment
• glide (j vs w)</td></tr>
</table>

4.5 Discussion

4.5.1 Epenthetic vowel harmony versus Ito & Mester vowel harmony

This experimental study investigates the factors that influence the quality of the epenthetic vowel and the relation between those variables. Two terms are clarified here for the discussion in this section and onwards: 'epenthetic vowel harmony' and 'Ito & Mester vowel harmony'. In this thesis, 'epenthetic vowel harmony' refers to the process in which a segment from the input nucleus spreads its PLACE feature to the epenthetic vowel. 'Ito & Mester vowel harmony' refers to the front vowel harmony between Sino-Japanese V_1 /e/ and V_2 /i/, and back vowel harmony between Sino-Japanese V_1 /a o u/ and V_2 /u/, as discussed in Ito & Mester (2015), Heffernan (2007), among others. The main difference between the two processes is that in epenthetic vowel harmony, the epenthetic vowel gets the place feature from the nucleus in the source form, whereas in Ito & Mester vowel harmony, the epenthetic vowel, or Sino-Japanese V_2, gets the place feature from the adapted form.

At first glance, the most obvious relation between the result for Class I and Class II stimuli is the striking similarity of the response by stimuli condition data pattern as presented previously in Figure 13 & Figure 16. Figure 18 below shows a stacked bar chart for the combined results of Class I and Class II stimuli, with 1 & 3 grouped together and 2 & 4 grouped together. There seem to be some kind of connection between the result for type 1 & 3, and type 2 & 4 AB pairs.

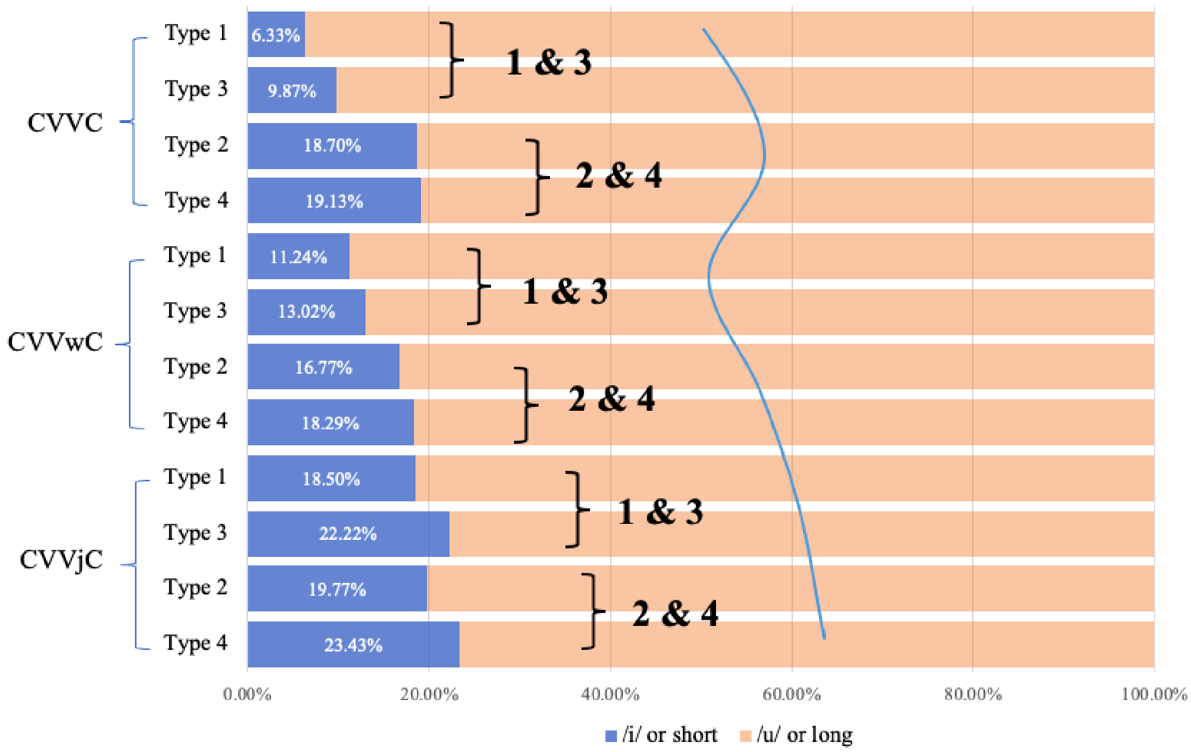


Figure 18 XAB Class I & II result – response by stimuli condition stacked bar

On the face of it, it seems that type 1 & 3 and type 2 & 4 AB pairs can be grouped by how natural they are as adaptation forms in Modern Japanese. Type 1 AB pairs have long nucleus and Type 3 AB pairs have epenthetic /u/. Both long nucleus and epenthetic /u/ are the preferred options in Modern Japanese. Type 2 AB pairs have short nucleus and Type 4 AB pairs have epenthetic /i/. These two types of adaptations are both odd for Modern Japanese speakers. For now, we re-group Type 1 & 3 AB pairs under the Condition 'natural' and Type 2 & 4 under the Condition 'unnatural' for the ease of discussion and analysis.

A comparison among input X shows that when X = /CVVC/ or /CVVwC/, the natural condition (Type 1 & 3) have more epenthetic /u/ and long nucleus adaptation responses than the unnatural condition (Type 2 & 4). It seems that there is a strong two-way relationship between how the nucleus is adapted and the quality of the epenthetic vowel. When X = /CVVjC/, however, regardless of the oddness of the AB options, there are more epenthetic /i/ and short nucleus adaptation responses.

Furthermore, the statistic results for X last nucleus segment in both Class I and Class II stimuli (see Sections 4.4.2.3.2 and 4.4.2.4.2) indicate that the above data pattern might not be caused by a difference in X glide (/j/ vs /u/ & Ø) but a difference in the last segment in the nucleus. The X input can be re-organised into two groups: (1) input with [CORONAL, HIGH] features for the last nucleus segment (including structures /CViC/ and /CVVjC/); and (2) input without [CORONAL, HIGH] features in the last nucleus segment (including structures /CVuC/, /CVaC/ and /CVVwC/). These two groups are referred to as [CORONAL, HIGH] X and non [CORONAL, HIGH] X henceforth.

The data for Class I & Class II stimuli are combined and analysed together. Table 110 shows the stimuli conditions and response result. The independent variables are re-coded for X and AB. X input differs in features ([CORONAL, HIGH] vs non [CORONAL, HIGH]) and AB adaptation options are organised by naturalness. The responses are also coded for naturalness. Responses of epenthetic /u/ and long nucleus adaptations are marked as NATURAL and responses of epenthetic /i/ or short nucleus adaptations are marked as UNNATURAL in the last two columns of the table.

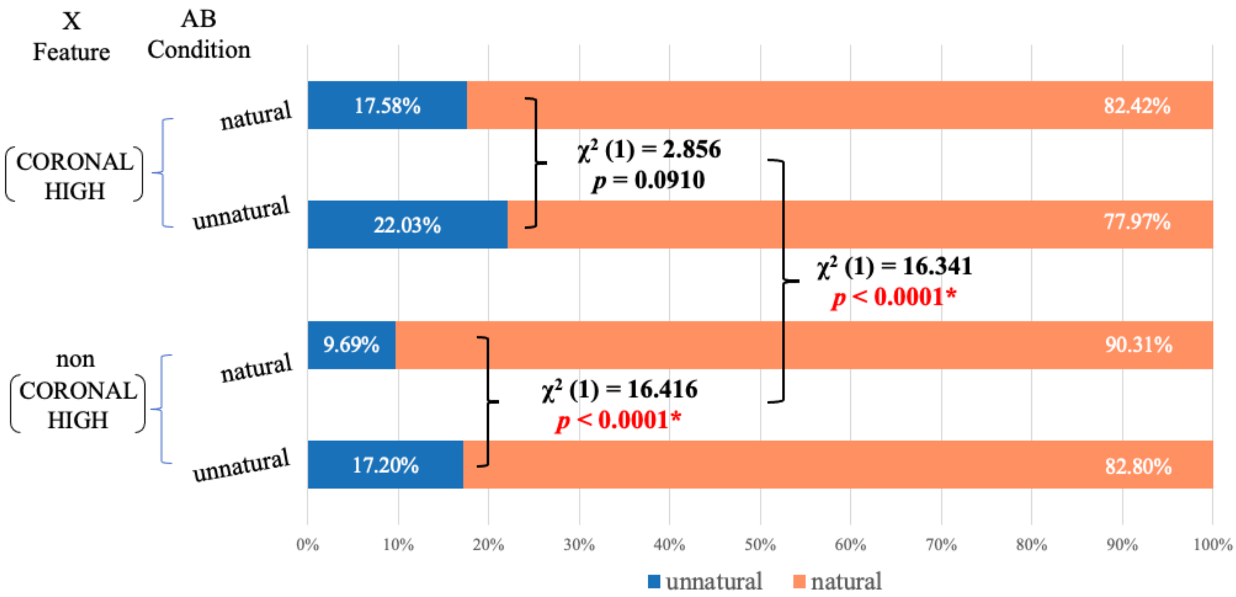
Table 110 XAB Class I & II stimuli conditions and response result. In the Structure and Example columns, the independent variable for each text condition is in bold. When the variable is the epenthetic vowel, it is marked in red; when the variable is the adapted nucleus length, it is marked in blue. In the Result columns, the percentages are in bold.

X		A – B							Result	
Feature	Example	Condition	Type		Structure		Example		NATURAL (epenthetic /u/ & long nucleus adaptation)	UNNATURAL (epenthetic /i/ & short nucleus adaptation)
[CORONAL, HIGH]	/kaik/ /kiajk/	natural	1	long nucleus adaptation	CGVC**i**	CGVC**u**	/kjak**i**/	/kjak**u**/	**82.42%**	**17.58%**
			3	epenthetic /u/	**CGV**Cu	**CV**Cu	/k**ja**ku/	/k**e**ku/	375	80
		unnatural	2	short nucleus adaptation	CVC**i**	CVC**u**	/kek**i**/	/kek**u**/	**77.97%**	**22.03%**
			4	epenthetic /i/	**CGV**Ci	**CV**Ci	/k**ai**ki/	/k**e**ki/	361	102
non [CORONAL, HIGH]	/kauk/ /kiawk/	natural	1	long nucleus adaptation	CGVC**i**	CGVC**u**	/kjak**i**/	/kjak**u**/	**90.31%**	**9.69%**
			3	epenthetic /u/	**CGV**Cu	**CV**Cu	/k**ja**ku/	/k**e**ku/	606	65
		unnatural	2	short nucleus adaptation	CVC**i**	CVC**u**	/kek**i**/	/kek**u**/	**82.80%**	**17.20%**
			4	epenthetic /i/	**CGV**Ci	**CV**Ci	/k**ai**ki/	/k**e**ki/	568	118

The response pattern and statistical test results are shown in Figure 19. The difference between the two X groups [CORONAL, HIGH] and non [CORONAL, HIGH] is significant (χ^2 (1)

= 16.341, $p < 0.0001$). In the non [CORONAL, HIGH] group, the percentage of natural responses is significantly lower than the percentage of unnatural responses ($\chi2$ (1) = 16.416, p < 0.0001). In the [CORONAL, HIGH] group, however, there is no significant difference between the natural and unnatural groups of AB Conditions ($\chi2$ (1) = 2.856, $p = 0.0910$).

Figure 19 XAB Class I & II result – response by stimuli condition stacked bar



The above data patten shows that when the input nucleus ends in /j/ or /i/, regardless of the naturalness of the AB Condition, there is a higher chance (in comparison to when the input nucleus does not end in /j/ or /i/) that Modern Japanese speakers will choose the epenthetic /i/ and short nucleus adaptation. For all the X stimuli that have input nuclei ending in /j/ or /i/ in this study, the short nucleus in the AB option is always /e/, e.g. for X = /kyajp/. We have two observations from this result: when the input nucleus ends in a [CORONAL, HIGH] segment, (1) there is a vowel harmony between the [CORONAL, HIGH] segment and epenthetic /i/, regardless of whether the nucleus is contracted by 1 or 2 segments; and (2) more Japanese speakers prefer to adapt /Vi/ and /VVj/ forms as /e/ instead of the more natural longer form (e.g. /iaj/ adapted as /e/ instead of /ja/) in comparison to when the input does not end in a [CORONAL, HIGH] segment.

The first observation supports the vowel epenthesis data in the corpus study. In natural Modern Japanese language data, the default epenthetic /u/ has a strong presence, as shown by the forced-choice study, and epenthetic vowel harmony is not usually observed. Yet the experiment managed to elicit results showing statistically significant vowel harmony. The context where vowel harmony occurred in Sino-Japanese *kan-on* in the corpus study was when the input nucleus had three distinct segments with the last segment being /j/. In this experiment, vowel harmony occurred with the last segment of the input nucleus being /i/ or /j/, and the input nucleus being contracted by 1 or 2 segments. In both cases, the harmony was a spreading of the [CORONAL, HIGH] place feature from the last segment in the input nucleus to the epenthetic vowel, with the input nucleus being contracted in the adapted form. The data from the corpus study and experimental study align. This observation cannot be explained by the Ito & Mester vowel harmony theory. For X [CORONAL, HIGH] stimuli, the long nuclei in the AB options are /a: ja ai/, with /a: ja/ taking up 75% of the data. According to the Ito & Mester vowel harmony theory, there should be no front / back vowel harmony between the epenthetic /i/ and a preceding vowel /a/. We would expect statistically significant difference between AB natural and unnatural groups. Nevertheless, the experimental results show significantly more /i/ even when the adapted nucleus is not /e/, suggesting that epenthetic /i/ in Sino-Japanese *kan-on* is not triggered by the preceding vowel in the Sino-Japanese form but the nucleus in the source form.

The second observation seems to conform to the nucleus adaptation data in the corpus. Long Chinese nuclei are always contracted into a single V, despite the language allowing heavy syllables. However, as vowel adaptation is beyond the scope of this thesis, we will not expand on this issue.

As shown in Figure 19, when the input nucleus does not end in /j/ or /i/, there is a correlation between the adaptation of the input nucleus and the quality of the epenthetic vowel. When the nucleus in the adapted form is long, the epenthetic vowel is more likely to be /u/; when the epenthetic vowel is /u/, the nucleus tends to be long. Conversely, when the nucleus in the adapted from is short, there is a higher chance of the epenthetic vowel being /i/; when the epenthetic vowel is /i/, there are more short nuclei. This pattern seems puzzling at first sight. Upon scrutinizing the stimuli, we found a plausible interpretation with reference to Ito & Mester vowel harmony. The long nuclei adaptations in the AB options are /ja a: au/ and short nuclei are /e o/. The correlation between long nucleus adaptation and epenthetic /u/ is between /ja, u/ in /CjaCu/, /a:, u/ in /Ca:Cu/ and /au, u/ in /CauCu/. The epenthetic vowel /u/ shares PLACE feature [DORSAL] with the preceding vowel /a/ or /u/. As for short nuclei, 64% of them are /e/ and only 36% are /o/. The correlation between the short nucleus /e/ and epenthetic /i/ is between /e/ and /i/ in /CeCi/. /e/ and /i/ share the PLACE feature [CORONAL]. In the Sino-Japanese literature, Ito & Mester (2015) noted the uniform V_2 = /u/ after the V_1 back vowels /a, o, u/, and V_2 = /i/ after the V_1 front vowel /e/ for Sino-Japanese roots that end with /k/. The correlation between the adaptation of the input nucleus and the quality of the epenthetic vowel observed in this experimental study resembles the Ito & Mester vowel harmony. The data could be re-interpreted as a two-directional vowel harmony in the adapted forms.

4.5.2 Adaptation versus Analogy

After establishing the vowel harmony processes, the subsequent question that arises is: What motivates the epenthetic vowel harmony observed in the experiment? It is important to first understand whether the harmony reflects online adaptation or are instead due to varying degrees of analogy. If the data pattern is not a result of analogy, what connections does it reveal between Modern Japanese and EMJ? To address these issues, we investigate the presence of exceptional epenthetic /i/ and vowel shortening in Modern Japanese.

As introduced in Section 4.1 (19)b, epenthetic /i/ exists in two contexts in Modern Japanese loanwords[23]: 1 after palatoalveolar affricates [tʃ] [dʒ] (surface allophones of /t/ /z/, respectively; e.g. English 'peach' adapted as Japanese [piitʃi]), and 2 after [k] in some old borrowings (e.g. English 'cake' adapted as Japanese [keeki]). While the first context is a regular adaptation rule due to allophonic variation, the second context is of interest to the current study. It remains unclear why [i] was inserted in some archaic loanwords. Later borrowings inserted [u] in the same context. Quackenbush and Ohso (1990) found minimal pairs, e.g. English 'brake' as Japanese [bureeki]/ vs. English 'break' as Japanese [bureeku], in which the former is older than the latter, and old versus new adaptation pairs, e.g. the older adaptation of English 'ink' is [inki], which was later adapted again as [inku]. Despite the rarity of old loanwords with /i/, there is still the possibility that they might trigger analogy, especially the loanword [keeki] for English 'cake', which has very similar structure as [keki], one of the high frequency AB options in the experiment. However, a major difference between foreign loanwords and other strata of Japanese is that loanwords are mostly accented, whereas other strata are more often unaccented. For example, the loanword 'cake' has an accent on the first [e]: [ke'eki]. The AB options in the experimental study are all unaccented. In this pitch accent language, we would not expect the few loanwords with epenthetic /i/, which are mostly accented, or the single word 'cake,' to have analogical influence on the experimental result.

Regarding vowel sequences, Japanese disfavours vowel hiatus, apart from the allowed diphthongs and long vowels. Japanese employs the following four strategies to resolve this marked structure (Kubozono, 2015: 333):

[23] Note that loanwords in Modern Japanese refer to *gairaigo* 外来語 foreign words, another strata of Japanese besides native Japanese (*wago* 和語, or *yamatokotoba* 大和言葉), and Sino-Japanese (*kango* 漢語), as introduced in Section 1.1. A large percentage of these loanwords (84% according to Sibata, 1994) are from English.

(20) a. Consonant insertion: VV → V<u>C</u>V, e.g. English loanword ‘piano’ [pi.<u>j</u>a.no]

b. Glide formation: <u>V</u>V → <u>G</u>V(:), e.g. English loanword ‘calcium’ [ka.ru.s<u>juu.</u>mu]

c. Vowel elision: V_1V_2 → V_2 (or V_1), e.g. native word ‘rocky coast’ /a.ra+i.so/ → /a.r<u>i.</u>so/

d. Vowel coalescence: V_1V_2 → V_{12}, e.g. native word ‘lament’ /na.ga+i.ki/ → /na.<u>ge.</u>ki/

Of the four processes, c and d involve vowel sequence shortening, and the example in d, /a+i/→ /e/, resembles that of input nucleus /ai/ being adapted as /e/ in the experimental study. However, interestingly, only a and b are used in loanwords.[24] 'c' and 'd', on the other hand, are rarely employed as adaptation strategies, with two notable exceptions. Loanwords adaptation are more faithful than the compounds formation process for native and Sino-Japanese words.

The two exceptions that involve vowel shortening in loanword adaptation are shown in (21).

(21) a. Pre-nasal vowel shortening: long vowels and diphthongs in English are shortened in Japanese before the moraic nasal, e.g. English ‘stainless’ is adapted as Japanese [su.t<u>en.</u>re.su] instead of *[su.t<u>ein.</u>re.su].

b. English /au/ sequence is shortened to /a/ when it occurs before /ə/ in English. In other words, English triphthong [aʊə] is adapted as [a.waa] instead of [au.waa], e.g. English ‘power’ [paʊə] is adapted as [pa.waa] instead of *[pau.waa] ‘power’ (Katayama, 1998).

These two exceptional cases lead to the observation that /i/ and /u/ behave asymmetrically in Japanese loanwords. While the English sequence /aun/ is influenced by the shortening rule in (21)a, e.g. English ‘foundation’ is adapted as Japanese [fan.dee.sjon] instead of

[24] Note that a and b apply optionally in loanwords, e.g. English ‘piano’ is also adapted as [pi.a.no].

*[faun.dee.sjon], the English sequence /ain/ is not influenced by this process – it is not shortened to /an/. This asymmetry introduces superheavy syllables which are not preferred by the native Japanese phonotactics, e.g. English 'sign' as Japanese [sain], English 'line' as Japanese [rain]. The other shortening process shown in (21)b also only applies to /au/ but not /ai/ in the same phonological environment. For example, English 'tire' [taɪə] is adapted as [tai.ja] in Japanese and not shortened to [ta.ja]. This asymmetry between /i/ and /u/ is not just observed in loanwords but also in native and Sino-Japanese words synchronically and diachronically. As discussed in Section 3.4.3 and Section 2.4.4.3, /u/ is less stable historically. Diphthongs that end in /u/ easily turned into monophthongs, whereas diphthongs that end in /i/ were not subject to vowel coalescence. The stability of /i/ is deeply rooted in Japanese phonology.

In the current vowel epenthesis experiment, we observed that when the input nucleus ends in a [CORONAL, HIGH] segment (/i/ or /j/), there is a significantly higher percentage of epenthetic /i/, in comparison to when the input nucleus does not end in /i/ or /j/. We can explain this by the stability of /i/ in Japanese. Japanese speakers prefer to violate native phonotactics rather than delete /i/ in sequences like /ain/, indicating a strong tendency to preserve /i/ whenever possible. When they are given an adaptation option where /ai/ or /aj/ is contracted, in order to preserve /i/ or /j/, they choose epenthetic /i/ which shares the same feature as the final segments in the input nucleus. This has been demonstrated by historical Sino-Japanese adaptations and the online adaptations in this experiment.

The vowel contraction pattern observed in the experiment do not have logical analogical explanations. As we have just seen above that there are almost no instances where /ai/ is shortened in Modern Japanese. In terms of word structure, bisyllabic forms with a heavy syllable followed by a light syllable is one of the most unmarked word structures in Modern Japanese, and light-heavy forms are the least favoured bisyllablic structure. (Kubozono, 2015). There are no reason for Modern Japanese speakers to voluntarily contract input nucleus based on analogy.

In summary, there is no direct evidence supporting an intuitive analogical process. The experimental results reflect an online adaptation process influenced by the asymmetry between /i/ and /u/, existing both historically and in Modern Japanese. Investigating historical loanwords in the modern language allows us to uncover changes in the native phonology and identify language phenomenon that are deeply rooted and persist to the present day. As Kubozono (2015: 356) describes, loanword phonology serves as a mirror reflecting the structure of the host language, revealing aspects that would not otherwise be clear.

4.5.3 Reponses to the research questions

In Section 4.2, we introduced five research questions for this experimental study. Here we discuss the answer to each research question.

Research question 1: *Under the forced-choice experimental condition, when Modern Japanese speakers could adapt the nucleus from the input freely and were asked to choose the epenthetic vowel between /i/ and /u/, which epenthetic vowel did Modern Japanese speakers chose to adapt words that have the structure of LMC?*

Findings: Participants consistently chose epenthetic /u/, the default epenthetic vowel for loanwords in Modern Japanese. The result is consistent with the Modern Japanese loanword literature (Kubozono, 2015). As discussed in Section 3.4.3, the Modern Japanese /u/ is perceptually the least salient and acoustically the shortest. Inserting epenthetic /u/ results in the adapted form being perceived as most similar to the source form. This finding supports the phonetic/perceptual account of loanword adaptation.

Research question 2: *Under the XAB experimental condition, when Modern Japanese speakers are given carefully designed adaptation options, will they adapt the words with the structure of LMC in the same way as EMJ speakers? Do the quality and length of the nucleus in the input influence the quality of the epenthetic vowel in the adapted form?*

Findings: Modern Japanese speakers did not adapt inputs that have the structure of LMC in the exact same way as EMJ speakers. However, we saw a similar pattern where an epenthetic vowel harmony could be triggered by (1) a [CORONAL, HIGH] segment, /i/ or /j/, that occurred at the end of the input, and (2) contraction of the input nucleus. Details on the influencing variables and how the experimental data support the corpus data are discussed in Section 4.5.1 and 4.5.2 above.

Research question 3: *Under the XAB experimental condition, does the place feature of the coda consonant from the input have an influence on the quality of the epenthetic vowel?*

Findings: Empirical data on vowel epenthesis from other languages has shown that dorsal codas tend to allow vowel harmony, but codas from other places of articulation tend to block vowel harmony (Uffmann, 2006; Rose & Demuth, 2006). Previous studies in Sino-Japanese have also assumed that the epenthetic vowel harmony only applies when the input coda is dorsal (Heffernan, 2007; Ito & Mester, 2015). Data from the current XAB study, however, shows that coda place does not have significant influence on any dependent variables. Dorsals in Modern Japanese do not seem to enjoy any special status when speakers are adapting input that has the same structure as LMC. Nevertheless, we cannot assert that dorsals also behaved the same way in EMJ.

Research question 4: *Under the XAB experimental conditions, when the source form has a /V_1V_2w/ nucleus, is there vowel harmony between the glide /w/ and the epenthetic vowel?*

Findings: The experiment results show that when the source form has a /VVw/ nucleus, there is significantly more epenthetic /u/ than when the source form has the /VVj/ nucleus. However, it is unclear whether this is a consequence of vowel harmony or if it was simply a default vowel insertion.

Research question 5: *Could Modern Japanese speakers perceive the difference between /a:/ and /a/ from the input, and do they adapt them differently under the XAB experimental condition?*

Findings: The coda adaptation corpus analysis showed that in Sino-Japanese *kan-on*, when the input nucleus is /a:j/, the epenthetic vowel is /i/ in 10.3% of the data and /u/ in 89.7% of the data. This was the only input that triggered inconsistent vowel epenthesis – for all other inputs, the epenthetic vowel is either always /i/ or always /u/. The prediction was that EMJ speakers might not be able to consistently perceive the long vowel /a:/, because it is not in their native phonology. They perceived /a:j/ like /ai/ the majority of time, and the input nucleus /ai/ consistently gave epenthetic /u/ in the adapted form. In this experimental study, we saw the opposite pattern – short input nucleus that ends in the [CORONAL, HIGH] vowel /i/ (e.g. /ai/) triggered epenthetic /i/ as significantly as a long input nucleus with a glide (e.g. /a:j/ or /iaj/). Vowel harmony no longer has the hard requirement of having 3 distinct segments in the input nucleus. We therefore cannot tell if Modern Japanese speakers considered /a:/ in /a:j/ to be different from /a/ in /ai/ in the experimental setting. In natural settings, long vowels are common in Modern Japanese due to the large intake of western loanwords and speakers can perceive the duration difference.

Chapter 5 General discussion and conclusion

5.1 Sino-Japanese as a subject for loanwords study

This thesis investigates Sino-Japanese *kan-on* from the perspective of loanword adaptation. Chinese has profoundly influenced the Japanese lexicon through historical language contacts. Chinese loanwords, however, have not received much attention in the field of loanword adaptation. Although due to the historical nature of the borrowing event we do not have acoustic data to ascertain the precise shape of every sound and structure of the source Chinese variety, borrowing Japanese variety and adapted Sino-Japanese forms at the time of adaptation, historical textual evidence, phonological reconstructions and sociolinguistic studies provide us with invaluable resources for the study of Sino-Japanese in the field of loanword adaptation.

In this thesis, data from source and borrowing language varieties are obtained from phonological reconstructions, and the adapted forms are based on a specialised Sino-Japanese root dictionary. The resources are critically examined against other historical studies and textual evidences before being used in the database. Given that vowel adaptation poses more controversy than consonants, the empirical investigations focus on the adaptation of consonants, specifically the initial and coda consonants, in Sino-Japanese *kan-on*. The data covers segmental adaptations and structural adaptations.

Sociolinguistic studies paint the background and parameters of the language borrowing event. The adaptation occurred within a unique sociolinguistic context where the borrowing language community nativized the pronunciation of Chinese characters while simultaneously developing its own writing system. Chinese was first being learned as a foreign language before the readings of characters became nativized. While EMJ speakers had exposure to both spoken LMC (through interactions with native LMC speakers) and written LMC, the input to the adaptation process was orally based. LMC scripts did not provide phonetic cues to EMJ speakers, and there were no existing EMJ scripts capable of representing the foreign sounds at the early stage of the language contact. There was a high level of bilingualism among the upper class and LMC enjoyed high prestige at the time of language contact.

This thesis differs from philological and textual analysis studies of Sino-Japanese in that it (1) provides detail on the size of the database and how it is constructed, (2) performs systematic analysis and shows statistics for each sound and structural adaptation, (3) discusses the choice of adaptation strategies with regard to the phonetics vs phonology theoretical debate, and (4) tests the findings through psycholinguistic experiments.

The empirical findings in this thesis underscore the significance of examining Sino-Japanese within the realm of loanword adaptation. The results:

- Provide corpus and experimental evidence for the theoretical debate in loanword adaptation.
- Offer insight and clarification on which aspects of Sino-Japanese *kan-on* are the result of adaptation and which aspects reflect source and borrowing language specific synchronic phonology. Specifically, coda distribution analyses indicate that the reason why epenthetic [i ĩ] only occur after [DORSAL] consonants in Sino-Japanese is due to the distribution of [DORSAL] codas in Chinese.
- Complement studies on Sino-Japanese strata in Modern Japanese, e.g. Ito & Mester vowel harmony.
- Complement the Sino-Japanese textual analysis and diachronic studies by presenting statistics for each correspondence.

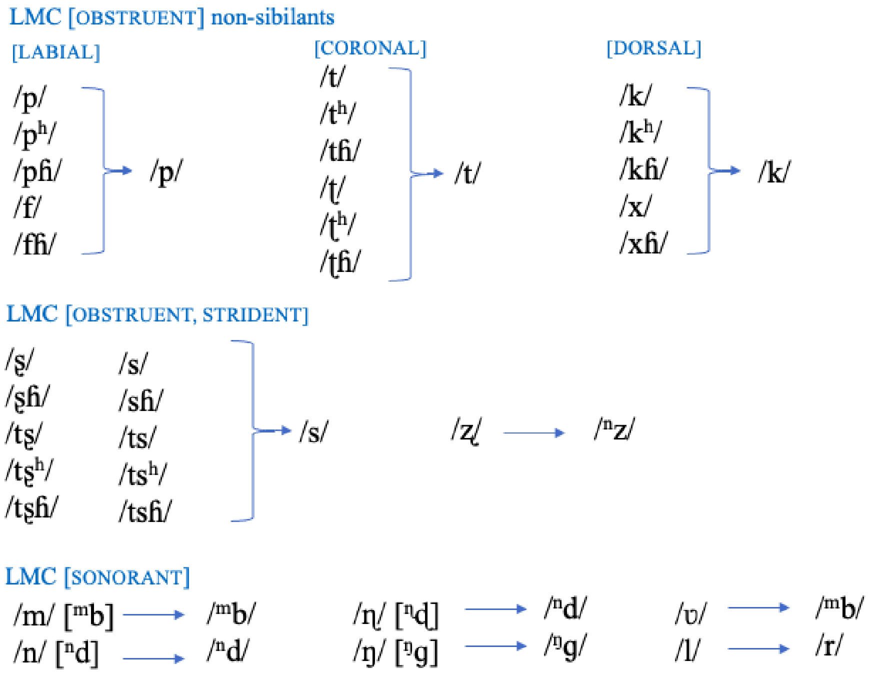
- Reveal the link between vowel epenthesis in EMJ and Modern Japanese, which is not obvious from the native language data.

5.2 Segmental adaptation and feature mapping

The first corpus analysis investigates the adaptation of Sino-Japanese *kan-on* initial consonants. Since both EMJ and LMC allow initial consonants, adaptation took place at the segmental level. LMC has a large number of phonemes that are foreign to the native phonology of EMJ. EMJ speakers had to identify native phonemes to represent the foreign segments.

Figure 20 shows a summary of the segmental adaptation data from the initial consonant corpus study.

Figure 20 Summary of initial consonant adaptation result. For each column, the source consonants are on the left before the arrow and the Sino-Japanese adapted consonants are on the right after the arrow.



The main results are listed below:

- The adaptation is highly consistent with each sound in the input only matching with one adaptation form.

- Despite the high level of bilingualism and the prestige of the source language, there is a large number of mergers, because the borrowing language has much fewer contrasts in the initial consonant phonemic inventory than the source language.
- There is a consistent preservation of PLACE of articulation. An extreme example is the LMC sonorant labial-dental /ʋ/ which is adapted as EMJ prenasalised voiced obstruents /^{m}b/. The manner of articulation is changed but the place remains.
- At the [CORONAL] PLACE, LMC affricates are adapted as EMJ sibilants.
- At the [LABIAL] and [DORSAL] PLACE, LMC fricatives are adapted as EMJ non-sibilants of the same PLACE.
- All adapted Sino-Japanese *kan-on* forms have the same ARTICULATOR feature as the source forms. The TONGUE HEIGHT feature of the LMC retroflexes is ignored in adaptation.
- All LMC voiceless obstruents with breathy release ('muddy' voiced) and voiceless aspirated obstruents are adapted as voiceless unaspirated obstruents in EMJ, e.g. /kɦ/ → /k/. The three way voicing and aspiration contrast in LMC is not preserved in Sino-Japanese *kan-on*.
- LMC nasals (/m n ɳ ŋ/) which surface as prenasalised obstruents ([^{m}b ^{n}d ^{ɳ}ɖ ^{ŋ}g]) are adapted as the prenasalised obstruents in EMJ (/^{m}b ^{n}d ^{n}d ^{ŋ}g/). Surface forms in the source language are matched with underlying forms in the borrowing language.

When loanwords are introduced orally, the adaptation process involves speakers of the source language producing the words and listeners of the borrowing language adapting the acoustic input into their native phonology. EMJ speakers extract features from the acoustic signal of LMC and map them onto their native phonemes. For example, the [OBSTRUENT, NASAL] features from the signal of the LMC surface prenasalised obstruents [^{m}b ^{n}d ^{ɳ}ɖ ^{ŋ}g] are extracted and mapped onto the [OBSTRUENT, NASAL] features of the prenasalised obstruent phonemes /^{m}b ^{n}d ^{n}d ^{ŋ}g/ in EMJ.

The distribution of phonemes, phonological processes and feature specifications in the native phonology of the borrowing language guides adaptation. From a purely perceptual perspective, LMC /ʋ/ should be best matched with EMJ /w/ which is also [LABIAL, SONORANT]. However, /w/ was in the process of diachronic change and had increasingly limited distribution during EMJ. EMJ /^{m}b/ is selected instead as the adapted form. In terms of native phonological process and feature specifications, EMJ has two groups of obstruents /^{m}b ^{n}d ^{ŋ}g ^{n}z/ and /p t k s/ which contrast in both nasality and voicing from a phonetic perspective. As discussed in Section 2.4, [NASAL] is an active feature in EMJ. It participates in synchronic phonological processes such as postnasal neutralisation and vowel nasalisation, and the diachronic *onbin* sound change. The feature [VOICE] is therefore not needed to be specified for the two groups of obstruents in EMJ according to FUL because it does not establish additional contrasts. LMC voiceless obstruents with breathy release (‘muddy voiced’) which are [VOICE, SPREAD GLOTTIS] cannot match with EMJ prenasalised voiced obstruents which are [NASAL]. EMJ voiceless non aspirated obstruents are therefore selected as the adaptation candidate instead.

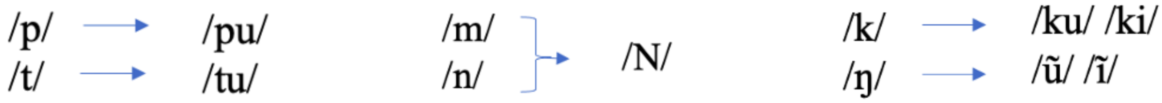
Despite the high level of bilingualism and prestige associated with LMC, merger is still inevitable due to the larger number of phonemes in LMC than in EMJ. Languages do not easily accept brand new phonemes through adaptation (Kennard & Lahiri, 2020).

5.3 Structural adaptation and vowel harmony

The second corpus analysis and the experimental study together examine the adaptation of Chinese codas. EMJ does not allow obstruent codas in word-final position. The adaptation is therefore at the structural level. The corpus analysis shows that Sino-Japanese *kan-on* chooses vowel epenthesis as the repair strategy, and reveals an epenthetic vowel harmony. The experimental study builds on the findings of the corpus study and further investigates the factors that condition the vowel harmony. The findings provide a clearer picture of the epenthetic vowel harmony and address the proposal of Ito & Mester (2015) vowel harmony which is the generally agreed theory for V_2= /i ĩ/ in the Sino-Japanese literature.

A summary of the coda adaptation data in the corpus study is shown in Figure 21. Labial and coronal obstruent codas are adapted with the insertion of the default epenthetic /u/. Labial and coronal nasals are adapted as the bound moraic nasal /N/. The dorsal obstruent is adapted with the insertion of the default vowel /u/ or the [CORONAL HIGH] vowel /i/. The dorsal nasal is adapted as a nasalised default vowel /ũ/ or a nasalised [CORONAL HIGH] vowel /ĩ/.

Figure 21 Summary of coda consonant adaptation result – corpus study. The source consonants are on the left before the arrow and the Sino-Japanese kan-on adapted consonants are on the right after the arrow.



What is particularly interesting from a loanword adaptation perspective is the epenthetic /i/ and /ĩ/ for the Chinese dorsal codas. Distribution and statistical analysis were performed on the corpus data to further investigate what conditions the quality of the epenthetic vowel. A summary of the findings on vowel epenthesis (including the nasalised vowels for the dorsal nasals) is shown in Table 111. The quality of the epenthetic vowel is influenced by the interaction of two variables: (1) the number of distinct segment in the input nucleus, and (2) the final glide in the input nucleus.

- When EMJ speakers perceive less than three segments in the input nucleus, the default epenthetic vowel /u/ is inserted.

- When EMJ speakers perceive three segments in the input nucleus, a vowel harmony process is triggered and the input glide /j/ spreads its [CORONAL, HIGH] features to the epenthetic vowel.

Table 111 Summary of vowel epenthesis corpus study result

Adaptation strategy	Input nucleus		Epenthetic vowel	Theoretical explanation
Default insertion	< 3 distinct segments in the input nucleus		/u/	Perceptual similarity
Vowel harmony	3 distinct segments in the input nucleus	final glide /j/	/i/	Phonology: feature spreading

However, the epenthetic vowel harmony account based on the corpus data is incomplete. It has limitations including the following:

- Due to the distribution of Chinese codas, we do not know if the [DORSAL] PLACE feature has an influence on the quality of the epenthetic vowel.
- Due to the distribution of the glide /w/ in LMC, there are no items in the corpus with the nucleus /V_1V_2w/. We cannot prove with the corpus data what epenthetic vowel would be inserted for /V_1V_2w/ nucleus.
- The result proposes a novel hypothesis that the length of the input nucleus influences the quality of the epenthetic vowel. This hypothesis requires further testing to be confirmed. It is possible that this data pattern is not due to an adaptation strategy from EMJ but is instead a consequence of the unique structure and distribution of LMC input.

These limitations lead to the design of the experimental study, aiming to provide a complete picture of the epenthetic vowel harmony in Sino-Japanese *kan-on*. A summary of the experimental study result is presented in Table 112.

Table 112 Summary of vowel epenthesis experimental study result

Adaptation strategy	Input nucleus	Adapted form	Result	Theoretical explanation
Epenthetic vowel harmony	last segment [CORONAL, HIGH]	short nucleus /e/	epenthetic /i/	Phonology: feature spreading
		long nucleus /ja a: ai/	epenthetic /i/	
Ito & Mester Vowel harmony (i.e. harmony in the adapted form)	last segment not [CORONAL, HIGH]	short nucleus /e o/	epenthetic /i/	
		long nucleus /ja a: au/	epenthetic /u/	
		epenthetic /i/	short nucleus /e o/	
		epenthetic /u/	long nucleus /ja a: au/	

The results see robust link between the final [CORONAL, HIGH] segment in the input nucleus and epenthetic /i/, corroborating the findings from the corpus data. The default vowel /u/ is the dominant epenthetic vowel (> 80%) across all conditions. The percentage of epenthetic /i/ vary by test condition. It is influenced by the interaction of two variables: (1) whether the input nucleus is contracted in adaptation, and (2) the final segment in the input nucleus. The forced-choice study shows that when the input nucleus is not contracted, the default epenthetic /u/ is always inserted. The XAB study shows that when the input nucleus is contracted in adaptation, like in Sino-Japanese *kan-on*:

1. When the input nucleus ends in a [CORONAL, HIGH] segment, then regardless of the degree of contraction (by 1 or 2 segments), there is a significantly higher percentage of epenthetic vowel harmony. The nucleus final [CORONAL, HIGH] segment spreads its PLACE feature to the epenthetic vowel, turning it into /i/. The data cannot be explained by the Ito & Mester vowel harmony theory (Ito & Mester, 2015) which is based on the adapted form.
2. When the input nucleus does not end in a [CORONAL, HIGH] segment, there is a two-directional backness vowel harmony in the adapted form due to the stimuli design. There is a [DORSAL] feature mapping between epenthetic /u/ and the preceding vowel /a/ or /u/, and a [CORONAL] feature mapping between epenthetic /i/ and the preceding vowel /e/.

The findings of the corpus study and experimental study completement each other and they together complete a full scale survey of coda adaptation and epenthetic vowel harmony in Sino-Japanese and Modern Japanese. LMC obstruent codas are adapted by the insertion of an epenthetic vowel in Sino-Japanese *kan-on*. The epenthetic vowel is the [DORSAL, HIGH] vowel /u/ by default. However, an epenthetic vowel harmony can be triggered when the source nucleus (1) ends in a [CORONAL, HIGH] segment and (2) is being contracted in adaptation. The coda PLACE does not have an influence on the epenthetic vowel harmony. While we cannot directly test the precise conditions that trigger vowel harmony in EMJ, we have proved that the interaction of these two factors contribute to epenthetic vowel harmony in Modern Japanese. The study contributes to the investigation on the asymmetry between Japanese /i/ and /u/ in the history of Japanese and in the modern language (Kubozono, 2015). The results contribute to the vowel epenthesis literature with a novel proposal: the source nucleus and how it is adapted (note that not the adapted form,) influence the quality of the epenthetic vowel.

The Ito & Mester vowel harmony theory (Ito & Mester, 2015; Tateishi, 1990), which is the widely accepted theory for explaining the quality of the second vowel (i.e. the epenthetic vowel) in Sino-Japanese roots (Heffernan, 2007), has been examined in this thesis. For a Sino-Japanese root of the structure $C_1(G)V_1C_2V_2$, the theory argues that when C_2 is [DORSAL], V_2 takes on the backness of V_1: when V_1 is the front vowel /e/, V_2 is the front high vowel /i/; when V_1 is one of the back vowels /a, o, u/, V2 is the back default vowel /u/ . However, when V_1 is the front vowel /i/, V_2 can be /i/ or /u/. Note that the theory is based on Sino-Japanese words from all substrata. From an adaptation perspective, the theory would suggest that the quality of the epenthetic vowel (Sino-Japanese V_2) is conditioned by the adapted form of the source nucleus (Sino-Japanese V_1). This thesis has the following findings about the Ito & Mester vowel harmony theory:

1. The vowel harmony prerequisite C_2 = [DORSAL] is not the result of the special status of [DORSAL] feature in Japanese, but the distribution of dorsal codas in LMC source forms. In Modern Japanese, we could elicit the same type of vowel harmony with C_2 $\neq$[DORSAL].
2. When C_2 = [DORSAL] and V_1 = /i/, V_2 is not consistently /i/ because the quality of the epenthetic vowel, or V_2 in Sino-Japanese, is not conditioned by Sino-Japanese V_1 but the source nucleus form. For Sino-Japanese *kan-on* substrata, data from our corpus shows that when C_2 = [DORSAL]: when V_1 = /i/, V_2 = /u/; when V_1 = /e/, V_2 = /i/. A comparison of the data with V_1 = /i/ and V_1 = /e/ shows that for all V_1 = /e/, the source nucleus are /VVj/; for all V_1 = /i/, the source nucleus are /iw/. There is therefore no [CORONAL, HIGH] feature spreading for all cases with V_1 = /i/.
3. While the two vowel harmony processes – epenthetic vowel harmony and Ito & Mester vowel harmony – coexist in Japanese, experimental evidence shows that the quality of the Sino-Japanese epenthetic vowel is a result of the [CORONAL, HIGH] feature spreading from the source nucleus instead of a backness spreading from the adapted form nucleus. In the XAB task, when the input nucleus ends in a [CORONAL, HIGH] segment, then regardless of the phonological shape of the adapted nucleus /a: ja ai e/, there is a significantly higher percentage of epenthetic /i/ (Sino-Japanese V_2 = /i/); only when the input nucleus does not end in a [CORONAL, HIGH] segment we see the Ito & Mester vowel harmony come into play.

5.4 Unifying the phonetic and phonological theories

This thesis proposes that the perceptual and phonological theories are complementary rather than contradictory, and a unification of the theories is needed to account for the adaptation of Sino-Japanese *kan-on*.

In the loanword adaptation literature, theories are frequently based on empirical evidence on a specific adaptation phenomenon, e.g. the adaptation of English voicing contrast in Mandarin, the adaptation of English consonant clusters in Spanish. This thesis assesses the theories by bringing together evidence from both the segmental level and structural level of the adaptation of Sino-Japanese *kan-on*. Data covers the adaptation of all consonant phonemes in the initial and coda positions in LMC. Segmental adaptations often offer direct evidence supporting phonetics and phonology explanations because perceptual similarities are more easily measurable, and the preservation of contrasts can be straightforwardly observed. Therefore, some of the strongest evidence in favour of these theories come from segmental adaptation cases. However, exclusively focusing on segmental adaptation would fail to provide a comprehensive view of the overall adaptation process of Sino-Japanese *kan-on*. The narrow perspective may lead to a misleading assumption that EMJ only has the repair strategies they employ in segmental adaptation available in the native language. In contrast, structural adaptations typically involve more complex repair processes beyond simple sound matching. Evidence from both levels of adaptation needs to come together for a holistic assessment.

As discussed in Section 1.3, the first question in loanword adaptation is whether speakers of the borrowing language have access to the phonology of the source language or only to its surface acoustic properties. During the time of adaptation, there was a high level of bilingualism among the elites, and LMC was seen as a language of prestige and taught in institutes by native instructors. However, despite these sociolinguistic factors, EMJ lacks sufficient native phonemes to represent the larger number of foreign contrasts, resulting in an abundance of cases of mergers. Additionally, the coda structure in LMC is unacceptable in EMJ, regardless of whether EMJ speakers have access to the underlying phonology of LMC. The corpus data in this thesis does not show any evidence of phoneme or structural importation. Hence, even if we assume that EMJ speakers had access to LMC's phonology, it still appears that the input to adaptation rely on the surface forms of LMC.

The next question is how the acoustic surface signals are being processed by speakers of the borrowing language. Does the adaptation happen in the raw perception or in the phonology of the borrowing language? The segmental adaptation data supports a phonology-based-perception account. While some of the initial consonant adaptation data can be explained by both the perception and phonology theories (see Section 3.3.3), the adaptation of LMC voiceless obstruents with breathy release and labiodental approximant /ʋ/ provide evidence that the input to adaptation is the surface acoustic of the source language, and the process is driven by the phonology of the borrowing language. Perceptual similarities are guided by feature specifications and phonological processes in the native phonology (Lahiri, 2018).

The structural adaptation data support both the phonology-based-perception and purely perception theories. Japanese chooses vowel epenthesis over consonant deletion to adapt illegal obstruent codas, a strategy similarly observed in other languages such as Tswana (Batibo, 1996) and Fijian (Kenstowicz, 2007), conforming to the *Preservation Principle* proposed by Paradis & LaCharité (1997). The case of Japanese default epenthetic vowel /u/ has been used as one of the strongest pieces of evidence in support of the perceptual 'deafness' theory (Peperkamp & Dupoux, 2003), as introduced in Section 1.3. Our data from the experimental study confirms that in the majority of cases, Modern Japanese speakers choose the default epenthetic /u/, which is perceptually the least salient vowel. On the other hand, a [CORONAL, HIGH] vowel harmony is also observed. Vowel harmony is traditionally analysed in the field of phonology, with references to autosegmental representation and feature spreading. It is doubtful if Japanese speakers, when given a foreign acoustic input like /kiajk/, would arrive at a form like /keki/ already in perception before the signals reach the level of phonological computation. It is also arguably difficult to define perceptual minimality for vowel epenthesis in general.

Each case of language contact is unique, shaped by a multitude of factors that influence the loanword adaptation process. It is crucial to recognise that evidence favouring one theory doesn't necessarily invalidate another theory. The Sino-Japanese *kan-on* segmental and structural adaptation data presented in this thesis provide support for both phonological and perceptual theories. The results underscore that the theories should not be viewed as mutually exclusive; rather, when integrated, they could offer a comprehensive framework for explaining a wider range of loanword adaptation data.

5.5 Future directions

While this thesis looks at the adaptation of the input nuclei in relation to the epenthetic vowel, it does not present a thorough analysis of nucleus adaptation in terms of vowel quality. One of the reasons for this is the controversiality of the Sino-Japanese vowels documented in dictionaries and other modern Japanese materials. The thesis also does not address onset glide adaptation – recall that in Section 2.4.3.5 we mention that Sino-Japanese loanwords reintroduced complex onsets through the adaptation of Chinese rhymes. Attempts have been made to look at both onset glides and vowel adaptation, but we have had some messy and puzzling observations like the one below.

We looked at the adaptation of Chinese nucleus /ia/ and /ya/, and the data reveal a complex relationship wherein the nucleus and onset glide in the adapted forms appear to be susceptible to influences from the nucleus, coda, and even the initial consonant of the source form. A distribution analysis showed that LMC nucleus /ia/ occurs before all six codas and also without a coda, and LMC nucleus /ya/ occurs before the coronal codas, the dorsal nasal coda and without a coda. Table 113 shows the adaptation of LMC nuclei /ia ya/ with different codas. LMC nucleus /ia/ is adapted as /e/ when the coda is coronal or labial, as /ja/ or /jo/ when the coda is dorsal or ∅. LMC nucleus /ya/ is adapted as /e/ when the coda is coronal, /(j)a/ when the coda is dorsal, and /iu/, /ju/ or /u/, depending on the initial consonant, when there is no coda. For the nucleus /ia/, it is clear that the labial and coronal codas pattern together, and the dorsal and ∅ codas pattern together. The case of LMC nucleus /ya/ is more complicated because EMJ does not have the high front rounded vowel /y/. The syllable initial consonant can also influence the adaptation of /ya/. Nonetheless, it is evident that labial and coronal codas exhibit analogous behaviour, and their impact on nucleus adaptation differs from that of dorsal and ∅ codas.

Table 113 The adaptation of Chinese nuclei /ia ya/ with and without a coda

Coda / Nucleus	/p/	/m/	/t/	/n/	/k/	/ŋ/	/∅/
/ia/	/e/ + /pu/	/e/ + /N/	/e/ + /tu/	/e/ + /N/	/ja/ or /jo/ + /ku/	/ja/ or /jo/ + /ũ/	/ja/ or /jo/
/ya/	–	–	/e/ + /tu/	/e/ + /N/	–	/a/ or /ja/ + /ũ/	/iu/, /ju/ or /u/ (influenced by initial consonant)

Future efforts could be made in an in-depth investigation on the nucleus and onset glide adaptation with the help of uncontentious materials, in order to complete the systematic study of Sino-Japanese *kan-on* adaptation and complement the initial and final consonant study in this thesis.

Section 1.2.2 briefly discussed the proportion and usage of Sino-Japanese words in Modern Japanese. However, the data is quite outdated. There are not many recent comprehensive surveys on the percentage and frequency of Sino-Japanese words in the Japanese lexicon and in ordinary speech. Further study could be conducted for a more contemporary picture of the Sino-Japanese strata in Modern Japanese, with a focus on both written and oral materials.

5.6 Concluding remarks

The overarching aim of this thesis is to address a notable gap in the Sino-Japanese literature, presenting empirical data to enrich the ongoing theoretical discussions in loanword adaptation, and proposing innovative research methods for historical adaptation data. While studies on Sino-Japanese have predominantly concentrated on strata-specific linguistic features or focused on historical textual analysis, this thesis is one of the very few studies that examines Sino-Japanese from the loanword adaptation perspective and provides statistical evidence. Additionally, the experimental study is one of the first psycholinguistic experiments on Sino-Japanese, providing fresh insights into historical adaptations.

The findings of this thesis demonstrate that Sino-Japanese can be fruitfully examined in the field of loanword adaptation, opening up a promising pathway for future research and exploration. Furthermore, the empirical evidence suggests a unification of the phonetics and phonological adaptation theories.

References

Arora, Vipul, Aditi Lahiri, & Henning Reetz (2017). Automatic speech recognition: What phonology can offer. In A. Lahiri & S. Kotzor (eds.) *The Speech Processing Lexicon: Neurocognitive and Behavioural Approaches*, 211–235 Berlin: Mouton de Gruyter.

Batibo, H. M. (1996). Loanword clusters nativization rules in Tswana and Swahili: A comparative study. *South African journal of African languages*, *16*(2), 33-41.

Baxter, W. H. (1992). *A Handbook of Old Chinese Phonology.* Berlin and New York: Mouton de Gruyter.

Best, J. W. (2006). *A History of the Early Korean Kingdom of Paekche, together with an annotated translation of The Paekche Annals of the Samguk sagi*. Harvard: Harvard University Asia Center.

Boersma, P., & Hamann, S. (2009). Loanword adaptation as first-language phonological perception. In A. Calabrese, & W. L. Wetzels (Eds.), *Loan phonology* (pp. 11-58*)*. John Benjamins.

Boersma, P., & Weenink, D. (2022). Praat: doing phonetics by computer [Computer program] version 6.2.06, January 21, 2022

Clements, G. N. M., & Hume, E. V. (1995). The internal organization of speech sounds. In J. A. Goldsmith (Eds.), *The handbook of phonological theory* (pp. 245-306). Blackwell.

Chang, C. B. (2008). Phonetics vs. phonology in loanword adaptation: Revisiting the role of the bilingual. *Proceedings of the Annual Meeting*, Berkeley Linguistics Society*, 34.*

Chao, Y. (1928). *Xiandai Wu yu de yanjiu.* Beijing: Science Publishing.

Chomsky, N., & Halle, M. (1968). *The sound pattern of English*. New York: Harper & Row.

Coblin, W. S. (1994). A Compendium of Phonetics in Northwest Chinese. *Journal of Chinese Linguistics monograph series*, (7), 1-504.

De Boer, E. M. (2008). The Middle Chinese tones through Japanese eyes. In R. Djamouri, B. Meisterernst, & R. Sybesma (Eds.), *Chinese Linguistics in Lepzig*: CLE no. 2 (pp. 71-86). EHESS-CRLAO.

De Boer, E. M. (2010). *The historical development of Japanese tone.* Wiesbaden: Harrassowitz Verlag.

Dohlus, K. (2005). Phonetics or phonology: Asymmetries in loanword adaptations – French and German mid front rounded vowels in Japanese. *ZAS Papers in Linguistics*, *42*, 117–135.

Dong, H. (2014). *A history of the Chinese language*. London: Routledge.

Duanmu, S. (2000). *The phonology of Standard Chinese*. (1st ed.). Oxford: Oxford University Press.

Duanmu, S. (2007). *The phonology of standard Chinese*. (2nd ed.). Oxford: Oxford University Press.

Dupoux, E., Kakehi, K., Hirose, Y., Pallier, C., & Mehler, J. (1999). Epenthetic vowels in Japanese: A perceptual illusion?. *Journal of experimental psychology: human perception and performance*, *25*(6), 1568.

Endo, M. (2015). Language contact between Chinese and Japanese. In W. S. Wang, & C. Sun (Eds.), *The Oxford handbook of Chinese linguistics* (pp. 215-225), Oxford University Press.

Feng, S. (2014). Historical syntax of Chinese. In C. J. Huang, Y. A. Li, & A. Simpson (Eds.), *The handbook of Chinese linguistics* (pp. 535-575). John Wiley & Sons.

Frellesvig, B. (l995). *A Case Study in Diachronic Phonology - The Japanese Onbin Sound Changes.* Aarhus: Aarhus University Press.

Frellesvig, B. (2010). *A History of the Japanese Language.* Cambridge: Cambridge University Press.

Frellesvig, B. (2018). On Feature Ranking in Japanese Onset Obstruents, In A. Vovin., & W. McClure (Eds.), *Studies in Japanese and Korean Historical and Theoretical Linguistics and Beyond* (pp. 22-36). Brill.

Friesner, M. L. (2009). The adaptation of Romanian loanwords from Turkish and French. *Loan phonology*, *307*, 115-129.

Fujimoto, M. (2015). Vowel devoicing. In H. Kubozono (Eds.) *Handbook of Japanese phonetics and phonology* (Vol. 2, pp. 167-214). Walter de Gruyter.

Gelbart, B., & Kawahara, S. (2007). Lexical cues to foreignness in Japanese. *Proceedings of Formal Approaches to Japanese Linguistics*, 4, 55-67.

Ghini, M. (2001). *Asymmetries in the phonology of Miogliola*. Berlin: Mouton de Gruyter.

Handel, Z. (2014). Historical phonology of Chinese. In C. J. Huang, Y. A. Li, & A. Simpson (Eds.), *The handbook of Chinese linguistics* (pp. 576-598). John Wiley & Sons.

Hasegawa, Y. (2014). *Japanese: A linguistic introduction.* Cambridge: Cambridge University Press.

Haspelmath, M., & Tadmor, U. (2009). The loanword typology project and the world loanword database. In M. Haspelmath, & U. Tadmor (Eds.), *Loanwords in the world's languages: A comparative handbook* (pp. 1- 34). De Gruyter Mouton.

Haugen, E. (1950). The analysis of linguistic borrowing. *Language*, *26*(2), 210-231.

Hayes, B. (1989). Compensatory Lengthening in Moraic Phonology. *Linguistic Inquiry*, *20*(2), 253-306.

Heffernan, K. (2007). The role of phonemic contrast in the formation of Sino-Japanese. *Journal of East Asian Linguistics*, *16*(2), 61-86.

Hyman, L. (1970). The role of borrowing in the justification of phonological grammars. *Studies in African linguistics*, *1*(1), 1.

Irwin, M. (2011). *Loanwords in Japanese*. Amsterdam: John Benjamins.

Ito, J., & Mester, A. (1993). Japanese phonology: constraint domains and structure preservation. In J. Goldsmith, (Eds.) *The handbook of phonological theory (pp.* 817-838*)*. Blackwell.

Ito, J., & Mester, A. (2015). Sino-Japanese phonology. In H. Kubozono (Eds.) *Handbook of Japanese phonetics and phonology* (Vol. 2*,* pp. 290-312). Walter de Gruyter.

Jacobs, H., & Gussenhoven, C. (2000). Loan phonology: Perception, salience, the lexicon and OT. In J. Dekkers, F. van der Leeuw, & J. van de Weijer (Eds.) *Optimality Theory: Phonology, syntax, and acquisition* (pp. 193-210), Oxford University Press.

Jakobson, R., Fant, G., & Halle, M. (1952). *Preliminaries to speech analysis: The distinctive features and their correlates* (Technical Report No. 13). Cambridge, MA: MIT, Acoustics Laboratory.

Karlgren, B. (1915–1926). *Études sur la phonologie chinoise.* Leiden: E. J. Brill.

Karlgren, B. (1957). *Grammata Serica Recensa*, Stockholm: Museum of Far Eastern Antiquities.

Kamei, T. (1954). *Chinese Borrowings in Prehistoric Japanese*. Tokyo: Yoshikawa Kōbunkan.

Kang, Y. (2011). Loanword phonology. *The Blackwell companion to phonology*, 1-25.

Kang, Y., & Schertz, J. (2021). The influence of perceived L2 sound categories in on-line adaptation and implications for loanword phonology. *Natural Language & Linguistic Theory*, *39*, 555-578.

Katayama, M. (1998). *Optimality Theory and Japanese loanword phonology*. Santa Cruz, California: University of California dissertation.

Kawamoto, E. (1977). Onbin. In S, Kiyoji (Eds.), *Kokugogaku Kenkyūjiten* (pp. 66-67). Shoin.

Kennard, H. J., & Lahiri, A. (2020). Nonesuch phonemes in loanwords. *Linguistics*, *58*(1), 83-108.

Kenstowicz, M. (2007). Salience and similarity in loanword adaptation: a case study from Fijian. *Language Sciences*, 29(2-3), 316-340.

Kenstowicz, M., & Suchato, A. (2006). Issues in loanword adaptation: A case study from Thai. *Lingua*, *116*(7), 921-949.

Kilpatrick, A., Kawahara, S., Bundgaard-Nielsen, R., Baker, B., & Fletcher, J. (2021). Japanese perceptual epenthesis is modulated by transitional probability. *Language and Speech*, 64(1), 203-223.

Kim, H. (2008). Loanword adaptation between Japanese and Korean: Evidence for L1 feature-driven perception. *Journal of East Asian Linguistics*, *17*(4), 331–346.

Kim, H. (2009). Korean adaptation of English affricates and fricatives in a feature-driven model of loanword adaptation. In A. Calabrese, & W. L. Wetzels (Eds.), *Loan phonology* (pp. 155–180). John Benjamins.

Kim, N. (2015). A Study on the Sino-Korean Poetry about the Pavilions in Cheongsong-Focusing on Changyeonglu, Sugojeong and Okryujeong, etc. *Journal of Korean Literature*, (31), 229-253.

Kobayashi, A. (1981). Ennin no kijutsu suru sansukuritto onsetsu 'ca' no onka: kyii-seiki nihongo suitei no kokoromi. *Osaka Gaikokugo Daigaku Gakuho*, *52*, 63-80.

Kobayashi, N. (2011). *Shinsen Kanwa Jiten.,* (8th ed.). Tokyo: Shogakkan.

Kotzor, Sandra, Allison Wetterlin, Adam C. Roberts, & Aditi Lahiri (2015). Processing of phonemic consonant length: Semantic and fragment priming: Evidence from Bengali. *Language and Speech* 59, 83-112.

Kubozono, H. (2006). Where does loanword prosody come from? A case study of Japanese loanword accent. *Lingua*, *116*(7), 1140–1170.

Kubozono, H. (2015). Introduction to Japanese phonetics and phonology, In H. Kubozono (Eds.) *Handbook of Japanese phonetics and phonology* (Vol. 2*,* pp. 1-41). Walter de Gruyter.

Kurisu, K. (2000). Richness of the base and root fusion in Sino-Japanese. *Journal of East Asian Linguistics, 9*(2), 147–85.

LaCharité, D., & Paradis, C. (2002). Addressing and disconfirming some predictions of phonetic approximation for loanword adaptation. *Langues et linguistique*, (28), 71-91.

LaCharité, D., & Paradis, C. (2005). Category preservation and proximity versus phonetic approximation in loanword adaptation. *Linguistic inquiry*, *36*(2), 223-258.

Lahiri, A. (2018). Predicting universal phonological contrasts. In L. M. Hyman, & F. Plank (Eds.), *Phonological Typology* (pp. 229-272), Mouton de Gruyter.

Lahiri, A., & Kennard, H. (2019). Pertinacity in loanwords: same underlying systems, different outputs. In M. Cennamo, & C. Fabrizio (Eds.), *Historical Linguistics 2015* (pp. 57-74), John Benjamins.

Ladefoged, P., & Maddieson, I. (1996). *The sounds of the world's languages*. Oxford: Blackwell.

Lev-Ari, S., & Peperkamp, S. (2014). An experimental study of the role of social factors in language change: The case of loanword adaptations. *Laboratory Phonology*, *5*(3), 379-401.

Lev-Ari, S., San Giacomo, M., & Peperkamp, S. (2014). The effect of domain prestige and interlocutors' bilingualism on loanword adaptations. *Journal of Sociolinguistics*, *18*(5), 658-684.

Li, H., & Yu, B. C. (2018). Lun Riyu "Hehan Hunxiaoti" De Baiojichuangsheng Yu Hanyulishi Yicunguanxi, *Wakumon, 21*(34), 21-29.

Lombardi, L., 2003. Markedness and the Typology of Epenthetic Vowels. Unpublished manuscript, University of Maryland (ROA).

Loveday, L. (1996). *Language contact and Japan—a socio-linguistic history*. New York: Clarendon Press and Oxford University Press.

Luo, C. (1933). *Tang Wudai xibei fangyin*. Shanghai: Academia Sinica.

Luo, C. (1956). *Hanyu Yinyunxue Daolun*. Beijing: Zhonghua Shuju.

Maddieson, I., & Precoda, K. (1990). *The UCLA Phonological Segment Inventory Database.* http://web.phonetik.uni-frankfurt.de/upsid.html [Accessed: 27/10/2023]

Martin, S. E. (1987). *The Japanese language through time*. New Haven: Yale University Press.

Mattingley, W., Hall, K. C., & Hume, E. (2019). Epenthetic vowel production of unfamiliar medial consonant clusters by Japanese speakers. *Laboratory Phonology*, *10*(1): 21.

Mattingley, W., Hume, E., & Hall, K. C. (2015). The influence of preceding consonant on perceptual epenthesis in Japanese. *Proceedings of the 18th International Congress of Phonetic Sciences*, 888-893

Miyake, M. (2003). *Old Japanese: a phonetic reconstruction*. London: Routledge.

Moreton, E., & Amano, S. (1999). The effect of lexical stratum phonotactics on the perception of Japanese vowel length. *The 6th European Conference on Speech Communication and Technology (EUROSPEECH'99)*, 2679–2682.

Moreton, E., Amano, S., & Kondo, T. (1998). Statistical phonotactics in Japanese. *The Acoustical Society of Japan*, 63–70.

Monahan, P. J., Takahashi, E., Nakao, C., & Idsardi, W. J. (2009). Not all epenthetic contexts are equal: Differential effects in Japanese illusory vowel perception. *Japanese/Korean Linguistics*, *17*, 391-405.

Numoto, K. (1993). Sino-Japanese kana usage. *Acta Asiatica*, *65*, 65–84.

Okumura, M. (1980). Onbin. In Kokugo Gakkai (Eds.) *Nihon Kokugo Daijiten* (pp. 123-125) Tokyodo.

Packard, J. L. (2015). Classifying Chinese Morphemes. In W. S. Wang, & C. Sun, (Eds.). *The Oxford handbook of Chinese linguistics* (pp. 263-273). Oxford University Press.

Pan, W. (2000). *Hanyu Lishi Yinyunxue.* Shanghai: Shanghai Jiaoyu Chubanshe.

Pan, W., & Zhang, H. (2015). Middle Chinese Phonology and Qieyun. In W. S. Wang, & C. Sun, (Eds.). *The Oxford handbook of Chinese linguistics* (pp. 80-90). Oxford University Press.

Paradis, C., & LaCharité, D. (1997). Preservation and minimality in loanword adaptation. *Journal of Linguistics*, *33*(2), 379–430.

Paradis, C., & LaCharité. D. (2008). Apparent phonetic approximation: English loanwords in Old Quebec French. *Journal of Linguistics*, 44, 87–128.

Paradis, C., & LaCharité, D. (2011). Loanword Adaptation: From Lessons Learned to Findings. In J. Goldsmith, J. Riggle, & A. C. L. Yu (Eds.) *The handbook of phonological theory (*2nd ed., pp. 751–778), Blackwell.

Paradis, C., & Tremblay, A. (2009). Nondistinctive features in loanword adaptation: The unimportance of English aspiration in Mandarin Chinese phoneme categorization. In A. Calabrese, & W. L. Wetzels (Eds.), *Loan phonology* (pp. 211-224). John Benjamins.

Peperkamp, S. (2004). A psycholinguistic theory of loanword adaptations. *Annual Meeting of the Berkeley Linguistics Society*, 30(1), 341-352.

Peperkamp, S., & Dupoux, E. (2001). Loanword adaptations: Three problems for phonology (and a psycholinguistic solution). *Laboratoire de Sciences Cognitives et Pscyholinguistique, 8*, 1-2.

Peperkamp, S., & Dupoux, E. (2002). A typological study of stress 'deafness'. *Laboratory phonology*, *7*, 203-240.

Peperkamp, S., & Dupoux, E. (2003). Reinterpreting loanword adaptations: the role of perception. *Proceedings of the 15th international congress of phonetic sciences*, 367-370.

Peperkamp, S., Vendelin, I., & Nakamura, K. (2008). On the perceptual origin of loanword adaptations: experimental evidence from Japanese. *Phonology*, 25(1), 129-164.

Peirce, J. W., Gray, J. R., Simpson, S., MacAskill, M. R., Höchenberger, R., Sogo, H., Kastman, E., & Lindeløv, J. (2019). PsychoPy2: Experiments in behavior made easy. *Behav Res, 51, 195–203. https://doi.org/10.3758/s13428-018-01193-y*

Prince, A., & Smolensky, P. (2004). Optimality Theory: Constraint interaction in generative grammar. *Optimality Theory in phonology: A reader*, 1-71.

Pulleyblank, E. G. (1984). *Middle Chinese: A study in historical phonology*. Vancouver: UBC Press.

Pulleyblank, E. G. (1991). *Lexicon of reconstructed pronunciation in Early Middle Chinese, Late Middle Chinese, and Early Mandarin*. Vancouver: UBC Press.

Quackenbush, H. and Ohso, M. (1990). *Gairaigo no keisei to sono kyōiku* [Word formation and teaching of loanwords]. Tokyo: Kokuritsu Kokugo Kenkyūjo.

Roberts, A. C., Wetterlin, A., & Lahiri, A. (2013). Aligning mispronounced words to meaning: Evidence from ERP and reaction time studies. *The Mental Lexicon*, *8*(2), 140-163.

Rose, Y., & Demuth, K. (2006). Vowel epenthesis in loanword adaptation: Representational and phonetic considerations. *Lingua*, *116*(7), 1112-1139.

Sagart, L. (1999). The origin of Chinese tones. *Proceedings of the Symposium/Cross-Linguistic Studies of Tonal Phenomena/Tonogenesis, Typology and Related Topics,* 91-104).

Sagey, E. C. (1986). *The representation of features and relations in non-linear phonology* [Doctoral dissertation, Massachusetts Institute of Technology]

Sagisaka, Y. & Tohkura, Y. (1984). Phoneme duration control for speech synthesis by rule, Trans. *IECE Jpn*, *J67-A*, 629-636.

Schmidt, C. K. (2009). Loanwords in Japanese. In M. Haspelmath, & U. Tadmor (Eds.), *Loanwords in the world's languages: A comparative handbook* (pp. 545- 574). De Gruyter Mouton.

Shibatani, M. (1990). *The languages of Japan*. Cambridge: Cambridge University Press.

Shoji, S., & Shoji, K. (2014). Vowel epenthesis and consonant deletion in Japanese loanwords from English. *Proceedings of the Annual Meetings on Phonology*, *1*(1).

Silverman, D. (1992). Multiple scansions in loanword phonology: Evidence from Cantonese. *Phonology, 9*, 289–328.

Smith, J. L. (2006). Loan phonology is not all perception: Evidence from Japanese loan doublets. *Japanese/Korean Linguistics*, *14*, 63–74.

Steriade, D. (2001). Directional asymmetries in place assimilation: A perceptual account. In E. Hume, & K. Johnson (Eds.), *The role of speech perception in phonology* (pp. 219–250). Academic Press.

Tateishi, K. (1989). Phonology of Sino-Japanese morphemes. *University of Massachusetts Occasional Papers in Linguistics, 13*, 209–35.

Ting, P. H. (1996). Tonal evolution and tonal reconstruction in Chinese. In C. J. Huang & Y. A. Li (Eds.), *New Horizons in Chinese Linguistics* (pp. 141–158). Springer Science & Business Media.

Tôdô, A. (1978). *Gakken Kanwa Daijiten.* Tokyo: Gakushû kenkyûsha.

Uffmann, C. (2006). Epenthetic vowel quality in loanwords: Empirical and formal issues. *Lingua*, *116*(7), 1079-1111.

Uffmann, C. (2015). Loanword Adaptation. In P. Honeybone, & J. Salmons (Eds.). *The Oxford handbook of historical phonology* (pp. 644 - 666). Oxford University Press.

Vendelin, I., & Peperkamp, S. (2006). The influence of orthography on loanword adaptations. *Lingua*, *116*(7), 996-1007.

Wang, L. (1979). Xiandai hanyu yuyin fenxi zhong de ji ge wenti. *Zhongguo Yuwen*, 4, 281–6.

Wynne, Hilary S. Z., Sandra Kotzor, Beinan Zhou, Swetlana Schuster, & Aditi Lahiri (2021). Asymmetries in the processing of affixed words in Bengali. *Language* 97, 599–628

Xu, Shirong (1980). *Putonghua Yuyin Zhishi* [Phonology of Standard Chinese]. Beijing: Wenzi Gaige Chubanshe.

Yip, M. (1993). Cantonese loanword phonology and Optimality Theory. *Journal of East Asian Linguistics*, *2*(3), 261-291.

Yip, M. (2006). The symbiosis between perception and grammar in loanword phonology. *Lingua*, *116*, 950–975.

Yuan, J. (1989). *Hanyu Fangyan Gaiyao.* (2nd ed.). Beijing: Wenzi Gaige Chubanshe.

Appendix A Stimuli list

Table 114 XAB Stimuli

X Input	AB Options			
	Long Nucleus + /u/	Long Nucleus + /i/	Short Nucleus + /u/	Short Nucleus + /i/
ka:jk	ka:ku	ka:ki	keku	keki
ka:jp	ka:pu	ka:pi	kepu	kepi
kyajk	kjaku	kjaki	keku	keki
kyajp	kjapu	kjapi	kepu	kepi
kiajk	kjaku	kjaki	keku	keki
kiajp	kjapu	kjapi	kepu	kepi
kajk	kaiku	kaiki	keku	keki
kajp	kaipu	kaipi	kepu	kepi
kiak	kjaku	kjaki	keku	keki
kiap	kjapu	kjapi	kepu	kepi
kyak	kjaku	kjaki	keku	keki
kyap	kjapu	kjapi	kepu	kepi
kiawk	kjaku	kjaki	keku	keki
kiawp	kjapu	kjapi	kepu	kepi
kyawk	kjaku	kjaki	keku	keki
ka:wk	ka:ku	ka:ki	koku	koki
ka:wp	ka:pu	ka:pi	kopu	kopi
kawk	kauku	kauki	koku	koki
kawp	kaupu	kaupi	kopu	kopi

Table 115 Forced-choice stimuli

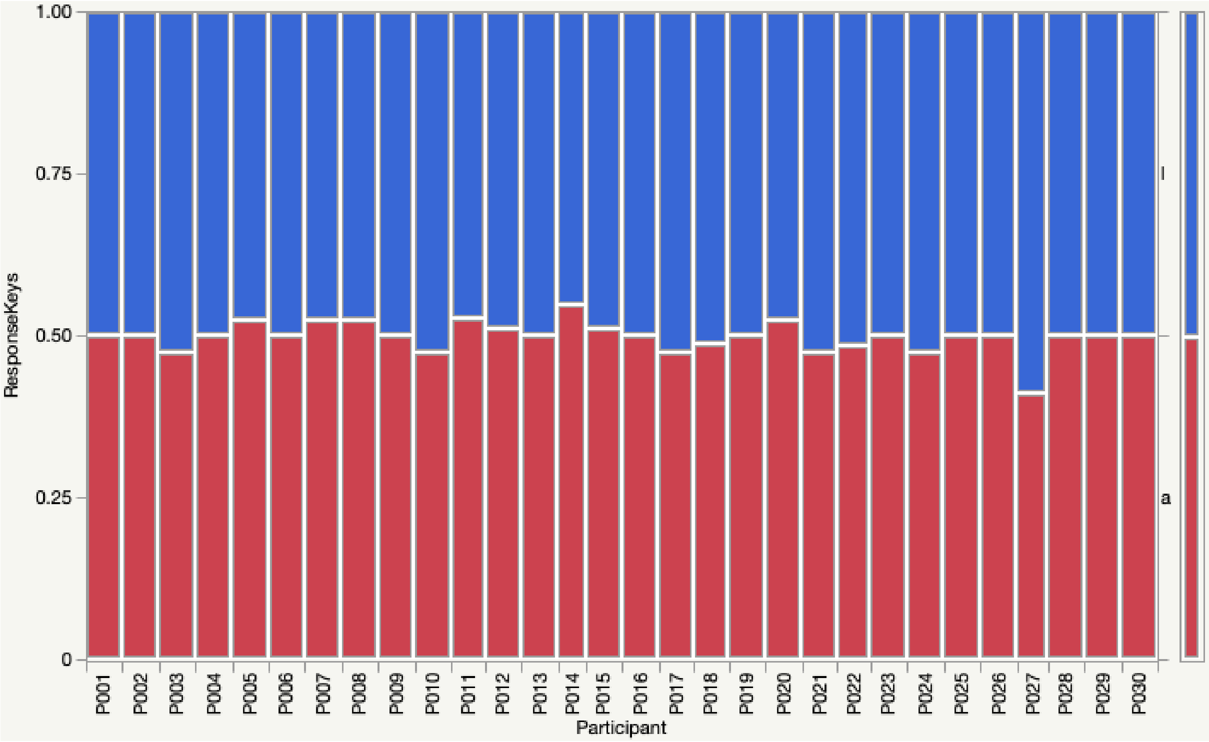
kiak	kaik	kiaik	kyaik	ka:ik
kiap	kaip	kiaip	kyaip	ka:ip
kyak	kauk	kiauk	kyauk	ka:uk
kyap	kaup	kiaup	kyaup	ka:up

Appendix B Experimental study figures

Forced-choice test

1. Data cleaning

Figure 22 Forced-choice - Mosaic Plot: Analysis of Response key (Y) by participants (X)



2. Response analysis

Figure 23 Forced-choice: distribution of response histogram

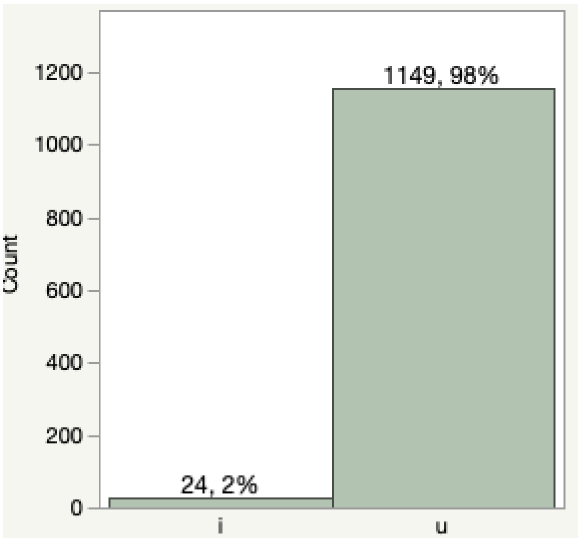
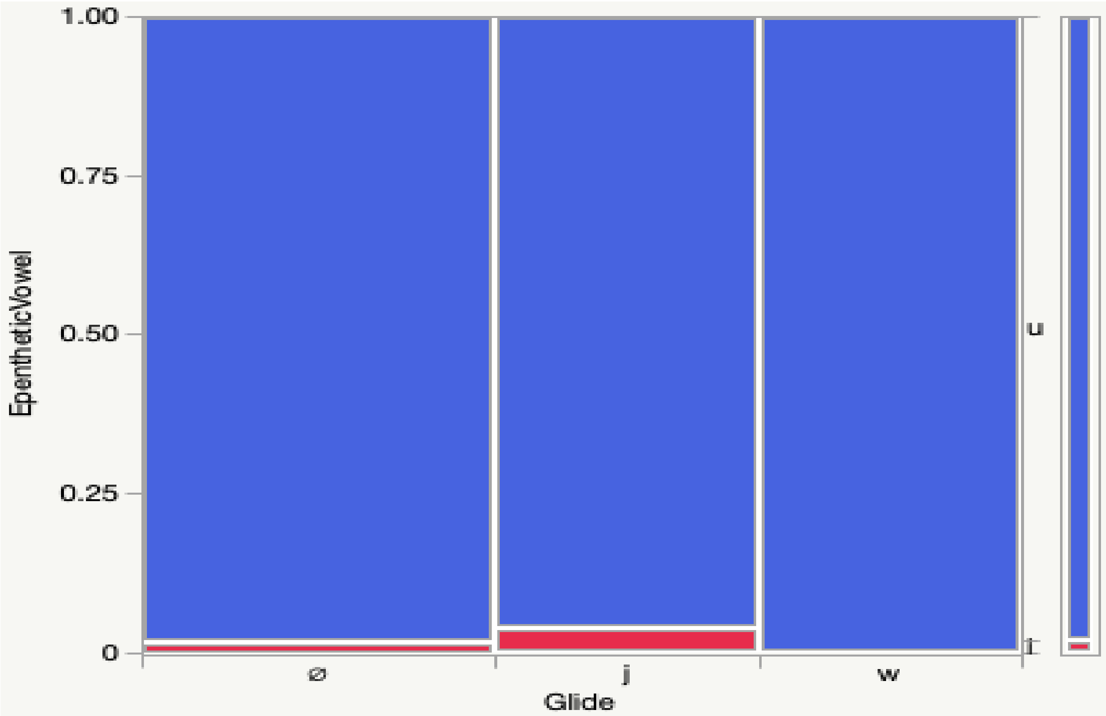


Figure 24 Mosaic plot - Epenthetic vowel (Y) by Glide (X)



3. Reaction time analysis

Figure 25 Forced-choice result – Distribution of RT by epenthetic vowel

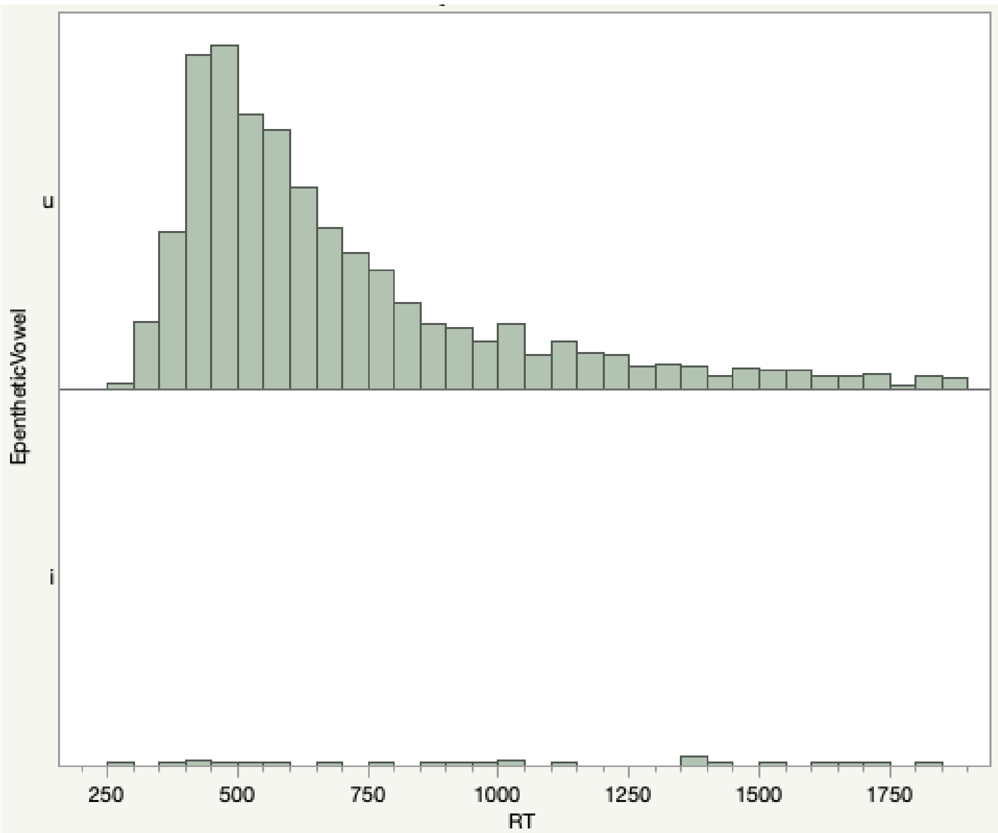


Figure 26 Forced-choice result – Distribution of RT by nucleus length.

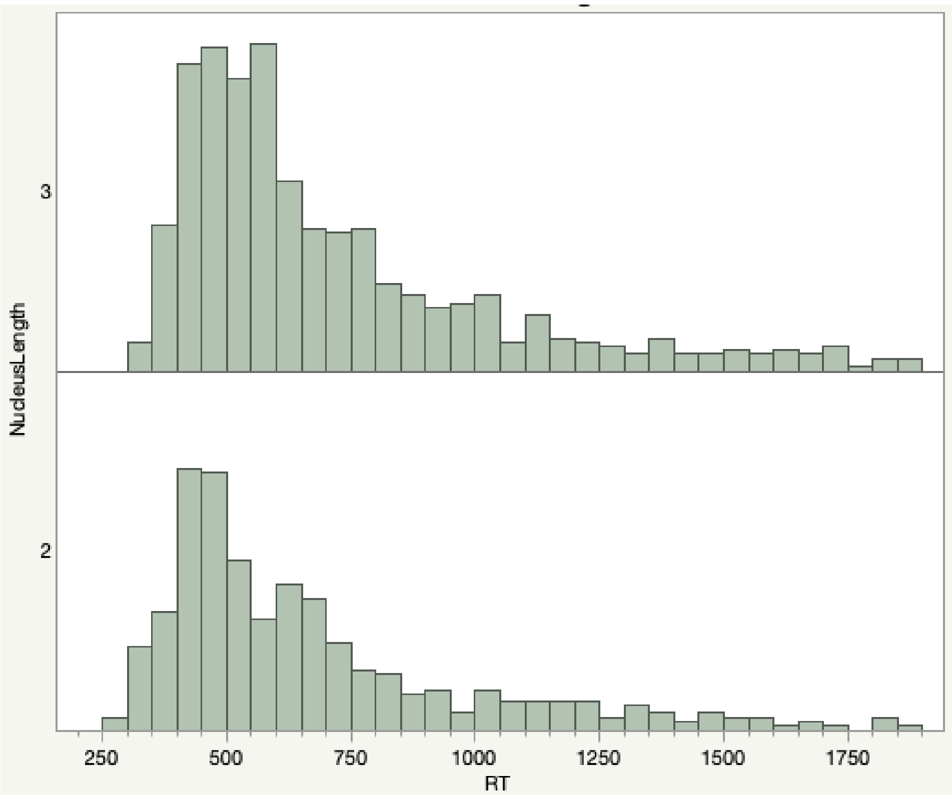


Figure 27 Forced-choice result – Distribution of RT by glide w vs j

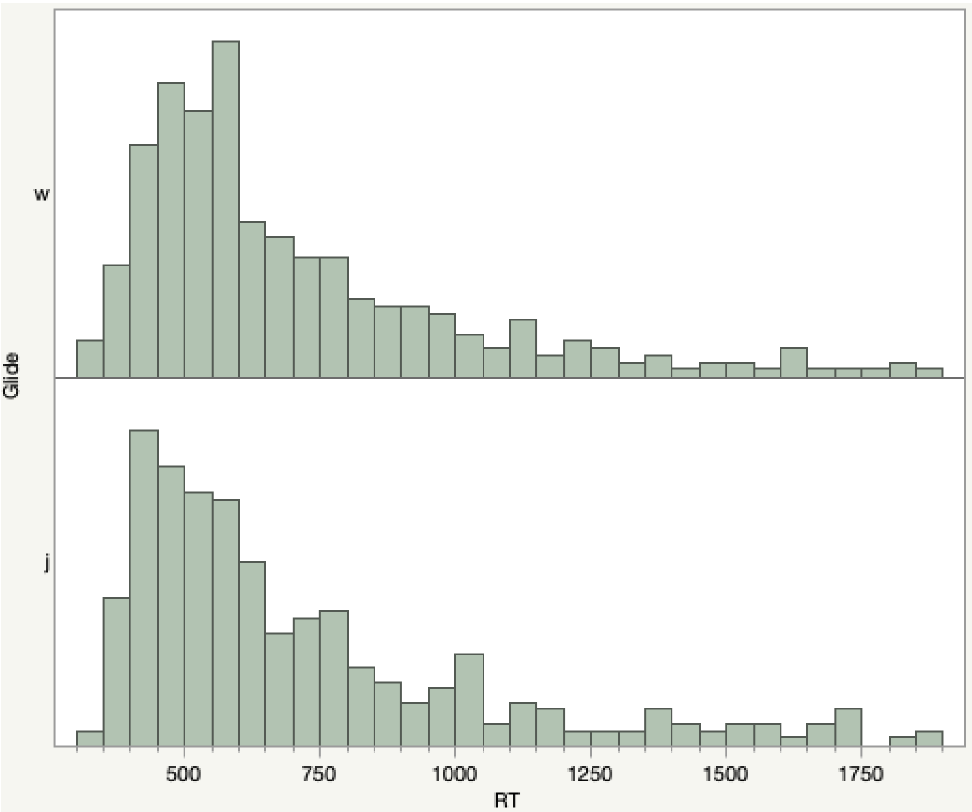


Figure 28 Forced-choice result – Distribution of RT by coda place

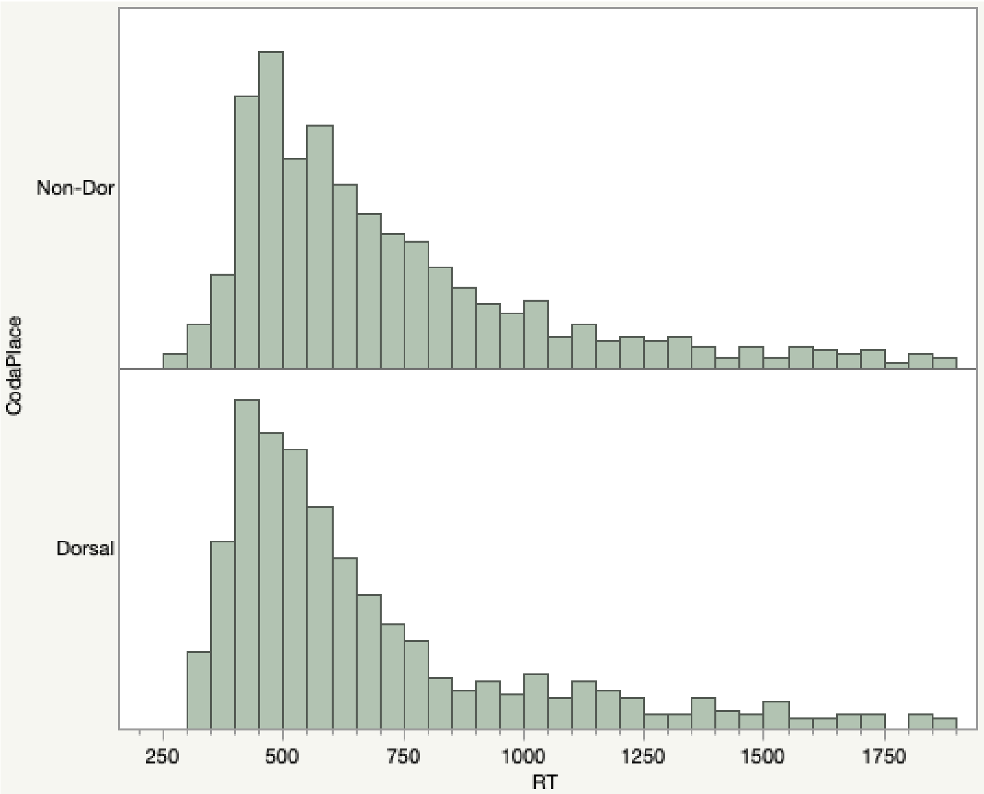
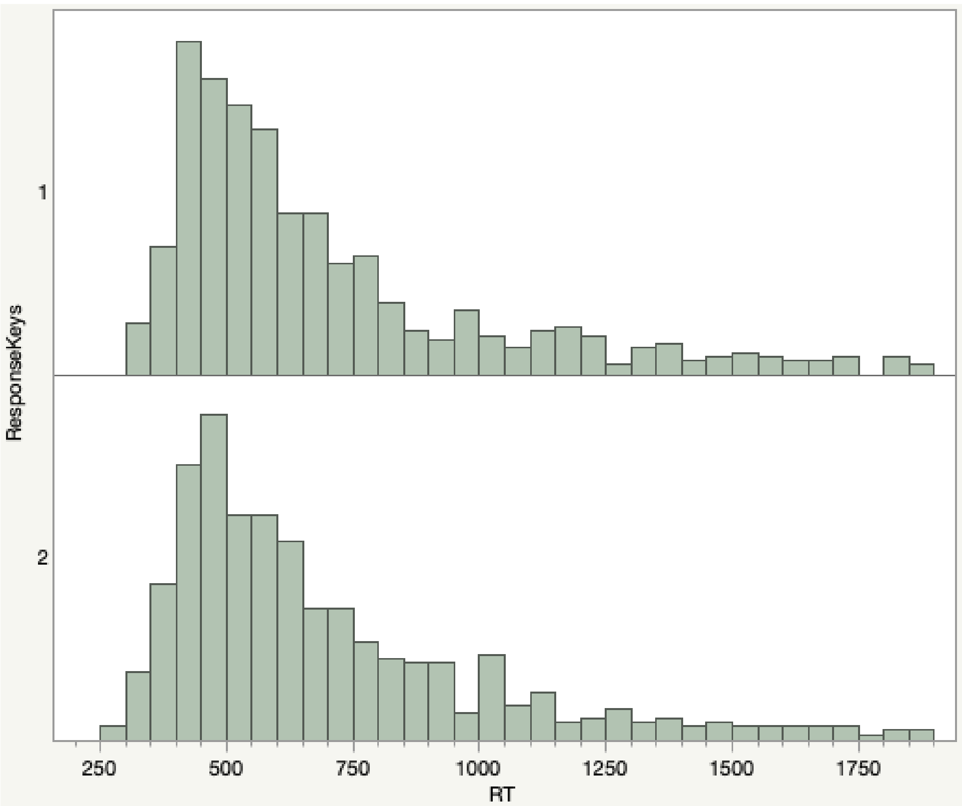


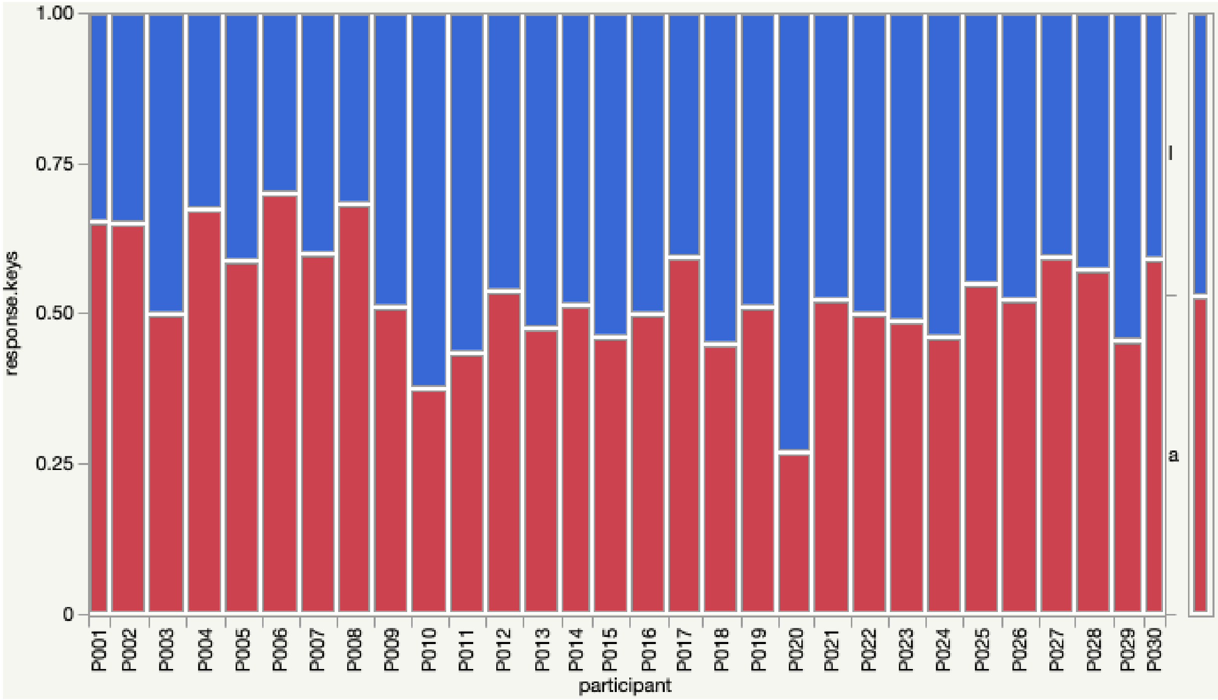
Figure 29 Forced-choice result – Distribution of RT by response key



XAB test

1. Data cleaning

Figure 30 XAB - Mosaic Plot: Analysis of Response key (Y) by participants (X)



2. Class I stimuli
2.1 Response analysis

Figure 31 XAB Class I result: distribution of response histogram

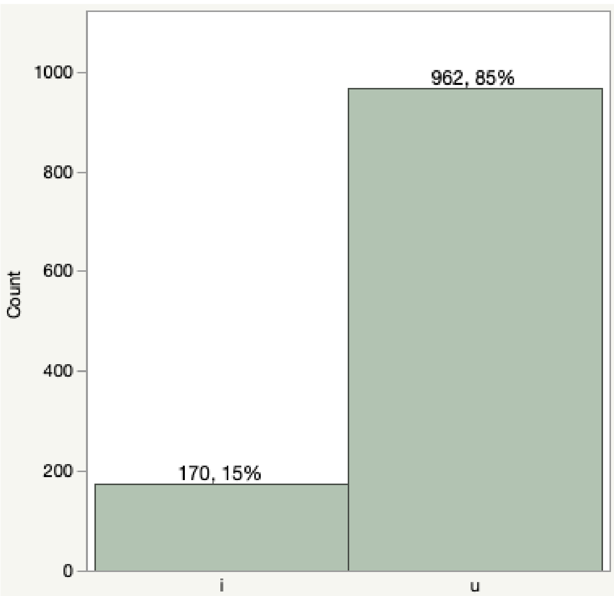
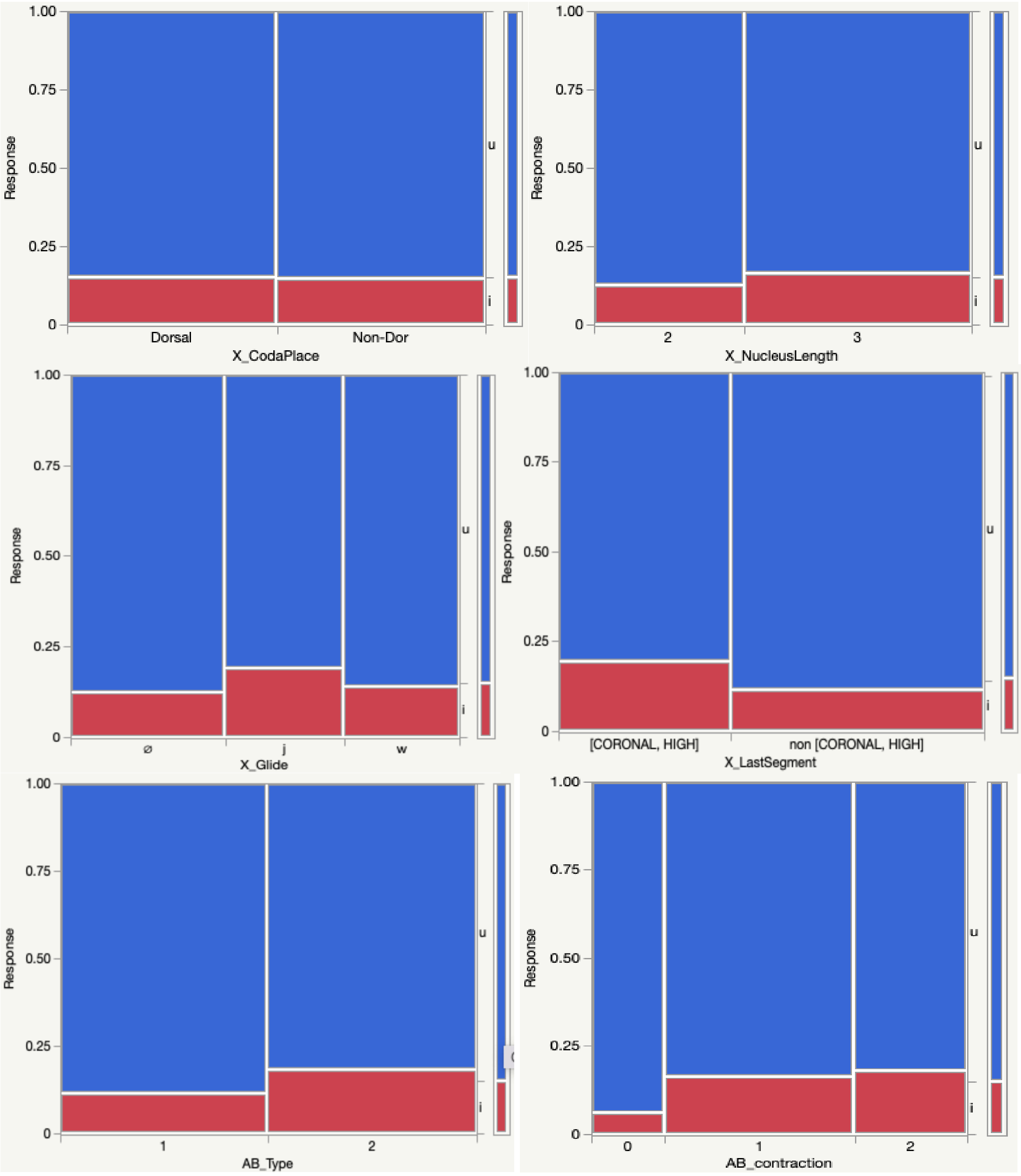


Figure 32 Mosaic plot: response (y-axis) by X coda place (top left), X nucleus length (top right), X glide (middle left), X last segment (middle right), AB Type (bottom left), and AB contraction (bottom right).



2.2. Reaction time analysis

Figure 33 XAB Class I result – RT by response

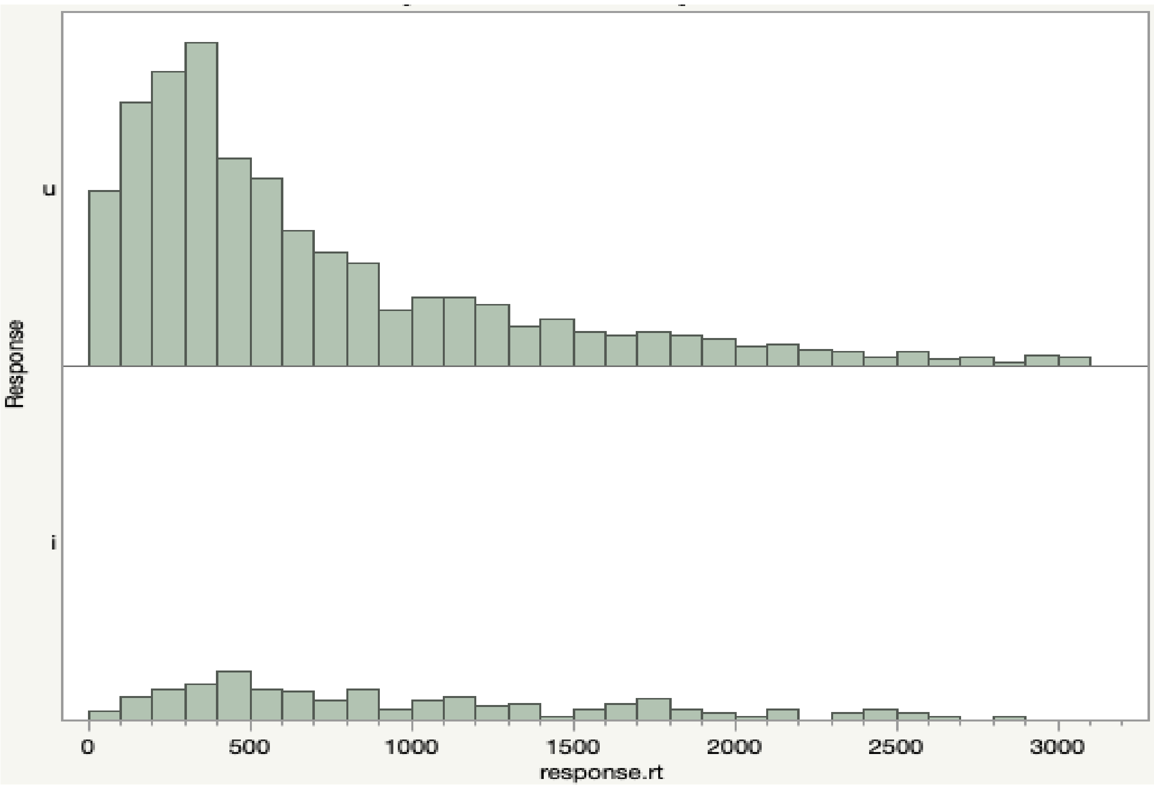


Figure 34 XAB Class I result – RT by AB_Type

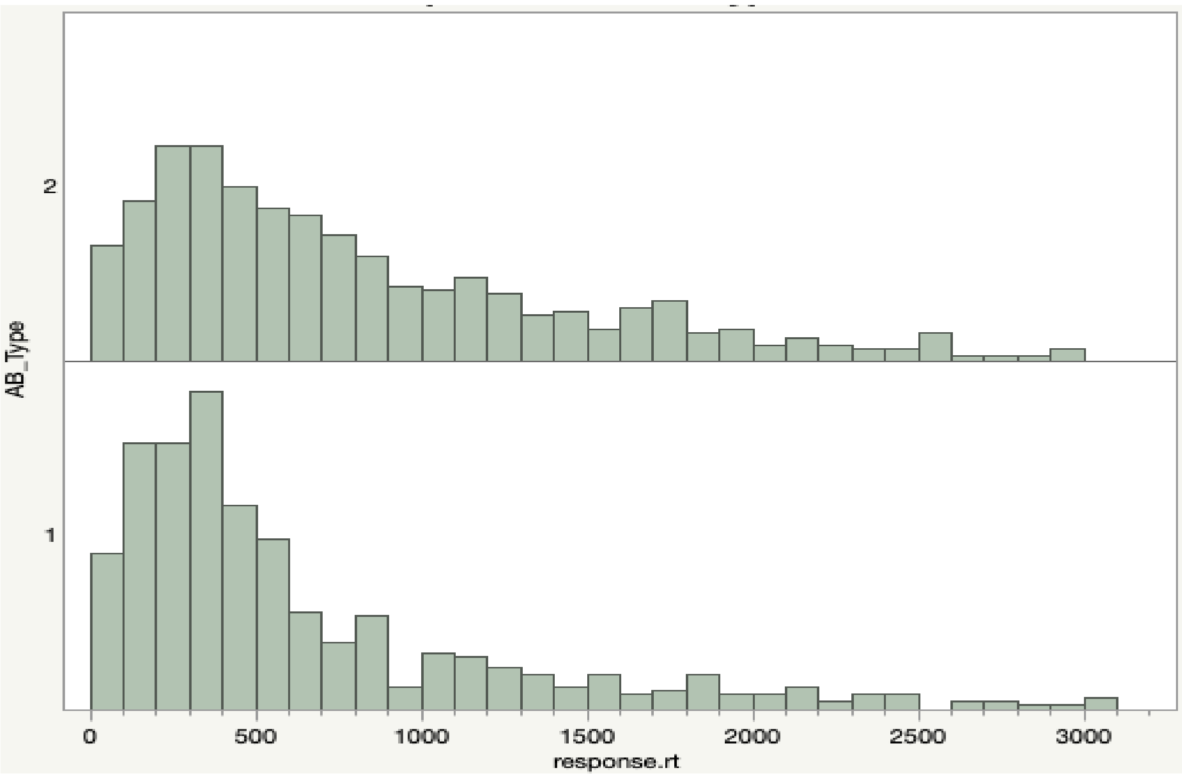
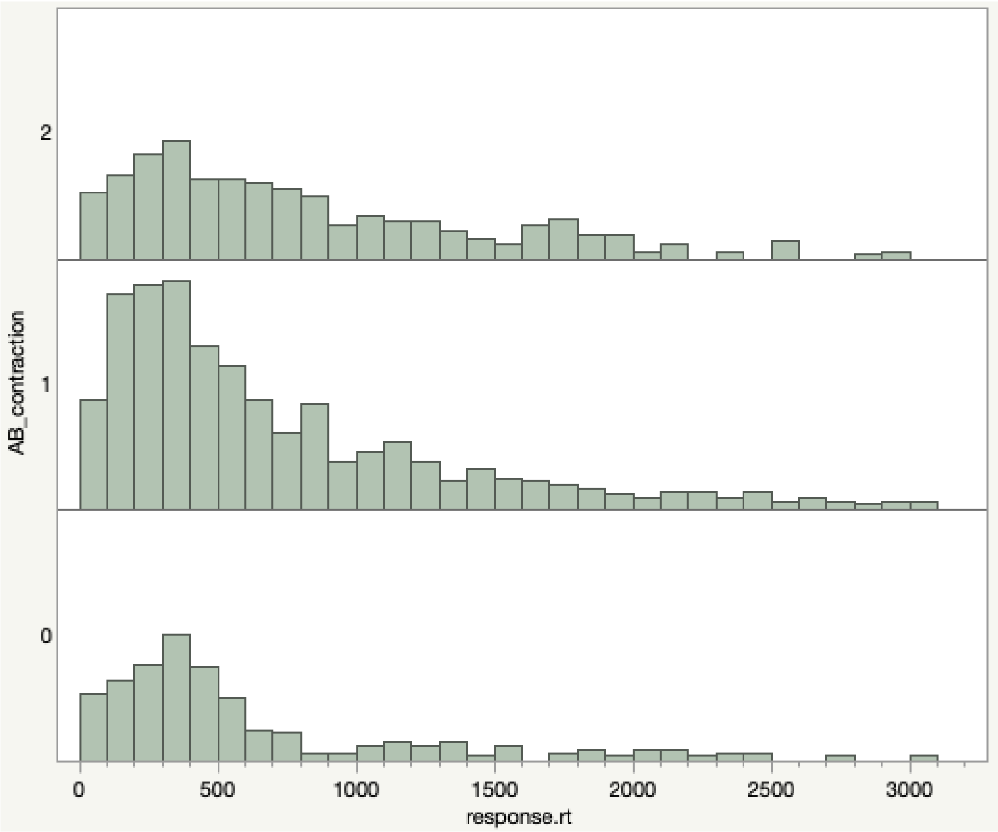


Figure 35 XAB Class I result – RT by AB_contraction



3. Class II stimuli

3.1 Response analysis

Figure 36 XAB Class II result: distribution of response histogram

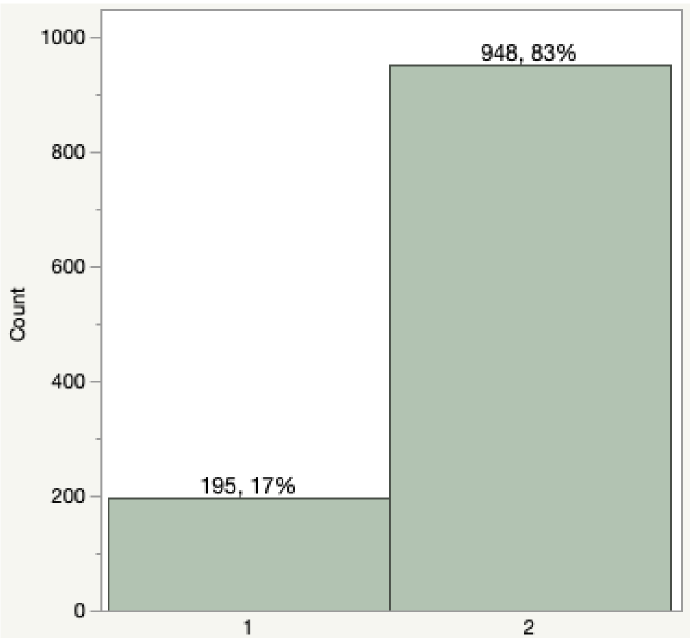
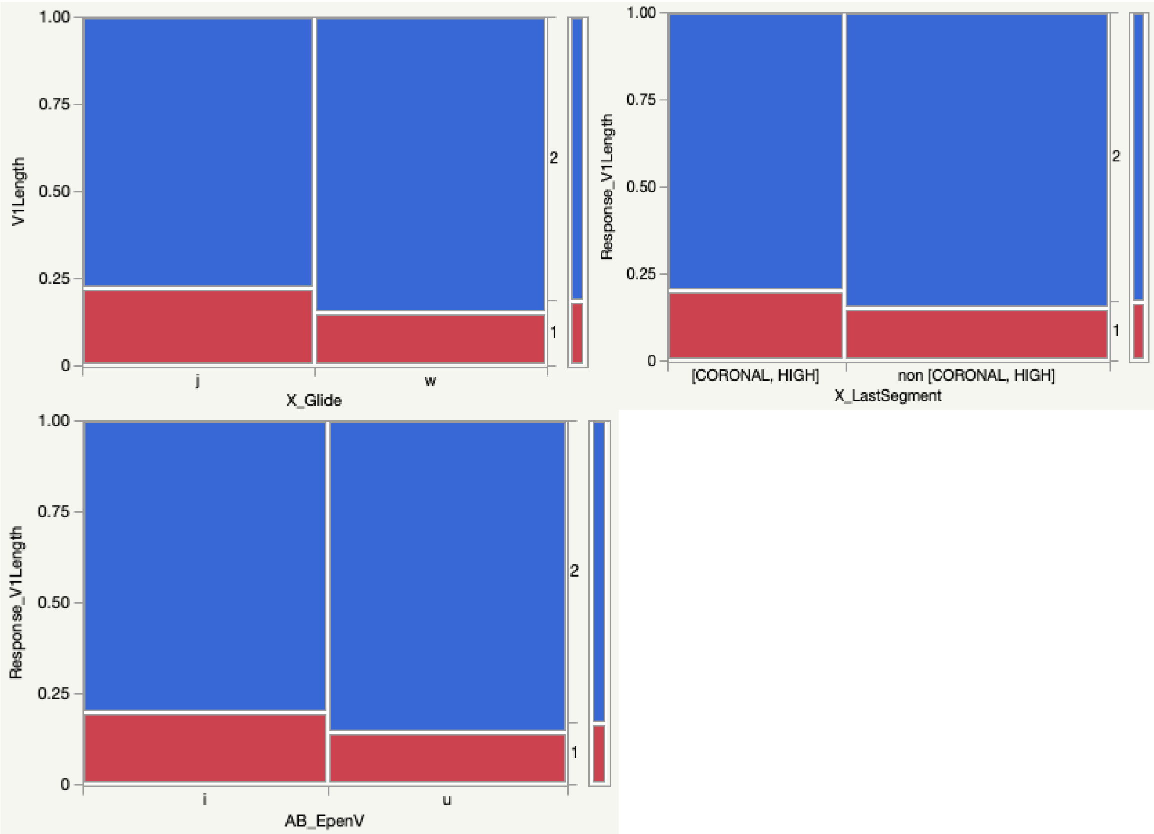


Figure 37 XAB Class II: Mosaic plot: response (y-axis) by X glide (top left), by X last segment (top right), and by AB type/epenthetic vowel (bottom left).



3.2 Reaction time analysis

Figure 38 XAB Class II result – distribution of RT by response (2 vs 1 segments in the nucleus adaptation)

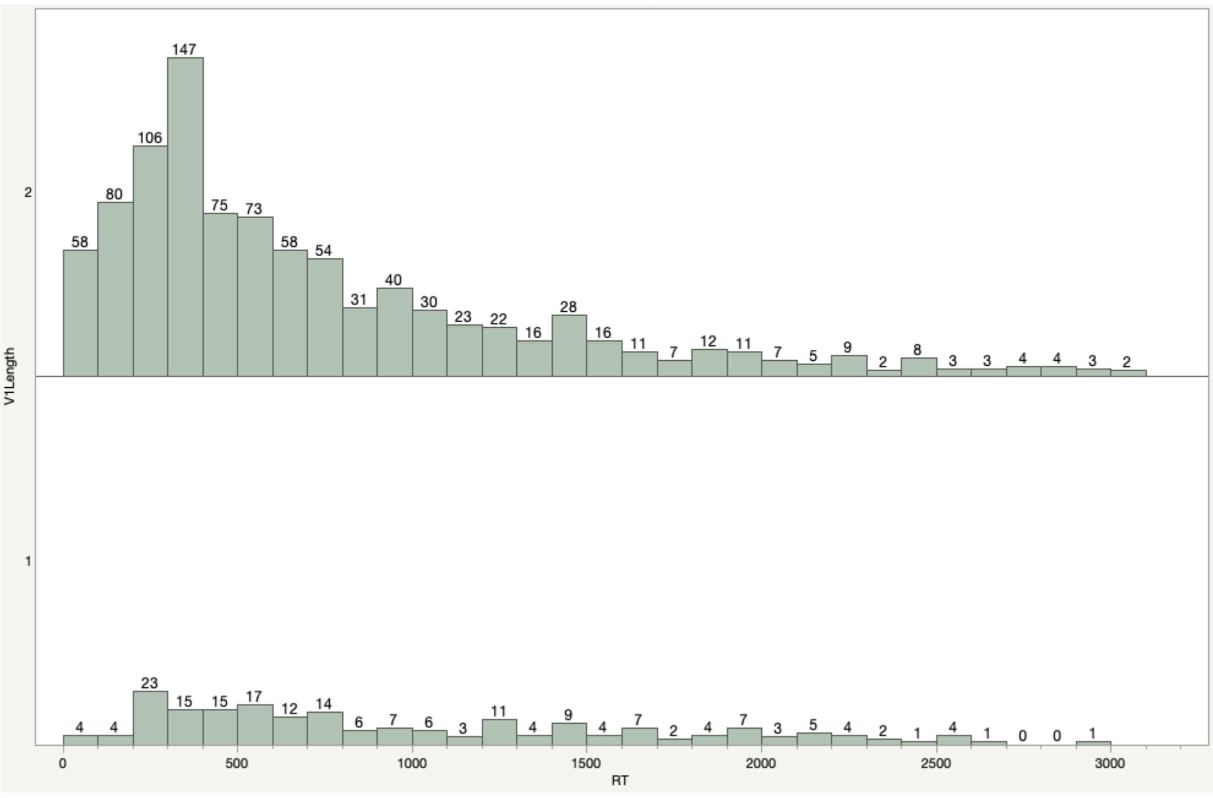


Figure 39 XAB Class II result – distribution of RT by X nucleus length (3 segments vs 2 segments in the input nucleus)

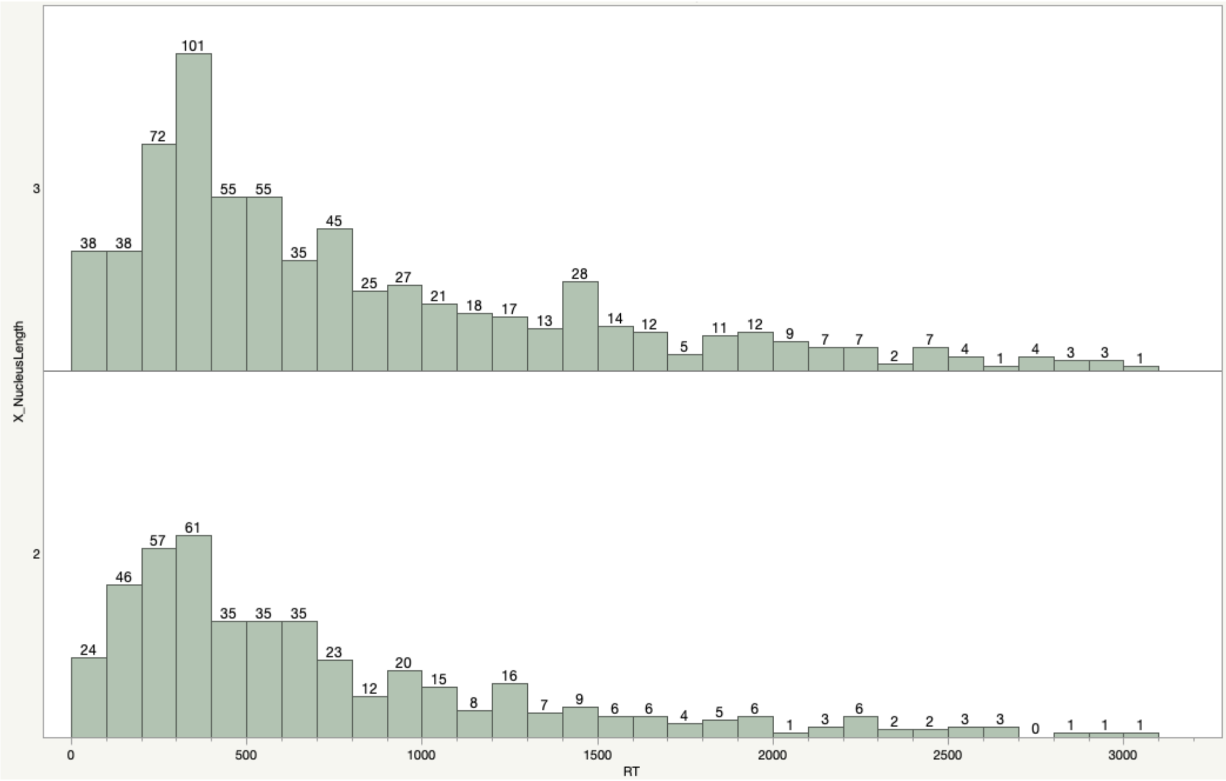
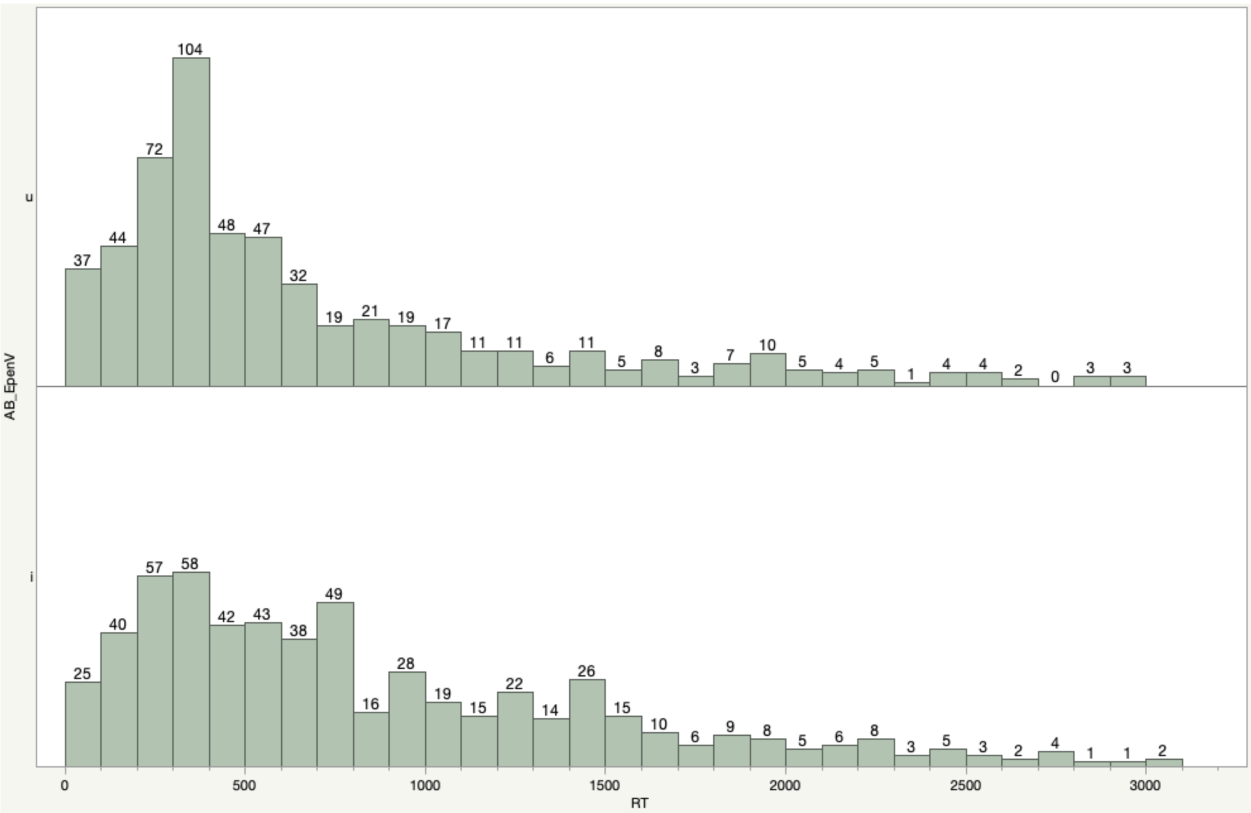


Figure 40 XAB Class II result – distribution of RT by AB Type/epenthetic vowel (Type 3 /u/ vs Type 4 /i/)



Appendix C Information sheet

An Experimental Study on the Adaptation of Loanwords in Japanese
PARTICIPANT INFORMATION SHEET
Central University Research Ethics Committee Approval Reference: R76652/RE002

Introduction

You are being invited to take part in a research project. Before you decide it is important for you to understand why the research is being done and what it will involve. Please take time to read the following information carefully and discuss it with others if you wish. Ask us if there is anything that is not clear or if you would like more information. Take time to decide whether you wish to take part.

Why is this research being conducted?

Language contacts between different speech communities give birth to loanwords. How words are being borrowed from one language to another has been a topic of research. This study looks specifically at how Japanese speakers nativize foreign words.

Why have I been invited to take part?

You have been invited because you fit the criteria for the project: you are a native speaker of Japanese, age 18-50 and without any vision or hearing deficits. You are born in Japan to Japanese-speaking parents and have not lived outside of Japan for longer than 5 years. You have undertaken six years of compulsory English education through middle and high school. The study will recruit 35-50 participants.

Do I have to take part?

No. It is up to you to decide whether or not to take part. If you do agree to participate, you can withdraw yourself from the study, without giving a reason, by advising me of this decision. The deadline by which you can withdraw any information you have contributed to the research is 1.10.2022. If you decide to withdraw, all the data that has already been collected from you will be destroyed.

What will happen to me if I take part in the research?

If you are happy to take part in the study, you will be asked to complete three behavioural experimental sessions. The study will take place at the Language & Brain Laboratory, 37 Wellington Square, Oxford, OX1 2JF. . Upon your arrival at the experiment location, you will be shown a paper copy of the information sheet again before you participate in the experiment. You will then be asked to sign the consent form if you are willing to participate in the experiment. You will have a copy of the completed consent form.

During the experiment, you will sit in a quiet room with a computer in front of you. In the first session, you will hear groups of two foreign words and you will be asked to make decisions on whether the two words you hear are the same or different by pressing different keys on the computer. In the second session, you will hear groups of three foreign words and have to identify whether the third one is the same as the first or second one by pressing keys on the computer. For the first two sessions, you will be asked to response as quickly as possible. Both your responses and your reaction time will be recorded. In the third session, you will hear one foreign word each time and you will be asked to type what you hear in Japanese katakana script. You can take your time and do not have to give fast responses for the third session. Only your responses, not your reaction time, will be collected. You will be offered a 1-minute break between each session.

There will be a training session to make sure you understand the instructions and feel comfortable with the way the experiment is carried out. The whole experiment should take around 30 minutes (including instructions and training). You can ask to pause or stop the research activities at any time. All the information collected from you during the course of the research will be kept strictly confidential and your responses will be anonymised.

What are the possible disadvantages and risks in taking part?

For the first two sessions, you will have to make decisions as fast as you can, so there will be potential stress from time pressure. However, it is not a test and you should just answer as best as you can in the time available.

The experiment will take place at the Language & Brain Laboratory. You will be informed about the closest fire exit in case of emergency before the experiment starts. You can open the door from inside of the room and leave the experiment at any time (withdraw you consent) without it affecting any benefit that you are entitled to in any way.

All the information collected from you during the course of the research will be kept strictly confidential and your responses will be anonymised. The researcher will not use your name or identity at any time. You will not be identifiable from the data and the research output.

Are there any benefits in taking part?

While there are no immediate benefits for those people participating in the project, it is hoped that this research will lead to a better understanding of the adaptation of loanwords in Japanese.

Expenses and payments

You will receive £10 compensation for participation.

What information will be collected and why is the collection of this information relevant for achieving the research objectives?

Consent forms will be stored in a locked drawer at the Language and Brain Laboratory, Faculty of Linguistics, Philology & Phonetics, University of Oxford. Both reaction time and response data will be encrypted and stored on a password protected computer. The data will be kept securely by the researcher for this specific research project. The experimental data collected will contribute to empirical research in the field of loanword adaptation in linguistics. Only the researcher and the supervisors will have access to the research data. All research data will be stored for a minimum retention period of 3 years after publication or public release of the work of the research.

Will the research be published? Could I be identified from any publications or other research outputs?

The findings from the research will be written up in a thesis and academic publications, and presented at conferences. You will not be able to be identified in any research outputs. A copy of my thesis will be deposited both in print and online in the Oxford University Research Archive where it will be publicly available to facilitate its use in future research.

Data Protection

The University of Oxford is the data controller with respect to your personal data, and as such will determine how your personal data is used in the study. The University will process your personal data for the purpose of the research outlined above. Research is a task that is performed in the public interest. Further information about your rights with respect to your personal data is available from https://compliance.admin.ox.ac.uk/individual-rights.

Who has reviewed this study?

This study has received ethics approval from a subcommittee of the University of Oxford Central University Research Ethics Committee (Ethics reference: R76652/RE002).

Who do I contact if I have a concern about the research or I wish to complain?

If you have a concern about any aspect of this study, please contact the primary researcher Huinan Zeng at huinan.zeng@trinity.ox.ac.uk and we will do our best to answer your query. We will acknowledge your concern within 10 working days and give you an indication of how it will be dealt with. If you remain unhappy or wish to make a formal complaint, please contact the Chair of the relevant Research Ethics Committee at the University of Oxford who will seek to resolve the matter as soon as possible:

The Chair, Social Sciences & Humanities Interdivisional Research Ethics Committee; Email: ethics@socsci.ox.ac.uk; Address: Research Services, University of Oxford, Wellington Square, Oxford OX1 2JD

Further Information and Contact Details

If you would like to discuss the research with someone beforehand (or if you have questions afterwards), please contact:

Huinan Zeng
Faculty of Linguistics, Philology and Phonetics
Clarendon Institute
Walton Street
Oxford OX1 2HG
United Kingdom
Email: huinan.zeng@trinity.ox.ac.uk

Appendix D Consent form

Consent to take part in the Experimental Study on the Adaptation of Loanwords in Japanese

Central University Research Ethics Committee (CUREC) approval reference: R76652/RE002

Purpose of Study: This study investigates how foreign words are nativized in Japanese.

	Please initial each box if you agree with the statement
I confirm that I have read and understand the information sheet for the above research. I have had the opportunity to consider the information, ask questions and have had these answered satisfactorily.	
I understand that my participation is voluntary and that I am free to withdraw at any point until 30.6.2022, without giving any reason.	
I understand who will have access to personal data provided, how the data will be stored and what will happen to the data at the end of the project.	
I understand that I will not be identifiable from any publications or conference presentations.	
I understand how to raise a concern or make a complaint.	
I agree to take part.	

Name of participant	Date	Signature
Name of person taking consent	Date	Signature