TO EPENTHESIZE OR NOT?
SEGMENT INSERTION IN MANDARIN LOANWORDS

By

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ABSTRACT

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This dissertation investigates segment insertion through two contextualized loanword adaptation processes: intervocalic nasal and coda [m] adaptations, with corpus and experimental data. My research focuses are: 1) to identify the phonological environments of segment insertion in the target adaptation processes in my corpus data, and propose explanations for the insertion patterns in Standard Mandarin loanwords; 2) to verify my arguments with experimental data; 3) to examine whether bilingualism affects target segment adaptations; and 4) to discuss what linguistic mechanism controls the adaptation processes.

Nasal insertion in Mandarin loanwords is considered an "unnecessary repair" since both English and Mandarin allow a syllable containing consonant-vowel-nasal. However, the existing loanwords show that nasal insertion has strong correlation to the prenasal vowel quality, and the primary word stress location in the source language. To trigger nasal insertion, the English prenasal vowel has to be lax (vowel type condition) and must bear the primary word stress (stress location condition), e.g. *ˈDenis* → [tan.niː.sɻ]. Nasal insertion rarely occurs when the prenasal vowel is tense or a diphthong, e.g. *ˈLina* → [liː.naː]. Variable adaptation occurs when the prenasal vowel is [ə], e.g. *ˈTiffany* → [tiː.fan.nei] ~ [tiː.fuː.niː]. Low back [ɑ] never triggers nasal insertion, e.g. *Caˈbana* → [kʰaː.paː.naː]. I propose that adaptors are sensitive to the fine acoustic cues of the prenasal vowel and stress syllabification pattern. I argue that the "unnecessary repair" is necessary for acoustic cue mapping so the input is perceptually similar to the output.

Vowel epenthesis is argued to fix illicit coda [m] in Mandarin, but it is related to syllable location and the following consonant type. It occurs in word-medial and word-final coda positions. It never occurs in homorganic environments with a prenasal lax vowel, e.g. *Columbia* → [kɤ:.lun.pi:ja:]. However, with a prenasal diphthong or tense vowel, vowel epenthesis still appears. Variable adaptation is present when coda [m] is in word-medial position followed by an obstruent, e.g. *Camden* → [k^ha:.mu:.təŋ] ~ [k^hən.tun]. I propose that vowel epenthesis takes place to preserve all the segmental information, although the output may be perceived as less similar to the input due to an excess vowel. Repairing with [n]/[ŋ] in homorganic environments not only preserves all the underlying features but also leads the output to be more perceptually similar to the input. Both modification methods suggest that coda [m] adaptation is motivated by phonological grammaticality, and acoustic cues play a relatively minor role.

33 Mandarin monolingual and 24 Mandarin-English bilingual speakers participated in the experiments. Test item structures followed the corpus generalizations. For intervocalic nasal adaptation, the results from both groups are similar to each other and to the corpus data patterns: participants were sensitive to prenasal vowel quality. Similar results from the two groups further confirm that nasal insertion is more phonetically driven. For coda [m] adaptation, the results from the bilingual participants follow the Preservation Principle, even in homorganic lax vowel environments. The monolinguals repair the coda [m] through epenthesis and nasal place change by chance. I suggest that the coda [m] adaptation process is phonologically driven.

This dissertation demonstrates that nasal adaptations in Standard Mandarin are contextualized. Two adaptation processes with essential differences in grammaticality are controlled by different linguistic mechanisms. Intervocalic nasal adaptation supports the perception-based loanword model, whereas coda [m] adaptation supports the phonology-based model.

For my parents, who have helped me in all things great and small.
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Chapter 1 Overview and Introduction

1.1 Overview

This dissertation investigates the phenomenon of segment insertion in loanword adaptation. In this dissertation, segment insertion is a term that refers to mapping from the SR (surface representation) of the donor language to the SR of the recipient language. The focus of this dissertation is on English loanwords in Standard Mandarin (SM or Mandarin in the rest of the dissertation). I shall discuss the different factors motivating this phenomenon and its variability.

Two types of segment insertion processes in SM loanwords are studied in detail with both corpus and experimental data—nasal insertion and vowel epenthesis. The nasal insertion process focuses on how English intervocalic nasals are adapted into Mandarin loanword system, whereas the vowel epenthesis process focuses on how English coda [m] is adapted into Mandarin loanwords. Both adaptation processes contain adaptation methods with and without segment insertion and variable adaptation, i.e. N → NN, N → N, N → N or NN for nasal insertion and mm] → [mu], [m] → [n]/[ŋ], [m] → [mu] or [n]/[ŋ]. The patterns are consistent in my corpus datasets. I propose phonological and phonetic explanations to account for the phenomena. To verify whether the explanations are valid, I ran acoustic perceptual experiments on both adaptation processes. The participants have different language backgrounds, Mandarin monolingual and Mandarin-English bilingual speakers.

Loanword adaptation occurs when foreign words are imported from source languages and nativized to meet the recipient languages' linguistic requirements. Adaptation happens when those words do not follow the native grammars; for example, when consonant clusters are grammatical in the donor language but ungrammatical in the recipient language. In general, loanwords in Standard Mandarin can generally be categorized into three categories:

1. Sound-based: this method is commonly used in proper names, e.g. *Michigan* → [miː.ɛiː.kən]. The borrowed forms sound very similar to their original pronunciation, meanwhile following the grammar of the recipient language.
2. Meaning-based: this method directly translates the meaning of each morpheme in the donor language, e.g. *honeymoon* → [miː.ɥeː], [miː] honey, [ɥeː] moon/month. One other type creates a new entity in the recipient language to capture the main feature of such an object without a morpheme by morpheme translation, e.g. train → [xwoː.tʂʰɤː], [xwoː] fire, [tʂʰɤː] vehicle.
3. Hybrid: this method shows the combination of 1 and 2 above, where one morpheme is literally translated, whereas other morphemes are added or translated by meaning, e.g. *beer* → [pʰiː.tɕjou]. This example demonstrates [pʰiː] in Mandarin is adapted the sound-based method, whereas the morpheme [tɕjou] is added later for expressing the meaning "alcohol".

The sound-based loan method is most commonly used in Standard Mandarin loanwords for foreign entities, such as proper nouns, for example the names of places, people, companies, and brands. Adaptation through the sound-based method is the main focus of the current research because it directly encounters sound modification and adaptation issues.

The special feature of sound-based loanwords is that not only do they have to follow the grammar of the recipient language, but they also bear as much sound similarity to their origin as possible. Sound-based loanword databases examine how native speakers of a recipient language make loanwords sound similar to the donor language without violating the native language's phonotactic constraints.

The two adaptation processes that this research examines are:

1. English intervocalic nasal adaptation, and
2. English coda [m] adaptation.

These two adaptation processes illustrate that loanword adaptations are not simple segment mapping and syllable repair processes; they also depend on fine phonetic cues and phonological environments of the target segments. The main focuses of this dissertation are:

1. identifying the generalizations in corpus data of how English intervocalic nasal and coda [m] are adapted to Mandarin,
2. providing phonological and phonetic factors that affect the adaptation processes based on the generalizations,
3. investigating whether bilingualism influences the Mandarin loanword outputs through online perceptual adaptation experiments, and
4. discussing the linguistic mechanisms that control the adaptation processes, i.e. phonologically driven, phonetically driven, or hybrid of both.

Previous Chinese loanword research, including Standard Mandarin and Cantonese loanword studies, has been primarily focused on segmental mapping (Lin, 2008b; Miao, 2005; Silverman, 1992), tonal adaptation (Hsiao-hung, 2006; Silverman, 1992; Wu, 2007, 2006b), i.e. tonal adaptation of the primary stressed syllables in English, and illicit syllable structures repair (Dong, 2012; Miao, 2005; Yip, 1993b, 2006), e.g. coda consonants and consonant clusters repair.

There has not been much research done on contextualized loanword adaptation. Hsieh, Kenstowicz, & Mou's (2009) study shows that the place of nasal consonant is decided by the backness of the prenasal vowel in English. Intervocalic nasal and coda [m] adaptations are of

interest in the current study because they also demonstrate that loanword adaptation is contextualized.

1.1.1 Data collection

The data examined in this dissertation are separated into two categories: the corpus data collected from the conventionalized loanwords and the results from perceptual experiments.

The current research started with the corpus data mainly from the Appendix I, a list of common British and American names, found in *A New English-Chinese Dictionary* (1988), for both adaptation processes.[1] The dictionary corpus consists of around 2400 British and American male and female names. Other than the dictionary corpus, I also collected data from public media, e.g. newspapers, magazines, movie posters, and movie subtitles in Mandarin. The dictionary corpus and self-collected loanwords are used in both adaptation processes.

Each entity in the dictionary consists of English spelling, pronunciation, gender information, and its Mandarin transliterated form (one form for most entities), e.g. *Denise* [dəˈniːz] *female* 狄妮斯. We usually can also get gender information from the Chinese characters. For example, in *Den(n)is* [ˈdɛnɪs] *surname & male* 丹尼斯 and *Denise* [dəˈniːz] *female* 狄妮斯，the characters 妮 and 尼 share the same pronunciation. However, the former one, with a radical 女 meaning female, indicates that it is a female name or a brand name related to women, whereas the latter one is used in male names and neutral brand names. Self-collected data only consists of English spellings and transliterated Chinese characters. Words from movie subtitles only have Chinese characters and acoustic strings without spelling/orthography.

[1] The Appendix I here refers to one of the appendices in *A New English-Chinese Dictionary* (1988) but not the Appendix of this dissertations, which is a word list of the experiment materials of this dissertation.

Although the dictionary is the 1988 1st edition, I suggest that the entities inside are still highly conventionalized. The 4th edition was published in 2009. It also has an appendix of "A list of common British and American names". I compared the content of the two editions, and the names and translations are the same as it is in the 1st edition. In addition, the loanword data in Hsieh et al. (2009) is from a loanword dictionary that was published in 1985. The loanword examples given in their study are still commonly in use nowadays, e.g. *bandage* → [pəŋ.tai], romantic → [lwoː.man.tiː.kɤː]. According to their data description, the borrowed words in their work are primarily from English into early Modern Chinese (circa 1890-1930). Another piece of evidence showing that the loanwords in the dictionary are still in use now is that when we search the names with their translation on Google, different outputs may pop up; the dictionary translation always appears. For example, *Brenda* is adapted as 布伦达 [puː.lun.taː] in the dictionary. The Google search provides 布伦达 and 布兰达 [puː.lan.daː] as the search results. The dictionary at most times only provides one translation form for each entity. However, for some cases it also provides another possible form in parenthesis for readers' references. For example, *Cobham* is adapted as 科伯姆 [kəː.pwoː.muː] (科巴姆 [kəː.pɑː.muː]) in the dictionary. A Google search provides exactly the same outputs and 科巴罕[kəː.pɑː.xan]. We need to be aware that whether or not there are variations in adaptation, the borrowed forms sound very similar to their original pronunciation, while following the grammar of Mandarin.

For coda [m] adaptation, other than the corpora mentioned above, I also include Google Maps to ameliorate insufficient cases of [m] in homorganic environments. The linguistics librarian at Michigan State University Libraries extracted the place names and their correspondent Mandarin translation to Excel files.[2] The Google Maps corpus consists of 1921 place names in the United

[2] Special thanks go to Thomas Padilla for extracting the place names from Google Maps.

States and Canada. Each entry consists of a name of a city, country/state information, population, latitude, longitude, capital (0/2), and Mandarin translation. For example, *Alhambra*, CA, 88857, 34.08, -118.13, 0, 阿罕布拉加利福尼亚州(the Mandarin translation includes the place name followed the state it belongs to).[3] The original files contain all the city names with [m] in syllable onset and coda positions. I extracted [m] in coda positions from the original files. Table 1.1 shows the actual number of different data sources for each adaptation process.

Table 1.1 The data number from different sources for nasal insertion and coda [m] adaptation

	Nasal insertion	Coda [m] repair
The Appendix in *A New English-Chinese Dictionary* (1988)	Word count: 2400	Word count: 2400
	With [n]: 672	With [m]: 392
	With intervocalic N: 120	With coda [m]: 121
Google Maps	Not in use	Word count: 1921
		With [m]: 459
		With coda [m]: 130
Social media	26	28
Total targeted nasals	146	279

The corpus data give us an idea of how intervocalic nasals and coda [m] are adapted into Mandarin. However, the data size seems small. Therefore, I ran perceptual similarity experiments to expand the data size and to see how speakers with different language backgrounds handle the target sounds. The perceptual similarity experiment data were collected from people with different language backgrounds: Mandarin-monolingual and Mandarin-English bilingual speakers. The results were drawn from ABX force-choice tasks. We can see if bilingual results show the same pattern with the corpus data, as this is based on my assumption that the corpus data were generated by proficient bilingual speakers. Monolingual results will provide information on whether speakers

[3] For capital information, a city is assigned a 0 for not being a capital, whereas a 2 for being a capital. For example, *Honolulu* is listed as Honolulu, HI, 386345, 21.32, -157.8, 2, 檀香山夏威夷. It is the capital city of Hawaii so the capital information is marked as 2.

with different backgrounds handle the two adaptation processes with different grammaticality differently.

1.1.2 Two adaptation processes: English intervocalic nasal and coda [m]

My corpus data (see §1.1.1) show that when intervocalic nasals enter the Mandarin loanword system, prenasal vowel type and primary word stress location are the two crucial conditions that cause nasal insertion (N → NN), which is a case of *unnecessary repair* (Y. Kang, 2011; Peperkamp, 2005) because there is no need to add another nasal to conform to Mandarin syllable structure. When the English prenasal vowel bears the primary word stress and is also a non-high lax vowel, the frequency of nasal insertion in Mandarin loanwords is very high. For example, *Canary* is adapted with an inserted nasal [kʰan.naː.liː] in Mandarin; whereas, *SONY* is transliterated to [swoː.niː] with only one nasal. In the word *Canary*, the first vowel [æ] is a lax vowel and meanwhile bears the primary word stress. In *SONY*, although the first vowel [o] bears the primary word stress, it is a tense vowel. Hence, nasal insertion does not appear. When the prenasal vowel is a schwa [ə] in trisyllabic words in the middle syllable and bears no stress, such input can often have two outputs, e.g. *Tiffany* can be adapted to [tiː.fan.nei] and [tiː.fən.niː]. Both forms are used frequently. When the prenasal vowel is a low back [ɑ], nasal insertion never appears in Mandarin loanword output, e.g. *Cabana* → [kʰaː.baː.naː].

My corpus data and data from Google Maps also show that in most cases, illicit coda [m] is repaired with an epenthetic vowel [u]. However, nasal place change ([m] → [n]/[ŋ]) specifically serves as the repair strategy when [m] is in homorganic environments in English. Variable adaptations also appear in the current corpus data in both adaptation processes. The observed generalizations evidence that phonological environments of the target sound play crucial roles in loanword adaptation. For example, *Tom* is adapted as [tʰɑŋ.muː] with an epenthetic [uː] after coda

[m]. The word *Camp*, with [m] in a homorganic environment, is adapted as [kʰan.pʰuː] with coda [m] changing to one of the grammatical nasals in Mandarin. Two adaptation forms in Mandarin from one single English input often happen when [m] is in word-medial syllable coda position, e.g. Camden becomes [kʰan.tun] and [kʰaː.muː.tun]. Both forms are used frequently.

The existing loanword data give us an idea of how proficient bilingual speakers process the intervocalic nasals and illicit coda [m]. However, from the previous literature, how those foreign entities enter the recipient language also matters. Adaptation done by reading leads to almost no variation, i.e. vowel epenthesis almost always applies for illicit syllable repair. However, variation occurs frequently when the adaptation is done via hearing (cf. Japanese doublets (Smith, 2006) and Korean consonant adaption (Y. Kang, 2003)). In order to better understand the factors at play, I run pure perceptual online adaptation experiments on monolingual and bilingual speakers to test the validity of the contextual factors that affect both adaptation processes. I also investigate whether bilingualism influences the adaptation outputs.

Other than the adaptation generalizations, perceptual experimental results, and bilingualism, another issue that I want to discuss is what linguistic mechanisms control the two adaptation processes since they are different substantially in grammaticality: nasal insertion is unnecessary, whereas coda [m] repair is necessary with different repair strategies, i.e. vowel epenthesis and replace [m] with a grammatical nasal coda in Mandarin. I hope to explain whether the adaptation processes are phonologically driven or phonetically driven, or both are at play based on the phonological and phonetic explanations I proposed for my corpus data and the experimental results from speakers with different language backgrounds.

The rest of the chapter sets the background for the current research. The three loanword phonological models are briefly reviewed in §1.2. The sound inventory and syllable structure of

Standard Mandarin are introduced in §1.3. The research questions and goals of the dissertation are presented in §1.4. The last section, §1.5, outlines the structure of the dissertation.

1.2 Loanword phonological theories

Language contacts sometimes force speakers to deal with structures that do not exist in their native language. Therefore, when foreign words (donor language) are borrowed by another language (recipient language), they are forced to change to fit into the recipient language's phonology when necessary. In loanword studies, one of the major issues often discussed is what linguistic mechanism controls the adaptation process.

Sound-based loanwords are adapted with patterns which lead them to sound very similar to the originals. Since the systematic patterns appear within the same recipient language, what strategies speakers use to fit the foreign words and structures in their native language while making them sound similar to the original forms is always the fundamental question to pose, i.e. do the patterns merge with the speakers' native phonological grammar or they are based on speakers' perception and acoustic signals from the source language, or are both speakers' native phonological knowledge and perception involved in adaptation?

Studies of Paradis and LaCharité (1997), LaCharité and Paradis (2005), and Paradis and Tremblay (2009) argue that loanword adaptations are mainly based on the phonological grammar of the speakers' native language. In contrast, allophonic features in the donor language are not important and are often ignored.

On the other hand, Dupoux, Hirose, Kakehi, Pallier, and Mehler (1999), Peperkamp and Dupoux (2003), propose that loanword adaptations are solely based on speakers' perception or misperception and the acoustic input from the source language. In other words, speakers' native phonological grammar plays a minimal role.

Silverman (1992) argues that loanword adaptation takes place at two different levels—the Perceptual Level and the Operative Level. Broselow (2009), Kenstowicz (2003, 2005, 2010), and Yip (2006) also argues that both phonology and perception/acoustic cues play important roles.

This section briefly reviews three major approaches, each with representative works. In the current study, the three major approaches will be tested and discussed with the two loan adaptation processes in the two corpus studies and the experimental results.

1.2.1 The phonology-based approach

Studies such as Paradis (1996), Paradis and LaCharité (1997) and LaCharité and Paradis (2005) argue for a production-based approach in which loanword adaptation follows category preservation/proximity principles where segment matching is based on phonological categories. Based on their CoPho corpus data, they claim that loanword adaptation is overwhelmingly done by bilinguals, who have access to L2 phonemes and syllable structures and then further transfer them into the closest categories and structures in L1, the recipient language.[4] That is, the L2/the donor language outputs are not perceived as just strings of acoustic cues. One example given in Paradis (1996) is the French word *avocat* [avɔka] is adapted as [awɔka] in Fula. French [v] is always adapted as [w] in Fula loanwords. I also noticed that [v] → [w] mapping often occurs in Mandarin loanwords in the onset as well, e.g. *Vincent* → [wən.sən], *Vivian* → [wei.wei.an]. In the coda position, [v] is more likely adapted to [f] with an epenthetic rounded vowel [u] or [o]. However, we need to note that in both Fula and Mandarin [v] and [w] share similar phonetic properties. They are both voiced and the lower lip is involved in articulation.

[4] The CoPho dataset consists of 12 corpora of English and French loanwords in different languages. Seven of which are English loanwords in Quebec City French, Montréal French, Paris French, Mexican Spanish 1, Mexican Spanish 2, Japanese and Calabrese Italian. The rest 5 are French loanwords in Moroccan Arabic, Kinyarwanda, Lingala, Fula and Canadian English.

Another example is given in Paradis & Tremblay (2009). Based on a corpus of 500 stops in 371 English-based SM loanwords, they show that the aspiration of English stops does not influence phoneme categorization since voiced stops /b, d, g/ in English are categorically adapted as /p, t, k/ in Mandarin, whereas voiceless stops /p, t, k/ in English are often adapted as /p^h, t^h, k^h/ in Mandarin loanwords. This also means that the speakers ignore the fine acoustic cue, VOT. Therefore, they argue that these facts disfavor the perceptual approach to loanword adaptation and lend support to the phonological one. However, based on what they report, I am aware that the adaptation results are quite variable. This is especially true for [p^h] adaptation. English voiceless aspirated [p^h] is adapted in Mandarin as /p/ with a frequency of 34.4%. In addition, English voiceless unaspirated [t] is adapted as /t/ with a frequency of only 46.6%. They show the difference is significant, but not exactly categorical.

Other than consonant adaptation, LaCharité and Paradis (2005) also provide a piece of evidence from vowel adaptation to support their view that loanword adaptation is mainly based on speakers' phonological grammar. LaCharité and Paradis (2005) point out that English lax vowels [ɪ] and [ʊ] are categorically mapped to [i] and [u] in Mexican Spanish and Paris and Quebec French, instead of mapping to their phonetically or acoustically similar vowels [e] and [o]. That is, English [ɪ] and [ʊ] have very similar F1 and F2 formant to [e] and [o] in the recipient languages. See table for a comparison of the formants of stressed vowels in English and Spanish (LaCharité & Paradis (2005, p.234)). Ladefoged & Johnson (2001, p.39) also states that listeners heavily rely on F1 and F2 formants to distinguish one vowel from another. However, speakers from the three languages all show that they tend to keep the [+high] feature of the vowel in the donor language instead of F1 and F2 matching. Lin (2008b) also suggests that for Mandarin vowel adaptation, the primary mapping parameter is the backness of vowels.

Table 1.2 Comparison of the formants of stressed vowels in English and Spanish

English /ɪ/	F2 1700	Spanish /e/	F2 1950	Spanish /i/	F2 2250
	F1 375		F1 475		F1 300
English /ʊ/	F2 1300	Spanish /o/	F2 950	Spanish /u/	F2 800
	F1 425		F1 475		F1 300

(LaCharité & Paradis (2005, p.234))

1.2.2 The perception-based approach

On the other hand, studies of phonetic approximation (e.g. Dupoux et al., 1999; Peperkamp and Dupoux 2003; Y. Kang 2003; Peperkamp, Vendelin, and Nakamura 2008) maintain that loanword adaptations involve speakers' perception or misperception. They focus on solving two puzzles:

1. Unnecessary repair, and
2. Patterns that violate the native phonological grammar.

Case studies of Japanese and Korean loanwords show these phenomena.

The main purpose of Peperkamp and Dupoux (2003) is to test if speech perception affects loanword adaptation results on vowel epenthesis. They use French and Japanese speakers to run perception experiments because French allows consonant clusters, whereas Japanese does not. They manipulate the duration of the epenthetic vowel [u] in between two consonants, e.g. [u] in [ebuzo]. Their results suggest that when the medial vowel is reduced to zero milliseconds, Japanese listeners still perceive an epenthetic vowel in a consonant cluster, [ebzo] → [ebuzo]. Therefore, they further conclude that the epenthetic vowel is due to misperception since the participants in the French group do not perceive the epenthetic vowel (cf. Durvasula & Kahng 2012 on Korean illusory vowels in loanwords).

In Dupoux, Parlato, Frota, Hirose, and Peperkamp (2011) and Peperkamp et al. (2008) on coda nasal adaptation in loanwords borrowed from English and French into Japanese (similar data can be found in Shinohara (1997)), they also argue that most loanword adaptations originate in

perceptual assimilation that maps the non-native sounds and structures at the perceptual level onto the phonetically closest native ones without directly involving phonology. They use Japanese speakers adapting English and French coda [n] to support their argument. The experimental results from monolingual Japanese and bilingual Japanese-French speakers indicate that the English coda nasal is replaced by the moraic nasal in Japanese loanwords. However, the French nasal coda is adapted with an epenthetic vowel after by both groups. They argue that the nasal adaptation asymmetry appearing in Japanese loanwords is perceptually driven because the [n] release is different between English and French. In the same study, they argue that there is an intervocalic-like schwa release after French coda [n] and this acoustic cue leads the Japanese speakers to map the [n] with the underlying vowel, [ɯ], which is the least specified, and also the shortest vowel in Japanese.

Y. Kang's (2003) Korean coda consonant adaptation case study shows that voiceless stops are variably adapted with vowel epenthesis, e.g. cut → [$k^hʌt^hɨ$]~[$k^hʌt$]. [5] She suggests that the unnecessary inserted vowel is due to the inconsistent allophonic consonant release in coda position in English.[6] Such fine acoustic cues are related to the pre-consonantal vowel quality (tense > lax), the quality of the consonant (voiced > voiceless), and the place of articulation of the consonant (coronal > dorsal ~ labial). Hence, an adaptor's perception plays an important role during the adaptation process.

[5] Based on Yoonjung Kang's loanword studies, she is in the hybrid camp, which considers both foreign phonetic cues and speaker's native phonology are at play. Her Korean consonant adaptation study shows that Korean speakers are sensitive to acoustic cues of inputs. Hence, I put her study under the perception-based approach.
[6] Durvasula and Kahng (2016) show that Korean listeners heard illusory vowels even when there was no release burst.

1.2.3 The multiple-scansion/hybrid approach

Silverman (1992), Yip (2006), Broselow (2009), and Kenstowicz (2003, 2005, 2007, 2010) hold the view that loanword adaptation takes both perception and phonology into account. Their works illustrate that although perception is relevant, it cannot fully explain all the loanword adaptation patterns. They suggest that speakers' perception and phonological grammar participate in the adaptation processes at different levels and they are manipulated by different grammars. They claim that the speakers of the recipient language have no access to the phonology of the source language. Before the production, at the perceptual level, more perceptually salient sounds will be preserved, whereas the less salient segments will be ignored and further be deleted in the output.

Silverman (1992) first proposes a model that has two levels—Perceptual (Scansion 1) and Operative (Scansion 2). The speakers perceive a string of acoustic cues and then process them in their native grammar. Silverman uses Cantonese to demonstrate his model. He assumes that the adaptors do not have access to the donor language's phonology. At Scansion 1, the Perceptual Level, the adaptors receive only the acoustic signals from the donor language and perceptually salient cues will be preserved. At Scansion 2, the Operative Level, adaptors' native phonological knowledge jumps in to fix the illicit structures or to modify the cues, for example, whether the illicit coda should be adapted with vowel epenthesis or deletion. If the coda is perceptually salient, then vowel epenthesis is more likely adopted to repair the syllable. If the coda is not perceptually salient, then deletion is applied, e.g. [t] gets deleted most of the time in Cantonese loanwords (*shaft* → [sɐf_]). This example shows that the fricative is more salient than the stop. Therefore, [t] gets deleted.

One of the examples given in Silverman's study demonstrates how the English word 'stick' is adapted into Cantonese, including segments and tone. The word *stick* is perceived as /stɪk/ (Dupoux et al. may argue that the perceived input is /sɪtɪk/) with a high tone at the Perceptual Level. Other fine phonetic details, such as voicing and aspiration, are perceived or misperceived at this level as well. Later, at the Operative Level, speakers repair the acoustic strings with vowel epenthesis to satisfy the Cantonese syllable structure since Cantonese does not allow consonant clusters in the onset position. The output, therefore, is [sɪtɪk] with [LH] tone and the high tone does not fall onto the epenthetic vowel. The epenthetic vowel is given a low perceptual tone because it does not appear in the original input.

Yip (2006) follows Silverman's argument that the more perceptually salient segments tend to be preserved, whereas perceptually less salient segments usually get deleted. For example, *bus* → [pa.si], and *cast* → [k^ha.si]. English fricative [s] is preserved alone or in a complex coda. The plosive [t] is less perceptually salient, hence, it is repaired by deletion. Working along Optimality Theory, Yip (2006) proposed a set of MIMIC constraints for loanword adaptation, which she ranks as either high or low.

If they are ranked high, then the loanword outputs will be more L2-like (donor language), while those ranked low will be more L1-like (recipient language). Her case study focuses on English vowel [æ] and [ə] adaptation in Cantonese loanwords. English [æ] is adapted as [ɛː] or [aː] in Cantonese when it is in an open syllable or before nasals. English [æ] is adapted to Cantonese [ɪ] when it is in closed stop-final syllables, especially when the final stop is [k]. Moreover, English [ə] is mapped to Cantonese [aː] when it is in an open syllable, but to [ɐ] or [ø] when it is in a closed syllable. Her acoustic data show that the formants of the English vowel and the adapted vowels in Cantonese are similar, which also means there is a correspondence in vowel adaptation. Her

perceptual experiment data also show that [æ] and [ə] have more than one match; however, the adapted vowels are the same as her observations in her case study. She further suggests that the MIMIC VOWEL constraint selects the vowels that are the most similar to the input.

Kenstowicz (2003), like other researchers using hybrid models, suggests that a solely phonological-based approach cannot explain all the loanword adaptation processes. The acoustic cues from the donor language play an important role as well. Kenstowicz (2003) argues that in Fon loanwords from French, speakers' perception and production grammars are separated and have different constraint rankings on deletion (Max-Consonant) and insertion (Dep-Vowel). For example, French word *poste* /post/ is adapted as [pos_] at the perception level. The segment /t/ gets deleted because it is less perceptually salient than /s/. In addition, Fon is an open-syllable language. Its maximal syllable template is CCV. Since Fon does not allow consonants in the coda position, at the production level [pos_] becomes [posu]. The coda [s] is repaired by vowel epenthesis. Presumably, the coda consonant cluster could be preserved by two epenthetic vowels. However, only the perceptually more salient [s] survives with an inserted vowel in the output. This pattern is also found in Silverman's (1992) study on Cantonese loanwords from English. Another piece of evidence he provides is that French *poste* has been lexicalized as /pos/ instead of /post/. This explains that the /t/ is deleted at the perception level and /s/ is not repaired at the production level.

In native Fijian vocabulary, the main stress always falls on the final heavy syllable. When the final syllable is not heavy, the main stress falls on the penultimate syllable. The Fijian native stress pattern causes asymmetries in stress adaptation because the primary stress in English does not always fall on the final or penultimate syllable. Kenstowicz (2007) argues that Fijian speakers perceive English stress correctly, and adaptations occur in production. The loanword data in the

study shows that Fijian speakers ensure that the main stress of the English source is matched by a stress in the loan forms. For example, *cólony* is adapted as [kòːlóni] and *tobácco* is adapted as [taváko]. The loanword-specific constrains, MAX-STRESS, determine the preservation of the prosodic prominence (stress) from English.[7]

Broselow (2009) uses stress adaptation patterns of Fijian (Kenstowicz, 2007) and Huave (Davidson & Noyer, 1997) to explain that the perception grammar affects the phonological grammar and argues that adaptation patterns can be seen as effects of interference from the native language's grammar. Loanword adaptors map the acoustic cues onto the native phonological representations.

Based on my corpus data, the two-scansion/hybrid approach best explains both adaptation processes at the first glance. However, I will demonstrate that, given the perceptual similarity experiment data, intervocalic nasal adaptation tends to be perception-based, whereas coda [m] adaptation is more phonology-based.

My experimental data show that Mandarin monolingual and Mandarin-English bilingual speakers are sensitive to the prenasal vowel quality. They perceive vowel duration differences and nasality on the prenasal vowel and decide whether they adapt the intervocalic nasals with nasal insertion or not. Furthermore, speakers from these two language backgrounds adapt intervocalic nasals similarly (cf. Peperkamp, Vendelin, & Nakamura (2008)), showing that bilingualism does not play a role.

As for coda [m] adaptation, I will argue that it is phonologically driven. The high percentage of vowel epenthesis in my corpus data can be attributed to the Preservation Principle (Paradis,

[7] [kòloníː] is another possible candidate; however, it is not the actual output. Kenstowicz suggests this is on the basis of relative auditory similarity to the source along a dimension of prosodic prominence. Although [kòloníː] matches the Fijian metrical structure, it is less auditory similar to the source word.

1996; Paradis et al., 1997). Additionally, my experimental data show that speakers from different language backgrounds treat the illicit coda differently. The bilingual speakers follow the Preservation Principle, whereas the monolingual speakers have no preferred syllable repair strategy.

Therefore, I will show that the two-scansion/hybrid approach is not the best model to explain the two adaptation processes, and will present data showing that (i) phonology plays a very minor role in intervocalic nasal adaptation; and (ii) weak acoustic cue such as the labial feature (which should be deleted) is perceived and retained with high percentage at the Perceptual Level in coda [m] adaptation.

1.3 Sound inventory and syllable structure in Standard Mandarin

For discussion of the later chapters, this section introduces the sound inventory of Standard Mandarin, including consonants and vowels. Syllable structures and major phonotactic constraints are also presented. The analyses stand on the same foundation as of Duanmu (2007) and Y. H. Lin (2007), which comprise the bulk of source material for the current overview. The examples given in this section come from Y.-H. Lin (2007) unless otherwise stated.

1.3.1 Sound inventory of Standard Mandarin

1.3.1.1 Consonant inventory

The Mandarin consonant inventory consists of 22 consonants, shown on Table 1.3. All the oral consonants in Standard Mandarin are voiceless, except for /l/ and /r/. All the liquids and nasal consonants are voiced. In the table we can see that when two phonemes are under the same place of articulation, the one in the shaded cell is voiceless unaspirated, whereas the one in the clear cell is voiceless aspirated.

Table 1.3 Standard Mandarin consonant inventory

	Labial		Dental		Post-alveolar		Alveolo-palatal		Velar	
Stop	p	p^h	t	t^h					k	k^h
Nasal	m		n						ŋ	
Fricative	f		s		ʂ		ɕ		x	
Affricate			ts	ts^h	$tʂ$	$tʂ^h$	tɕ	$tɕ^h$		
Liquid			l		ɹ					

1.3.1.2 Vowel inventory

The Mandarin vowel inventory consists of five phonemic vowels. See Table 1.4.

Table 1.4 Five phonemic vowels in Mandarin Chinese

	Front unrounded	Front rounded	Central	Back rounded
High	i	y		u
Mid			ə	
Low			a	

The five phonemic vowels can be derived into eleven surface vowels in different phonological environments. See Table 1.5.

Table 1.5 Surface vowels in Mandarin Chinese

	Front unrounded	Front rounded	Central	Back unrounded	Back rounded
High	i	y			u
Mid	e ɛ		ə	ɤ	o
Low	a		a_c	ɑ	

In Mandarin, mid vowels are not phonemes. They are allophones of /ə/ and appear in different phonological contexts. There is only one mid phonemic vowel, which is [ə] and four allophones. The allophones of /ə/ and their distributions are listed here:

1. [ə] in a closed syllable, before coda consonants, e.g. [pən]$_{55}$ ‘polite’ and [pəŋ]$_{55}$ ‘to collapse’
2. [e] in a diphthong followed by [i], and in syllable final position preceded by the glides [j] and [ɥ], e.g. [pei]$_{214}$ ‘north’ and [pje]$_{35}$ ‘do not’
3. [o] in a diphthong followed by [u], and in syllable final position preceded by the glide [w], e.g. [tou]55 ‘all’ and [pwo] ‘wave’
4. [ɤ] in an open CV syllable, e.g. [kɤ:] ‘songs’

Mandarin also has three glides (semi-vowels), [w], [j], and [ɥ]. They are often considered to be vowels rather than consonants (Lin, 2007). They are articulated like vowels, with a slightly narrower channel between the active part of the tongue and the upper part of the vocal tract, but they function like consonants. They sound like the vowels [u], [i], and [y] respectively. In Standard Mandarin, glides and their corresponding vowels are in complementary distribution. Glides appear only in the syllable onset position, whereas vowels occur in syllable nuclear position. Glides are not phonemes, but they are phonetic variants of their corresponding vowels in the syllable onset position. We can use vowel parameters to describe the features of glides, e.g. [j] is a high front unrounded glide, [w] is a high back rounded glide, and [ɥ] is a high front rounded glide (Lin 2007, p.21, 39, 67).

For the low central /a/, Y.-H. Lin (2008) divides the relative F2 values of the allophones of [a]. The low phonemic vowel [a] becomes a front [a] before [i] and [n], whereas it becomes a back [ɑ] before [u] and [ŋ]. It is fronted and raised to [ɛ] when between a high front vowel and [n], e.g. /ian/→[jɛn]. In an open syllable with a single [a] rime, [a] is also fronted, e.g. /ia/→[ja]. It is centralized after [w] or when not preceded by a glide, e.g. /a/→ [a$_c$], /ua/→[wa$_c$].

Table 1.6 F2 of low central vowel [a_c] allophones

High F2		Low F2
Front [a]	Central [a]	Back [ɑ]
[ja] [ai]/[an]	[a_c]/[wa_c]	[ɑu]/[ɑŋ]

Vowel duration, investigated in Yang (2014)'s acoustic study on the duration of the five phonemic vowels of Mandarin Chinese' [a, i, u, y, ɤ/ə], among different age groups (young and old children vs. adults) and monolingual Mandarin, bilingual Mandarin-English (high level vs. low level bilinguals) and English speakers. The mean vowel duration measurements show that monolingual and bilingual groups have similar vowel duration on each vowel. The acoustic measurement results suggest that the English proficiency does not change bilingual children's vowel duration in their native language relative to the monolingual children.

The mean vowel duration measurements of children and adults show that adults produced significantly shorter vowel duration for the vowels /i/ and /ɤ/ than both younger and older children did. For the vowel /u/, adults showed significantly shorter vowel duration than older children.

However, the duration of each vowel is not significantly different, although the vowel /u/ is the shortest vowel in all age groups. Yang's experimental results confirm Duanmu's (2007) and Y.-H. Lin's (2007) claims that vowel length is not contrastive in Mandarin. Hence, full open syllables, e.g. [ma:] and [mi:], in SM should have similar duration with the same syllable weight. This also means that vowels are phonetically long in full open syllables, such as $[ma:]_{51}$, and short in full closed syllables, such as $[man]_{51}$.

1.3.2 Syllable structure and syllable weight in Standard Mandarin

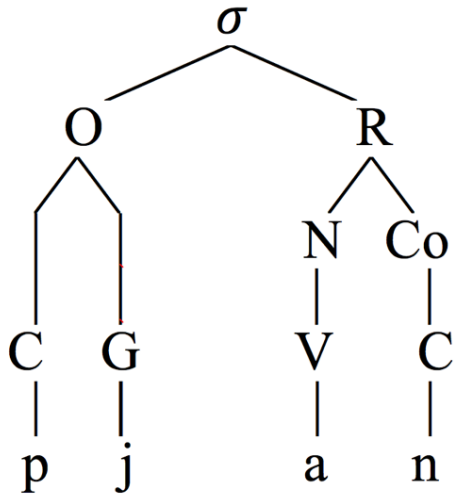
1.3.2.1 Syllable structure

Compared to other languages, e.g. English, Mandarin syllable structure is very simple. It does not allow complex onsets and complex codas. The maximum syllable structure is CGVX (Duanmu,

2007; Lin, 2007, 2008b), where C is a consonant, G is a glide, V is a vowel or a syllabic consonant, and X is a vowel or a nasal consonant. The minimal syllable is V. The coda consonant is restricted to nasal consonants only. The nasal consonants can also be in the onset position; however, they can only be [m] or [n]. On the other hand, the nasal coda can only be [n] and [ŋ] (Duanmu, 2007; Y.-H. Lin, 2007).

A maximal syllable has a nucleus and margins. The nucleus is obligatory; the margins are optional. Let's look at the syllable structure tree of a maximal syllable in Mandarin from the contemporary analysis.

Figure 1.1 Contemporary syllable structure analysis of [pjɑn]$_{55}$ 'side/margin'. σ = syllable, O = onset, R = rime, C = consonant, G = glide, N = nucleus, Co = coda, V = vowel



Most words in Mandarin are monosyllabic (Lin, 2007).[8] In the word [pjan]$_{55}$ (pīnyīn: biān) 'side/margin', under the syllable node, there are *Onset* and *Rime* nodes. In this syllable, the *Onset* has two constituents: *Consonant* and *Glide*. The *Rime* node dominates *Nucleus* and *Coda*. The nucleus is a low vowel [a], whereas the coda is one of the permissible nasal consonants [n].

[8] Some characters for defining measurements are not monosyllabic, e.g. 尺 is [tɕʰɐn.waːˊ]. Such characters are not in use very often nowadays.

1.3.2.2 Syllable weight

Syllable weight refers to whether a syllable has one or two moras. A mora is one syllable slot in the rhyme (rime). A heavy syllable has two moras, while a light syllable has one mora. A heavy syllable has a long vowel or a diphthong. For example, [maː] and [mai] are heavy syllables in Mandarin. Long [aː] and diphthong [ai] occupy two syllable slots in the rhyme. A light syllable only has one short vowel in the rhyme, e.g. a rhyme with a schwa [ə] is considered light by its phonological and phonetic features.

In Mandarin, all the syllables are heavy, except for neutral-toned ones. For example, in the noun phrase [baː.ba] *father* the first syllable is heavy because it has a long vowel occupying two slots in the rhyme. The second syllable is light because it is a neutral-toned syllable. The vowel in a neutral-toned syllable is shorter than its phonemic representation.

1.3.3 Phonotactic constraints of Standard Mandarin

Since the syllable structure is simple in Standard Mandarin, there are more restrictions to forming a licit syllable. Phonotactics or phonotactic constraints provide restrictions on what sequences of consonants and vowels can be combined. For example, English and many other languages allow consonant clusters in syllable onset and coda positions, but Standard Mandarin does not.

The maximal syllable structure is CGVX. The possible syllables should be $20 \times 4 \times 5 \times 23 = 9200$.[9] However, there are only 400 permissible syllables in use, less than 5% of the possible maximum (Duanmu, 2007, p. 48). In the following, I list the phonotactic constraints of Standard Mandarin.

[9] Segments in the C position are 22 consonants minus the 3 glides but plus nothing in the slot; hence, the number is 20. Glides are the 3 glides and nothing; hence, the number is 4. There are 5 phonemic vowels can be in the V slot. The X slot can be occupied by all 22 consonants or empty; hence, the number is 23.

1. General phonotactic constraints in Standard Mandarin:
    a. The maximal number of onset segment is two. The second one must be one of the three glides. For example, [**pj**an] is a good syllable, whereas *[**pl**an] is not.[10]
    b. In CGVX, the X slot is restricted to the second half of a diphthong or a nasal consonant.
    c. The permissible nasal codas are restricted to [n] and [ŋ], e.g. [pa**n**]/*[pa**m**]. [ɹ] is allowed in rhotacized rimes. Complex codas are not allowed, e.g. *[ba**nst**].
    d. A rime with a syllabic consonant (or traditionally called an apical vowel) cannot have a coda consonant, e.g. [sɻ̩]/*[sɻ̩n]. The apical vowel only follows after dental and post-alveolar consonants.
    e. The high front vowel [y] cannot be the second part of a diphthong, e.g. [ai]/*[ay].
    f. The phonemic central mid schwa [əː] has limited distribution. It only goes with a coda consonant, e.g. [ən]/*[əː], *[kəː]. In open syllables it changes to its allophone [ɤː].
2. Constraints on onset coronal affricates/fricatives:
    g. Alveolar-palatals can occur only before a high front vowel or glide, e.g. [tɕiː], [tɕ^{h}iː], [ɕiː]/ *[tɕaː], *[tɕ^{h}aː], *[ɕaː]
    h. Dental affricates and fricatives, post-alveolar affricates and fricatives, and velars cannot occur before a high front vowel or glide, e.g. [sai], [ʂei], [kɑu]/*[tsja], *[tʂy], *[ki].
    i. A dental syllabic consonant only occurs after dental affricates or fricatives, and a post-alveolar syllabic consonant occurs only after a post-alveolar consonant.
3. Other constraints:
    j. The segments in the rime must have the same backness or roundness, e.g. [an], [ɑŋ]. This is especially true for the low vowels.

k. In a syllable that has GVV, the high glide and the high vowel in the second part of the diphthong cannot be both [-back] or both [+round], e.g. [wai] and [jou] are allowed because the pre-nuclear high glides and the high vowel occupying the second V differ in height and roundness. *[wɑu] and *[jai] are not permitted because [w] and [u] are both [+round], and [j] and [i] are both [-back].[11] Hence, the phonotactic constraint is violated.

l. A glide has to have the same backness as the following vowel, e.g. [ji], [wu]/*[ju], *[wi].

1.4 Research questions and goals

In this section, I pose my major research questions and set up the goals I want to achieve. In §1.1, I briefly mentioned that intervocalic nasals can be adapted as CVN and CVN.NV. Nasal insertion seems unnecessary, since CVN is grammatical in both English and Mandarin. In addition, according to the corpus data adopted in the current study and other loanword studies, vowel epenthesis is preferred over other syllable repair strategies, e.g. deletion, in SM loanwords. However, vowel epenthesis is not always the syllable repair strategy for coda [m]. Coda [m] can be repaired by vowel epenthesis or by nasal place change (bilabial to alveolar or velar). Deletion rarely happens.

Both adaptation processes are contextualized. For intervocalic nasal adaptation, nasal insertion appears in specific phonological environments. This is also true for coda [m] repair. My initial research questions to both adaptation processes are:

[10] Note that some researchers treat the glide as the secondary articulation of the onset consonant.
[11] In some dialectal varieties, [jai] is marginally possible. For example, 生涯 [ʂəŋ.jai] Career.

1. In what phonological environments do nasal insertion, vowel epenthesis, and nasal place change serve as the sound adaptation methods?
2. What phonological and phonetic factors trigger such adaptation methods?

Based on 1 and 2 above, I also designed and ran online perceptual experiments on Mandarin monolingual and Mandarin-English bilingual speakers to find out the following:

3. Assuming that the existing corpus data were generated or created by Mandarin-English bilingual speakers, do the bilingual experimental results pattern with the identified corpus generalizations?
4. Do the experimental results validate the proposed analysis with phonological and phonetic explanations on the basis of the identified generalizations?
5. Do speakers with different language backgrounds use the same sound modification strategy for both adaptation processes?

In addition, I would like to explore what linguistic mechanisms control the targeted adaptation processes.

1.5 Structure of the dissertation

The rest of the dissertation is constructed as follows. Chapter 2 studies how English intervocalic nasals are adapted to Mandarin in the existing corpus data and proposes an analysis with phonological and phonetic factors. Chapter 3 presents the design and procedure of the perceptual experiments and the results of how intervocalic nasals are adapted by Mandarin speakers with different language backgrounds, Mandarin monolinguals and Mandarin-English bilinguals. Chapter 4 investigates how English coda [m] is adapted to Mandarin in corpus data and accounts for the adaptation process with possible phonological and phonetic factors. Chapter 5 presents the design and procedure of the perceptual experiments and the results of how English

coda [m] is adapted by Mandarin speakers with different language backgrounds. Chapter 6 summarizes, concludes and discusses the contributions of the current study and provides potential directions of future loanword studies.

Chapter 2 Intervocalic Nasal Adaptation: Corpus Study

2.1 Introduction

This chapter discusses how English intervocalic nasals are adapted into SM loanwords and explains when and why seemingly unnecessary nasal insertion occurs. Previous studies on Chinese loanword phonology have mostly focused on segment matching and syllable structure, for example Silverman (1992) and Yip (1993) for Cantonese; Shih (2004) and Miao (2005) for Standard Mandarin; Lin (2008b) for SM vowel adaptation. There are relatively fewer studies on contextualized vowel and consonant adaptation, for example Hsieh, Kenstowicz, & Mou (2009) on nasal-ending rimes in Standard Mandarin; Yip (2006) and Kenstowicz (2012) on the phonotactics of the Cantonese rimes.

Nasal consonants in English are adapted in several ways in Standard Mandarin loanwords. The most common and straightforward adaptation is faithful mapping in the syllable onset position, e.g. *Nate* → [nai.tʰɤː] , *Mark* → [maː.kʰɤː]. However, English nasal consonant adaptation is not always a direct mapping process. For example, although [n] and [ŋ] are permissible in the coda position, they sometimes are adapted into Mandarin interchangeably, e.g. *Alden* → [au.əɪ.təŋ] ~ [aː.əɪ.dan], *Addison* → [ai.tiː.ʂəŋ] ~ [ai.tiː.sən].

Of interest here is that, based on my corpus data, English intervocalic nasals can be adapted in three different ways: (i) faithful one-to-one mapping, e.g. *Lina* → [liː.naː], (ii) one-to-two mapping with nasal insertion, e.g. *Benedict* → [pən.niː.tiː.kʰɤː.tʰɤː], and (iii) variable adaptation with or without nasal insertion, e.g. *Tiffany* → [tiː.fan.nei] ~ [tiː.fuː.niː].

In loanword adaptation, various repair strategies are used to produce grammatical adapted forms. For example, segment deletion and vowel epenthesis are candidates to repair consonant clusters. However, there are cases in which an "*unnecessary repair*" is made even when a direct

mapping without any repairs would have produced a phonologically licit adapted form (Peperkamp, 2005, p. 344; Y. Kang, 2011, p. 2260). Nasal insertion in SM loanwords is one such case since there is no phonotactically illicit structure in need of repair. That is, an intervocalic nasal in English can be faithfully mapped as a single nasal consonant in Mandarin without incurring a phonotactic violation, i.e. to have a faithful one-segment-to-one-segment mapping. Mandarin speakers can use vowel lengthening to modify the prenasal vowel, instead of inserting another nasal sound. For example, *Lenny* can be adapted *as* *[lei.niː] or *[laː.niː] instead of [lan.niː], which is the conventionalized output of the foreign entity.[12]

Based on the generalization observed in the corpus data, I argue that the "unnecessary repair", nasal insertion, is actually necessary in the sense that it is guided both by perceptual assimilation, which promotes similarity between the perceived input and the actual output, and by the native phonology of Standard Mandarin that requires each full-toned syllable to be bimoraic. For example, Mandarin does not allow open syllables with a lax or a short vowel, e.g. *[lɛ] is disallowed in Mandarin because [ɛ] only takes one syllable slot. Hence, the syllable is light with one mora. However, a full-toned syllable [léi] or [lán] is permitted (see §1.3.2.2).

This chapter is organized as follows. In §2.2, I discuss unnecessary repair in loanword adaptation, previous literature on contextualized nasal consonant adaptation, and consonant gemination in other loanword systems. In section §2.3, I present the loanword source and the corpus data of English intervocalic nasal adaptation and generalizations identified in the corpora. In section §2.4, based on the generalizations, I propose an analysis with phonological and phonetic factors of the three adaptation patterns of English intervocalic nasals. In section §2.5, I present the

[12] Asterisks are given because they are never the outputs, although they are phonologically grammatical.

generalizations identified in another corpus to support my observations. The final section concludes the chapter with a summary of the main corpus findings and a discussion.

2.2 Background

2.2.1 Unnecessary repair

Unnecessary repair is one of the puzzling emergent patterns in loanword adaptations.[13] Loanword adaptations are mainly transformations that apply to foreign forms that would be ill-formed if they were borrowed without modification. There are, however, several cases of loanword nativizations that appear to be unnecessary, in the sense that they do not repair some ill-formed phonotactic structures (Peperkamp, 2005, p. 344; Y. Kang, 2011, p. 2260). For example, Korean allows voiceless stops in coda position, e.g. '*field* [pæt]', but English voiceless stops are variably adapted with vowel epenthesis. This occurs especially, though not exclusively, when the preceding vowel is tense, as in *cut* → [$k^hʌt^hɨ$] ~ [$k^hʌt$] (Y. Kang 2003). Also, an English cluster of a coronal stop followed by a [w] is adapted with epenthesis in Korean (*twin* → [$t^hɨ$win], *[t^hwin]) (H. Kang, 2006). Vowel epenthesis is usually applied to fix illicit consonant clusters in the recipient languages. However, when the [tw] cluster is licit in Korean, vowel epenthesis still applies to break down the Korean grammatical consonant cluster.

In addition, both Japanese and Korean allow a nasal consonant in the syllable coda position. However, in French loanwords in Japanese and Korean, an extra vowel is unnecessarily added following word-final nasals, e.g. French *Cannes* [kan] → Japanese [kanːɯ], *[kan] (Shinohara 1997, Peperkamp, Vendelin, & Nakamura, 2008), and French *comme* [kom] → Korean [k'ommɨ], *[k'om] (H. Kang 1996). In fact, in the corpora used in this dissertation, the French word *Cannes*

[13] Y. Kang (2011) categorizes the puzzling emergent patterns in loanword adaptation identified in the literature into five categories: too many solution problem, divergent repair, unnecessary repair, differential imported and retreated to be unmarked.

is variably adapted with two forms: 坎城 [kan]-[tʂʰəŋ] (城 [tʂʰəŋ] means 'city' in Standard Mandarin. Refer back to the hybrid adaptation method in Chapter 1.) and 戛纳 [kaː.naː]. The adapted form without vowel epenthesis is used in Taiwan Mandarin, whereas the form with vowel epenthesis is widely in use in Mainland China. I suggest that the epenthetic vowel in the latter adaptation form seems unnecessary because SM allows [n] in syllable coda position. However, one can also argue that the epenthetic vowel in the Mainland output is necessary due to the nasal release in French (cf. Peperkamp et al. (2008)).

Golston & Yang's (2001) study on French and English loanwords in Hmong is another case of unnecessary repair. They look at segment adaptation from foreign languages to Hmong. In general, the sounds they find in Hmong loans from English or French are simply the sounds that English or French and Hmong share, whereas the sounds that they find in Hmong loans from French are simply the sounds that French and Hmong share. However, they find that /ʒ/ in French loanwords is categorically adapted as /j/, despite the fact that /ʒ/ is a phoneme in Hmong (*Joseph* /ʒo.zɛf/ → /jɔ̀.sè/, */ʒɔ̀.sè/), for which they discovered no explanation.

As these examples demonstrate, unnecessary repair occurs quite often in loanword adaptation. However, the reason behind it can vary. It can be due to perception, e.g. vowel epenthesis in Japanese, and Korean. It can also be due to categorical phoneme mapping, e.g. French /ʒ/ → /j/ in Hmong. Nasal insertion is another unnecessary repair case. The main goal of this chapter is to investigate the generalizations and the nature of nasal insertion in Mandarin loanwords from English.

The following sections discuss related contextualized nasal adaptation studies and consonant gemination in previous loanword studies. Consonant gemination in other loanword systems is discussed because nasal insertion in Mandarin loanwords and consonant gemination share very

similar patterns. They are related to pre-consonantal vowel type/quality, word stress location, and ambisyllabicity.

2.2.2 Nasal adaptation in Standard Mandarin

Miao (2005) investigates phonemic substitution from English, German, and Italian loanwords in Standard Mandarin.[14] Three nasal consonants, /n, m, ŋ/, are permissible in coda position in the donor languages. English and German allow /n, m, ŋ/, whereas Italian allows only /n, m/. Since /n/ and /ŋ/ are licit codas in Mandarin, they are expected to be retained as codas without further adjustment. The bilabial /m/ is not a licit coda in Mandarin; therefore, when it is adapted into Mandarin loanwords from the donor languages, it has to fulfill Mandarin native phonotactic constraints. To modify /m/, three repair strategies are possible: deletion, vowel epenthesis, and nasal place change ([m] → [n] or [ŋ]).[15] The following table shows the nasal coda consonant adaptation patterns identified in the Miao's corpus (Miao, 2005, p. 99).

Table 2.1 Adaptation of simplex nasal codas. SL=source language(s)

	Source	V Epen	N Retention	/-m/→/-n, -ŋ/	N Deletion	σ Deletion
/-m/	English	46.43%	0	42.86%	3.57%	7.14%
	German	97.5%	0	2.50%	0	0
	Italian	0	0	0	0	100%[16]
/-n, -ŋ/	English	0.54%	94.02%	0	0	5.43%
	German	0	97.27%	0	0.91%	1.82%
	Italian	0	100%	0	0	0

(Miao, 2005, p.99)

The adaptation patterns show that the alveolar and velar nasals, which are permissible codas in Standard Mandarin, are generally retained, except for very few cases of deletion and vowel epenthesis. The coda /n/ and /ŋ/ sometimes are not mapped to their corresponding phonemes in

[14] Miao (2005) provides a detailed phoneme substitution study on all the phonemes. Nasal consonant mapping is a small part of her dissertation. Since this dissertation focuses on nasal adaptation, the review is only on nasal adaptations.
[15] The bilabial coda /m/ adaptation will be discussed in details in Chapter 4.
[16] There is only 1 case for syllable deletion. Hence, the rate is 100%.

Standard Mandarin, i.e. foreign coda /n/ → SM /ŋ/, e.g. *Avon* → [ja.faŋ], foreign coda /ŋ/ → /n/, e.g. *Corning* → [kʰaŋ.niŋ]. As for the bilabial nasal coda /m/, English and German simplex coda /m/ behave differently when they enter into Standard Mandarin loanwords. English coda /m/ is adapted with vowel epenthesis and nasal place change almost by chance. Her corpus pattern is very similar to my perceptual similarity experimental results from the monolingual group (See Chapter 5). However, the vowel epenthesis rate after German coda /m/ is close to 100%. Miao states that the deviation of the alveolar and velar nasal adaptations, the vowel epenthesis after coda /m/, and deletion can be attributed to sociolinguistic and sociocultural reasons. Words that are borrowed from English are more likely to be conducted through speech than those borrowed from German. Although in general lexical borrowing from foreign languages into Mandarin relies heavily on writing, oral contact between Mandarin and English is relatively more extensive than contact between Mandarin and other languages like German and Italian.

In addition, considering that loan adaptation based on orthography tends to show certain patterns different from auditory adaptation (Smith, 2006; Vendelin & Peperkamp, 2006), the higher preservation rates observed in the loanwords from German and Italian may well arise from the greater influence of spelling. Miao examines loanwords from English and German in different categories—place names, brand/company names, and other sound-based loanwords, and further concludes that when speakers borrow the brand/company names, deletion and deviation of consonant features occur more frequently than place names and other words (cf. T.-E. Kim, 2014).

Besides sociolinguistic and sociocultural observations, Miao's cross-linguistic findings about the changeability of consonantal features are due to perception. Her loanword corpus data show that voicing/aspiration and place features are more flexible than manner features. For example, the data show that [+nasal] nearly never gets deleted or changes to another feature. However, the place

feature of the nasal consonant deviates with higher probability even when the nasal is licit in the coda position. Following Steriade's (2009) P-map (Perceptibility-map) hypothesis, Miao conjectures that rankings of various correspondence constraints are projected by the perceptual similarity between the source form and the adapted form. This analysis is tested by data from perception and online adaptation experiments, the results of which corroborate the hypothesis that perceptual similarity plays an important role in loanword adaptation.

The study of Hsieh et al. (2009) is sparked by the observation that the loanword dictionary, *Dictionary of Loanwords and Hybrid Words in Chinese*, compiled by Liu et al. (1985) of words borrowed from Western languages, primarily English, into early Modern Mandarin (circa 1890-1930) contains about 600 items that contain a VN sequence (see more examples in Hsieh et al., 2009, p. 135 in (1)).[17] When the English source consists of a front vowel combined with the alveolar nasal [n], i.e. [æn] or a back vowel combined with a velar nasal [ŋ], i.e. [ɑŋ], they expect the Mandarin adaptation to contain a matching rhyme, i.e. [an] or [ɑŋ]. They have 31 English [æn] rimes in the corpus; 26 of them support the hypothesis. The examples marked with asterisks are exceptions.

(1) English	Mandarin	
Alexander [æn]	ya.li.shan.da	[an]
anchovy	an. chou	
angel	an. qi.er	
Atlanta	ya.te.lan.da	
pandora	pan.duo.la	

[17] The data (1) in are the original data provided in Hsieh et al. (2009). Their main argument is that the alternation of nasal coda adaptation in SM loanwords is restricted to SM rime harmony; they did not put tone markers on the Standard Mandarin forms in all their data. IPA symbols were only given to the [æ] and [ɑ] English and SM nasal-ending rimes. Other syllables were transcribed with Hanyu Pinyin.

romantic		luo.man.di.ke	
*bandage		lang.tang	[ɤŋ]
*vandal		wang.da.er	[ɑŋ]
Congo	[ɑŋ]	gang.guo	[ɑŋ]
franc		fa.lang	
furlong		lang	
pingpong		ping.pang	
*encore		an.ge	[an]
*gong		gun.ge	[un]

Since English freely combines front, back, mid, and low vowels with both nasals, the question arises whether it is the vowel or the coda consonant that will change when the adapter is faced with conflicting combinations. Their data evidence that the backness of the English vowel is preserved, whereas the nasal place changes with the vowel. That is, when the prenasal vowel is [-back] in English, the nasal will be the alveolar in Mandarin. When the prenasal vowel is [+back], the nasal will be adapted to velar. See examples below (Hsieh, 2009, p. 136-7).

(2)

English		Mandarin	
Bronx	[ɑn]	bu.lang.ke.si	[ɑŋ]
concept		gong.si.bu.tuo	
marathon		ma.la.song	
Oregon		e.le.gang	
Wisconsin		wei.si.kang.xing	
*gondola		gong.duo.la	[oŋ]
*neon		ni.hong	

Angora	[æŋ]	an.ge.la	[an]
bank		ban.ke	
Franklin		fu.lan	
tango		tan.ge	
tank		tan.ke	
*gangsa		gang.sha	[ɑŋ]
*Yankee		yang.ji	

Their data bear on the resolution of two conflicting adaptation paths with respect to a well-known phonotactic constraint on Mandarin syllable rimes according to which mid and low vowels take front and back allophones in harmony with the following coronal vs. velar nasal in the coda of the syllable (Duanmu, 2000/2007, among others).[18] Their analysis of the existing corpus suggests that it is the place of the nasal consonant that is changed while the front vs. back vowel feature in English holds constant. They argue that this is surprising from the phonemic point of view since in the standard analysis of Mandarin, the coda nasals /n/ vs. /ŋ/ are the locus of contrast while the front vs. back vowels are predictable variants. They thus expect the nasals to remain faithful and the vowels to adjust.

In the same study, Hsieh et al. also reports the results of experiments in which Mandarin participants (N=15) are asked to choose between [an] vs. [ɑŋ] adaptations for English stimuli series such as Dan [dæn], Dang [dæŋ], Don [dɑn], and Dong [dɑŋ]. In these experiments as well, participants sought to remain faithful to the vowel at the cost of changing the consonants except

[18] This constraint is proposed in Duanmu (2000/2007). In the context of nasal codas, the low vowel phoneme /a/ take a relatively front allophone before the dental nasal ([an]) and a relatively back, unrounded allophone before the velar nasal ([ɑŋ]). This distribution is called Rhyme Harmony.

in the case of the [ɑn] where Mandarin adaptations as [an] (50.9%) and [ɑŋ] (49.1%) occurred in roughly equal proportion.

Their findings suggest that when the adapter is presented with conflicting options to satisfy the phonotactic constraints of the recipient language, in their case Mandarin, the place of nasal articulation will be changed to that of the English low vowel. In their study, they also claim that the phonetic place features of the vowel are more salient than those of the nasal coda. They give phonetic evidence that it is the vowel that determines the nasal coda by mainly looking at [æ] and [ɑ] in English nasal-ending rimes. They conclude that the F2 (formant of backness) value of English low vowels determines the following coda nasal's place of articulation in loanwords in Mandarin.

Miao (2005) starts a detailed study on phoneme substitution patterns for consonants from English, German and Italian, and explains the consonant adaptation patterns from perceptual, sociolinguistic and sociocultural perspectives. Hsieh et al. (2009) start with the issue of coda nasal adaptation with contextualized conditions in SM loanwords. Both studies show that perception plays an important role in loanword adaptation.

This chapter investigates how English intervocalic nasal consonants are adapted into Standard Mandarin and how it corresponds to speech perception and Mandarin phonotactic constraints. The focus here is that when the English intervocalic nasal consonants appear in specific phonological environments, nasal insertion occurs, although SM allows one-to-one segment mapping. Nasal gemination/insertion process is similar to consonant gemination in other loanword systems. The following section discusses the nature of consonant gemination in previous loanword studies.

2.2.3 Consonant gemination in loanword adaptation

Gemination is a cross-linguistically widespread phenomenon in loanword adaptation. A singleton in the donor language is geminated in the recipient language even when the singleton is spelled with a single consonant letter in orthography. Some examples (from Magyar, 2016, p. 1) of consonant germination in different loanword systems are given below.

(3) Consonant gemination in different languages.

a. Japanese: [ka<u>tt</u>o] ‘cut [kʌ<u>t</u>]’ (Kubozono, Itô, & Mester (2008))

b. Telugu: [ro:<u>dd</u>u] ‘road [ro<u>d</u>]’ (Krishnamurti & Gwynn (1985))

c. Finnish: [po<u>pp</u>i] ‘pop [pɑ<u>p</u>]’ (Karvonen (2005, 2009))

d. Hungarian: [so<u>kk</u>] ‘shock [ʃɑ<u>k</u>]’ (Nádasdy (1989), Kertész (2006))

e. Italian: [fa<u>nn</u>] ‘fan [fæ<u>n</u>]’ (Passino (2004))

In the given examples above, we can see that the word-final consonant in the source language, English, gets geminated in the recipient languages Japanese, Telugu, and Finnish. In addition, vowel epenthesis occurs to form an open syllable to repair the ungrammatical geminated consonant. Loanword gemination in Hungarian and Italian are similar. The word-final consonant simply gets geminated in the recipient languages without vowel epenthesis after the geminated consonant.

Previous studies on consonant gemination are discussed in this section since the nasal insertion in the Standard Mandarin loanword system to some extent is similar to consonant gemination in other languages with gemination patterns, e.g. nasal gemination happens when the prenasal vowel is lax and non-high and the prenasal vowel bears the primary stress in the English source. Consonant gemination in loanword adaptation in general is also strongly correlated to the quality of the pre-consonantal vowel and stress location in the source language.

Consonant gemination is a high frequency repair strategy in loanwords from English to Japanese in similar contexts (Lovins, 1973/1975; Shirai, 1999; Kawahara, 2007; Kubozono, Itô, & Mester 2008). This repair strategy is also found in Italian (Repetti, 2009), Hungarian (Magyar, 2016), and one of the Chinese dialects, Cantonese (Yip, 1993). The given conditions that trigger nasal insertion in Mandarin loanwords also trigger consonant gemination in other languages' loanword systems. Those languages that have consonant gemination as a loanword adaptation repair strategy simply duplicate the targeted consonant to form a geminate, e.g. *cut* [kʌt] (English) → [katto] (Japanese).

However, I argue that in Standard Mandarin loanword adaptations, the nasal is not taken as a true geminate; rather, I treat it in this study as a nasal insertion process since in some cases the two neighboring nasal consonants are not identical. Three non-identical segment circumstances are discussed here:

1. [n] → [ŋ.n], e.g. *Mo<u>n</u>ahan* → [meŋ.naː.xan]
2. [m] → [n.m] / [ŋ.m], e.g. *Ha<u>m</u>ilton* → [xan.miː.əɹ.tun]
3. [ŋ] → [ŋ.k], e.g. *Young* → [jɑŋ.kɤː]

I suggest that the transformation of the first nasal in gemination is due to SM's native phonotactic constraints. When the intervocalic nasal consonant in English is [m], the adapted form changes to [n.m] or [ŋ.m] because Mandarin does not allow [m] in the coda position. Hence, the first nasal must change to one of the licit nasals. Which licit nasal is picked depends on the backness of the prenasal vowel in the source (cf. Hsieh et al. (2009)). When the intervocalic nasal consonant in English is [ŋ], the adapted form changes to [ŋ.k], or [n.k]. The second geminated half changes to [k] because the velar nasal [ŋ] cannot be in syllable onset position in SM. Hence, the nasal feature gets removed only the place feature remains. The voicing changes from [+voice] to

[-voice] is because Mandarin only has voiceless oral stops. It does not have /g/ in its consonant inventory. Therefore, [ŋ] → [k] is the closest sound mapping result.

In addition, even when the intervocalic nasal is [n], it can be adapted as [n.n] or [ŋ.n] (cf. Miao, 2005). Due to Mandarin phonotactics, perception, and sociocultural factors, either the [+nasal] or the place feature of the target consonant is geminated. Hence, I will use the term 'nasal insertion' in this study.

Lovins (1975) shows that Japanese loanwords from English often undergo gemination when the source word contains a stressed short vowel and an obstruent in the word-final position and that intervocalic consonants sometimes undergo gemination in loanwords. Lax vowels in English are adapted into Japanese as short vowels. Tense vowels are adapted as long vowels to block gemination. Lovin's discussion is mainly centered on the stress and the quality of the source vowels. The patterns of nasal insertion in Mandarin loanwords are also related to the shorter duration of the prenasal vowel and the primary word stress in English. Prenasal long vowels also block nasal insertion in loanwords in Mandarin.

Shirai (1999), by examining a corpus dataset with 3,399 Japanese loanwords adapted from English, also concludes that most geminates are from three source environments:

1. when a consonant is a singleton in word-final position of a source word or,
2. when a consonant follows a stressed syllable or,
3. the consonant is considered an ambisyllabic consonant.

In all environments, gemination requires two conditions: a lax vowel and a singleton. The lax vowel condition means the vowel preceding the geminate has to be a lax vowel as well. The singleton condition means the geminating consonant cannot be in a consonant cluster. With the generalizations, she further observes that voiceless consonants are geminated in most cases and

word-final consonants get geminated more often than ambisyllabic consonants. Nasal insertion also applies when an English nasal consonant follows a stressed syllable and is considered ambisyllabic. According to Gussenhoven (1986), Hayes (1995, 2009), and Kahn (1976), consonants are considered ambisyllabic when they can belong to two syllables at one time. For example, the [m] in *lemon* is an ambisyllabic consonant because [m] is double linked to the first and the second syllable. Native intuition seems to be indecisive whether the two syllables are divided to [lɛ.mən] or [lɛm.ən]. When syllabification is clear, ambisyllabicity does not occur, i.e. when a stressed vowel follows the targeted consonant, e.g. the [n] in *Denise* [də.ˈnis] is clearly syllabified to the second syllable, hence, not ambisyllabic. Giegerich (1992) suggests that ambisyllabicity is contextualized, i.e. an intervocalic consonant is more likely to be considered ambisyllabic when the preconsonantal vowel is lax and bears the primary stress, e.g. the [n] in *Dany* [ˈdæni] is ambisyllabic because the prenasal vowel is [æ] and bears the primary word stress.

Repetti (2009) examines gemination in English-based loanwords in American varieties of Italian, e.g. coal → [ˈkolle], and bushel → [ˈbuʃʃolo]. She argues that many factors play a role in gemination, such as the inventory of segments of the recipient language, the structure of the stressed syllables, the presence of similar native lexical items, and the phonetic details of the source words. She argued that speakers try to preserve the syllable structures of the source form by gemination, specifically the moraicity of final consonants. That is, if the stressed syllable in the source language is bimoraic, gemination is a repair strategy. She also takes Peperkamp & Dupoux's (2003) view, which argues that the speakers are able to interpret the fine acoustic detail of the vowel and consonant length of their own phonological system. For example, a consonant that follows a long vowel is phonetically shorter than if it follows a short vowel. She shows that American-Italian loanword gemination cannot be accounted for by only one of the factors

mentioned above; rather, a combination of both phonological and phonetic factors needs to be taken into consideration.

Yip (2002, 2006) discusses syllable weight as a factor for Cantonese consonant gemination in its loanword system. Duanmu (2000/2007) argues that the minimal syllable in Cantonese is [μμ]σ, i.e. in an open syllable, all vowels have to be long, for example, *flower* [faː], *[fa]. Yip agrees with Duanmu's claim on Cantonese syllable structure and concludes that Cantonese bimoraic syllable structure is supported by loanword phonology. English short, open syllables surface as closed syllables in Cantonese by gemination of the following onset, e.g. ˈ*copy* [kapi] → [kʰappi], *guiˈtar* → [kittʰa]. However, long open syllables in English do not trigger gemination in Cantonese loanwords, e.g. *soda* → [sota]. She further concludes that consonant gemination in Cantonese loanword system can be understood as the result of need for a bimoraic syllable. She also points out that stress is not the main factor that decides gemination in Cantonese loanwords. Her point regarding syllable weight of Cantonese loanword consonant gemination is very similar to nasal insertion process in the current study. However, I identify that stress plays a role in the appearance of the nasal insertion process in Mandarin loanwords.

Magyar (2014) investigates consonant germination in Hungarian loanwords. Gemination is possible in Hungarian native phonology, i.e. Hungarian consonant length contrasts word meanings, as well as in loanword adaptations. In her study with 1750 Hungarian loanword from English, German and French (occasionally), singleton consonants following a stressed lax vowel in the source word are regularly geminated in Hungarian loanwords, e.g. English *fit* → Hungarian *fitt* [fitː], German *frisch* → *friss* [friʃː], even if the source words do not contain a double consonant letter (Nádasdy (1989), Kertész (2006)). Gemination in loanwords appears very common in the word-final position in monosyllabic words. Both singletons and geminates are allowed in

intervocalic positions in Hungarian. In loanwords, consonant gemination also appears in intervocalic position in the source, although not quite often (similar to Japanese).

Table 2.2 Frequency of gemination in Hungarian loanwords with the target consonant in different syllable position and pre-consonantal vowel quality

Spelling	VC# (monosyll)	VCV (polysyll)	CV# (polysyll)	After V:
Double letter	frequent	frequent	frequent	never
Diagraph *-er*	frequent	less frequent	less frequent	never
Single letter	frequent	rare	rare	never

(Magyar, 2014, p.4)

The consonant inventory of Hungarian consists of 25 consonants and all the consonants can be geminated. However, in loanwords, gemination is restricted. Besides the syllable position in the source words and the pre-consonantal vowel quality, gemination in Hungarian loanwords also depends on consonant class. Voiceless obstruents are geminated more often than other consonants. Nasals are geminated more often than liquids and voiced fricatives are never geminated unless the source word contains a double letter spelling. In Mandarin, since the only possible codas are [n] and [ŋ], nasal insertion cannot be compared with consonants in other classes.

In summary, cross-linguistically, consonant gemination in loanword adaptation is related to the target consonant syllable location and the preceding vowel quality of the target consonant. It is also related to consonant class. Consonant gemination can also be related to the stress pattern in the donor language. However, it is not always relevant, e.g. Cantonese loanwords. In the next section, I will discuss how an English intervocalic singleton nasal is adapted in Mandarin loanwords in the existing corpora and identify the main factors that condition nasal insertion.

2.3 How is intervocalic nasal adapted to Standard Mandarin?

2.3.1 The corpora

The current corpus data are mainly collected from a list of common British and American names in Appendix I (see [1]) in *A New English-Chinese Dictionary* (1988). The dictionary corpus

consists of around 2400 British and American male and female names. Other than the dictionary corpus, I also collected some data from public media, e.g. newspaper, magazines, movie posters, and movie subtitles in Mandarin.

The loanword focus in this study is on proper nouns because the sound-based borrowing method is commonly used for proper names such as the names of places, people, or brand names of products in Mandarin. The sound-based method is also widely used by languages in borrowing foreign proper nouns in most languages. For example, the Chinese city names *Beijing* and *Shanghai* are pronounced as [pei]$_{214}$ [tɕiŋ]$_{55}$ and [ʂɑŋ]$_{51}$ [xai]$_{214}$ in SM, but English speakers typically pronounce them as [beidʒɪŋ] and [ʃæŋhai] without tones. However, with English stress patterns, although in English the orthographic spelling is directly adapted from Hanyu pinyin, *Beijing* and *Shanghai*.[19]

Another reason is that, other than the sound-based adapted proper nouns and scientific terms, loanwords in Mandarin are mostly adapted through the meaning-based method, unlike Cantonese, Japanese, and Korean. For example, *Koala* → 无尾熊 [wuː.wei.ɕjoŋ], '*no-tailed bear*'; *computer* → 电脑 [tjan.nao], '*electronic brain*'.[20] However, Japanese and Korean borrow foreign words through the sound-based method very frequently. For example, the English word *cat*, besides the native Japanese ねこ (Romaji: *neko*), can be [katto], and it is represented with Japanese orthographic scripts in the written form.

Yet nowadays, the sound-based method is adopted to borrow non-proper noun foreign entities more often, e.g. *Facebook* can be 脸书 [ljan.ʂuː], which is adapted via the meaning-based morpheme by morpheme translation '*face-book*', and 飞簿 [fei.buː] /非死不可 [fei.sɻ̩ː.buː.kɤː],

[19] Pīyīn is the official romanization phonetic system for Standard Mandarin in Mainland China, and to some extent in Taiwan.
[20] Koala has a sound-based adaptation form 考拉 [kʰao.laː], which is widely in use in Mainland China.

which is adapted via the sound-based adaptation method with either illicit coda consonant deletion or vowel epenthesis repair strategies. *Police* has a native Mandarin word 警察 [tɕiŋ. tʂʰaː], and a sound-based adaptation form [pwoː.liː.ʂɻ]. *Proposal* has a native Mandarin word, 提案 [tʰiː.an], but nowadays graduate students in Taiwan use the sound-based form 波波兽 [pwoː.pwoː.ʂou] quite often because 兽 [ʂou] means "a scary monster", which also reflects students' anxieties of writing academic articles.

From the given examples, we can see that the sound-based adaptation forms have to be adjusted with native SM phonology and phonotactics, e.g. illicit codas are repaired by vowel epenthesis or deletion (see Standard Mandarin syllable structure and phonotactic constraints in §1.3.2) and each syllable is assigned a Mandarin character.

Since the corpus data are from an English-Chinese dictionary and public media, it is reasonable to assume that the existing loanwords in SM are generated by proficient bilingual speakers, either Mandarin-English or English-Mandarin bilinguals. Y.-H. Lin (2007) points out that both older and modern loanwords are primarily created by intellectuals, professional translators, and media personalities who know English or relevant foreign languages well.[21]

Paradis & Lacharité (1997) study 545 French loanwords in Fula, a language spoken in Mauritania and Senegal, both of which have been influenced by French for more than a century since the initial French colonization. They find that the loanwords are introduced by bilinguals with varying degrees of bilingualism who adapted the foreign phonological sequences according to what they call "repair strategies".

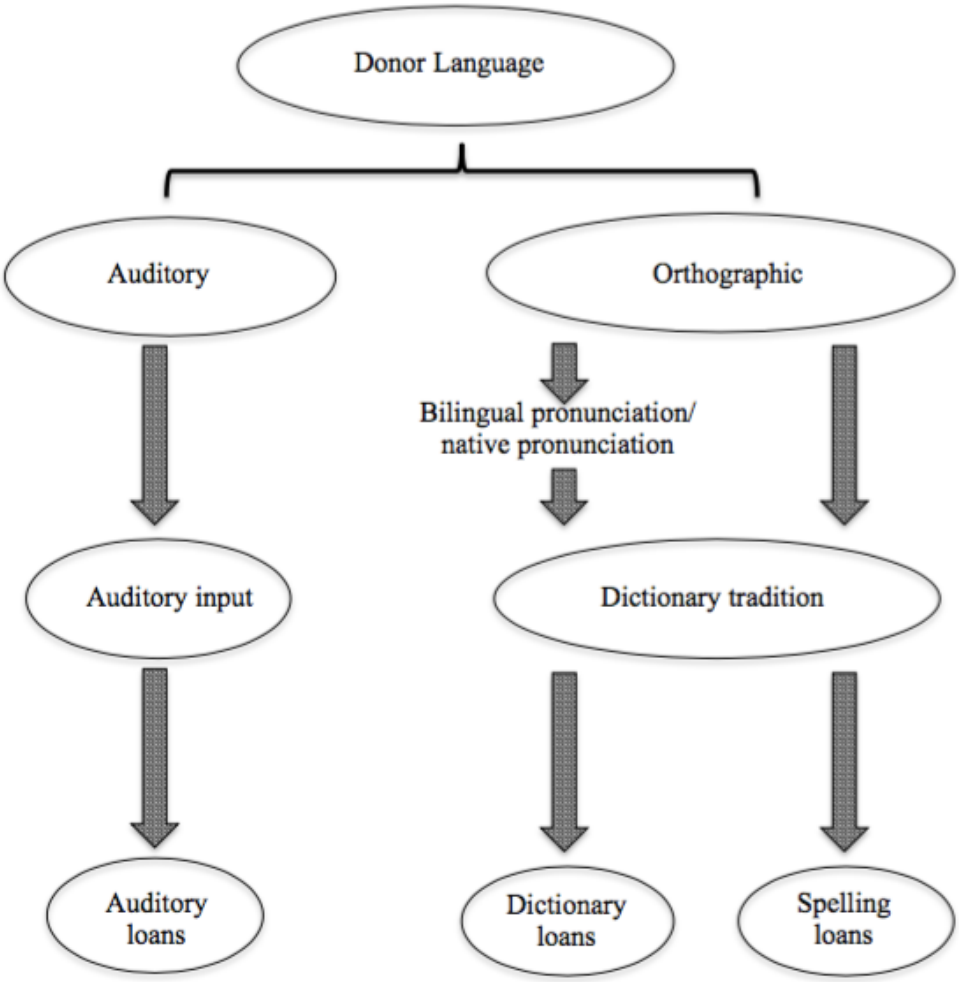
[21] Y.-H. Lin (2007) states that the new wave of extensive borrowing of foreign words began in the 16th century when Western missionaries came to China. English has been the major source of loanwords since the early 20th century. Words entering SM at that time were mostly adapted by Western missionaries and translators of foreign books.

2.3.2 The corpus input

Based on the bilingual borrowing assumption, the borrowing route of the existing SM loanword corpora can be schematized in Figure 2.1 (Irwin, 2011, p. 77).[22] The source of a donor word may be auditory or orthographic. If the source is auditory, the adaptation is based on auditory input. If the source is orthographic, foreign words are either assigned a dictionary pronunciation by bilingual speakers or native speakers of the recipient language, or adapted through the orthography/spelling of the donor language. These three different routes result in different types of loanword outputs: auditory, dictionary, and spelling. According to Miao (2005), Y. Kang (2003) and Smith (2006), we can assume that the auditory and dictionary loans result in more various adaptation forms than the spelling loans.

[22] I adopt the figure (with a little bit of change) that Irwin (2007) uses for Japanese loanwords adaptation.

Figure 2.1 Possible borrowing routes in SM loanwords



In addition, Dong's (2012) study on Mandarin loanwords also argues that input types and adapter types also affect the loanword outputs. She suggests that there are at least two input types. Every loanword adaptation process takes the orthographic input and/or the acoustic input of a source language word as its logical starting point. In one version of word adaptation, the process consists of looking at the orthographic input of the target word. She also points out the pronunciation given in dictionaries may play a role in loanword adaptation. She gives the English word *benefit* to illustrate vowel adaptations for the two *e* vowels with different pronunciations. Beginning-level English learners, who can also possibly be adaptors, may not be able to

differentiate between the two pronunciations of *e*. They need to rely on an English-Chinese dictionary to find out that the first *e* is pronounced as [ɛ] and the second one is [ɪ]. Accordingly, they will adapt the *e* in *be* and *ne* differently. The two possible loanword outputs are 斑宁妃 [pan.niŋ.fei] and 贝令妃 [pei.liŋ.fei]. The latter one is the actual brand name searched on Google.

In contrast, adaptation can be done via pure acoustic input of the target word. The adapters may not be provided with the orthographic form or they may disregard the original written form. Moreover, the adapters may consider the combination of the orthographic and the acoustic input at the same time.

As for the adapters, they can be monolinguals of the recipient language, non-proficient bilinguals, bilinguals who have developed an interlanguage perception grammar, and proficient bilinguals who have developed the grammar of both recipient and source languages (cf. Broselow, 2009). Dong (2012) combines different types of input methods and different types of possible adapters and creates seven loanword adaptation scenarios in Table 2.3. RL stands for recipient language. SL stands for source language.

Table 2.3 Seven loanword adaptation scenarios

Scenario	Factor 1	Factor 2
	Input type	Adapter type
1	Orthographic input	RL monolinguals
2		Non-proficient RL learners of SL
3	Acoustic input	RL monolinguals
4		Non-proficient RL learners of SL
5	Orthographic + Acoustic input	RL monolinguals
6		Non-proficient RL learners of SL
7	Orthographic input / Acoustic input / Orthographic + Acoustic input	RL/SL proficient bilinguals

(Dong, 2012, p.40)

The inputs of the current corpora of this dissertation are from both orthographic and acoustic sources. The adaptors are dictionary editors and professional movie translators and, all proficient bilinguals of English and Standard Mandarin. The movie translators mainly adapt words through acoustic inputs, whereas the dictionary editors may rely on both the orthography/spelling and their own pronunciation of the inputs.[23] This also means that their brains register the representation of the foreign words' pronunciation. They can be American English and/or British English speakers.

2.3.3 The corpus data and generalizations

The dictionary corpus along with data collated elsewhere consist of 2,426 English loanwords. Around 1,000 nasal consonants in different syllable positions, i.e. syllable onset, intervocalic, and syllable coda, are examined. It is not surprising that nasal consonants in syllable onset position are faithfully adapted into SM loanwords since both English and SM allow /n/ and /m/ in the onset position. The permissible codas /n/ and /ŋ/ in a few cases are not directly mapped to their corresponding phonemes, i.e. English *vitamin* → SM [wei.tʰa:.miŋ] ([n] → [ŋ]), English *bingo* → SM [pin.gwo] ([ŋ] → [n]). This unfaithful nasal place mapping is also observed in Miao's (2005) corpus. It occurs quite frequently when the coda nasal rimes with the high front vowel /i/ in SM. This is because the rime harmony constraint only strongly applies to SM low vowels. Another reason can be attributed to finding a proper Chinese character for the products or brands and looking for loanword specific characters.

As for the intervocalic nasal adaptation, the adaptation patterns can be grouped into three types. Each type consistently occurs under specific phonological environments. The data collected from

[23] Movie companies tend to hire translators to translate movies into other foreign languages. For good quality and accurate translations, the translators are provided official scripts. However, a lot of new movies now are translated and put online by amateur translators who are proficient with the foreign language.

different sources were analyzed together because the same patterns merge in the same phonological environments among words from different sources.

1. adaptation in SM loanwords with nasal insertion,
2. those without insertion, which are faithfully adapted,
3. and those that are variably adapted with and without nasal insertion.

The two main factors that condition the adaptation of nasal insertion in SM loanwords are the prenasal vowel quality and length and location of the primary word stress. To trigger nasal insertion in SM loanwords, the English prenasal vowel has to be lax and non-high and bear the primary word stress. The examples in the four subcategories in (4) illustrate how intervocalic nasal singletons in English are adapted with nasal insertion in SM loanwords.

(4) English intervocalic nasal singletons adapted with nasal insertion in SM loanwords. Note: each syllable represents one character in SM, e.g. ˈCanary → [khan.na.li] 坎納利.

a. English [ˈVnV]	SM [Vn.nV] (ˈV = stressed vowel)
ˈAneurin	[an.nai.lin]
ˈAniva	[an.ni:.wa:]
ˈCanary	[k^han.na:.li:]
Capiˈlano	[k^ha.p^hu.lan.nwo]
ˈDenis	[tan.ni:.sɻ]
Diˈana	[tai.an.na:]
ˈDanica	[tan.ni.k^ha:]
ˈEnid	[ən.ni:.tɤ:]
ˈFenick	[fən.ni:.k^hɤ:]
Heˈlena	[xɤ:.ljan.na:]

	ˈLeonard	[lun.naː.tɤː]
	Roˈmanes	[lwo.man.niː.sɻ]
b.	English [ˈVnV]	SM [Vŋ.nV]
	ˈBoniface	[pɑŋ.niː.fei.sɻ]
	ˈBonnie	[pɑŋ.niː]
	ˈConner	[kʰŋ.naː]
	ˈDonald	[tʰɑŋ.naːtɤː]
	ˈJonathan	[tʰɕʲaŋ.naː.sən]~[tʰɕʲaŋ.naː.ʂəŋ]
	ˈMonahan	[meŋ.naː.xan]
	ˈSauna	[sɑŋ.nɑː]
	ˈSonic	[sɑŋ.niː.kʰɤː]
	ˈSunny	[sɑŋ.niː]/[ʂan.niː]
	Tanˈzania	[than.sɑŋ.niː.jaː]
c.	English [ˈVmV]	SM [VnmV] or [VŋmV]
	ˈCommons	[kʰən.miŋ.sɻ]~[kʰɑŋ.miŋ.sɻ]
	ˈHaman	[xan.man]
	ˈHamilton	[xan.miː.əɹ.tun]
	Montˈgomery	[məŋ.kan.mʷoː.liː]~[məŋ.tʰɤː.kɑŋ.mʷoː.liː]
	ˈThomas	[tʰɑŋ.maː.sɻ]
d.	English [ˈVŋV]	SM [VnkV] or [VŋkV]
	ˈAngus	[an.kɤː.sɻ]
	ˈHingis	[ɕin.tɕiː.sɻ]
	ˈSinger	[ɕiŋ.kɤː]

Young [jɑŋ.kɤ:]

The examples in (4) show that the intervocalic nasal consonants in English can be adapted from [n] to [n.n], [n] to [ŋ.n], [m] to [n.m] or [ŋ.m], and [ŋ] to [n.k] or [ŋ.k^{h}]. The first part of the doubled nasal forms in SM is either identical (see (4)a)) to its second part or has variable adaptations (see (4)b, c, d). The change occurs because the place feature of the nasal coda has to agree with the coronal and dorsal feature of its preceding non-high vowels; i.e. when SM phonotactics are not violated, the place of articulation of the nasal changes with its previous vowel (cf. Hsieh, Kenstowicz and Mou, 2009). The bilabial [m] in English has two adaptation forms since [m] only appears in the onset position in SM. When nasal insertion takes place, the first nasal has to change to either [n] or [ŋ] to be a licit syllable coda in SM. When it alters to [n] or [ŋ], as predicted by Hsieh, Kenstowicz and Mou (2009), the nasal codas in SM agree in backness with their preceding non-high vowels in English.

I observe that the English intervocalic nasal is mostly adapted with nasal insertion in SM loanwords when the prenasal vowel in English is stressed, non-high, short, and lax. Following the current data, I also identify that the English intervocalic [n] is most frequently adapted with nasal insertion in SM loanwords, [m] is adapted with an extra nasal less often than [n] is, and [ŋ] is adapted with nasal insertion the least. I suggest that the bilabial nasal less frequently experiences nasal insertion because the place feature of the inserted nasal must change due to the phonotactics of Mandarin. The velar nasal triggers nasal insertion the least because it is not allowed in the onset position in SM, so insertion occurs in the forms of [n.k] or [ŋ.k], as shown in (4)d due to the following Mandarin phonotactic constraint:

Dental affricates and fricatives, post-alveolar affricates and fricatives, and velars cannot occur before a high front vowel or glide e.g. [sai], [ʂei], [kɑu]/*[tsja], *[tʂy], *[ki], [k^{h}i].

The example *Hingis* given in (4)d takes one more step to produce the output. Based on the nasal reform rule I proposed earlier, the loanword output of *Hingis* should be [ɕin.kiː.sɻ̩]. However, Mandarin does not allow the [kiː] combination. The English syllables [gi] and [ki] are mostly adapted as [tɕiː] or [tɕʰiː], e.g. *Kiwi* → [tɕiː.jiː.kwo], which is a hybrid loanword by adding a morpheme [kwo] to indicate that *Kiwi* is a "fruit". Similarly, *guitar* is adapted as [tɕiː.tʰaː]. Table 2.4 shows the number and percentage of different nasal consonants adapted with insertion in SM.

Table 2.4 The number and percentage of different nasal consonants in English get nasal insertion in SM loanwords

N→NN	[n] → [n.n]	[n] → [ŋ.n]	[m] → [n.m]	[m] → [ŋ.m]	[ŋ] → [ŋ.k]	[ŋ] → [n.k]
Numbers	88	35	10	9	2	2
Subtotal	123		19		4	
Percentage	84.24%		13.01%		2.74%	
Total =146 (100 %)						

However, not all intervocalic nasal consonants are adapted with insertion in SM loanwords since nasal insertion in SM loanwords is triggered by the stress location and the prenasal vowel quality/quantity. Nasal insertion does not surface in SM loanwords when:

1. the prenasal stressed vowel in English is high or tense/long, or is a diphthong,
2. the prenasal vowel is unstressed and the postnasal vowel is stressed (syllabification is clear, not ambisyllabic), and
3. the prenasal vowel in English is a stressed low back [ɑ] in a trisyllabic unstressed-stressed-unstressed word.

Examples from (5) to (7) show that nasal insertion does not appear in such environments.

(5) The prenasal stressed vowel in English is high or tense/phonetically long, or a diphthong.

English [ˈV:N] SM [VN]

ˈBruno [puː.luː.nwoː]

ˈCon̲an [kʰɤː.n̲an]

ˈEun̲ice [juː.n̲iː.sɻ̩]

ˈLin̲a [liː.n̲aː]

ˈLyn̲us [lai.n̲aː.sɻ̩ː]

ˈMon̲a [mwoː.n̲aː]

ˈNin̲a [liː.n̲aː]

ˈNon̲a [nwoː.n̲aː]

ˈSon̲y [swoː.n̲iː][24]

(6) The prenasal vowel is unstressed and the postnasal vowel is stressed.

English [VˈNV]	SM [V:.NV]
Beˈn̲et	[pei.n̲ei.tʰɤː]
Boˈn̲ita	[pʷoː.n̲iː.taː]
Deˈn̲ise	[tiː.n̲iː.sɻ̩ː]
Leoˈn̲ora	[liː.ao.nwoː.laː]
Reˈn̲ei	[lei.n̲iː]

(7) The prenasal vowel in English is a stressed low back [ɑ] in trisyllabic unstressed-stressed-unstressed words.

English [ˈɑNV]	SM [a.NV]
Caˈban̲a	[kʰaː.paː.n̲aː]
Asˈtan̲a	[aː.sɻ̩ː.tʰaː.n̲aː]
Guiˈan̲a	[tɕiː.jaː.n̲aː]

[24] It was adapted as 新力[xin.liː] in Taiwan. In 2009, the company picked 索尼[swoː.n̲iː] for its Chinese name globally.

Guaˈrana [gwa:.na:.na:][25]

In the 1600 proper names of the corpora with a nasal, there are 120 cases in which the intervocalic nasal consonants in English are adapted with nasal insertion in SM loanwords. Within the words with nasal insertion, four non-high, short/lax vowels in English are more likely to trigger nasal insertion in SM loanwords: [æ], [ɔ], [ɛ], and [ʌ] frequently. Among these four vowels, the lower the vowel is the higher the chance that there is insertion in SM loanwords. Some cases show high and long vowels or diphthongs triggering nasal insertion. However, this is very rare, e.g. *brownie* → [pu:lɑn.ni:]. The percentage of unstressed prenasal vowels that cause insertion is also very low (e.g. *Anita* → [an.ni:.ta:], however, some people adapted it as [a:.ni:.ta:] without nasal insertion as well). Table 2.5 shows the actual number counts and the percentage of different types of vowels that trigger nasal insertion and the percentage of insertion that occurs when either the vowel type condition or stress location condition is violated.

Table 2.5 Nasal insertion in SM loanwords with different English vocalic contexts and stress condition

	Non-high, lax				High/Tense		Unstressed
Vowels	æ	ɔ	ɛ	ʌ	ɪ	Tense vowels	Unstressed vowels
Number	58	33	33	11	4	4	3
Percentage	39.72%	22.6%	22.6%	7.53%	2.74%	2.74%	2.05%
Subtotal	92.47% (133/146)				5.48% (8/146)		2.05% (3/146)
Total=146 (100%)							

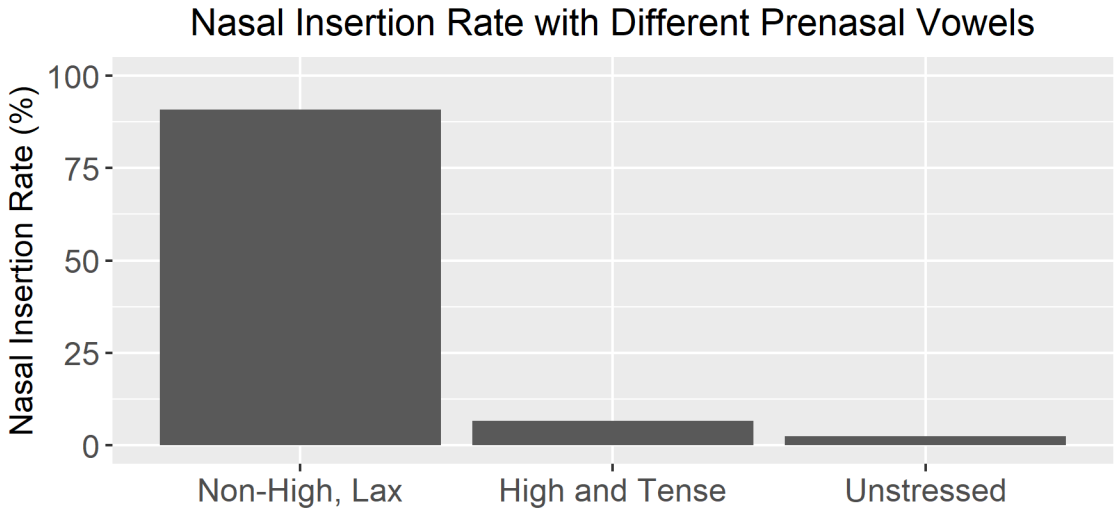
We can see that English vowel quality, such as tenseness and height, and primary word stress are the two main factors that affect whether nasal insertion appears in SM loanwords or not. If we look more closely, we see that among the four non-high lax vowels, [æ, ɔ, ɛ, ʌ], the lower the

[25] English [r] is adapted to [r] or [l] in most cases. However, it is adapted to [n] here. The reason is not clear.

vowel is, the more nasal insertion appears in loanwords in SM. English high vowels and tense vowels rarely trigger nasal insertion in such loanwords.

Figure 2.2 gives a better visual representation of how English vowel quality and stress location affect the nasal insertion rate in loanwords SM. When the prenasal vowel in English is non-high and lax, nasal insertion occurs at a rate of up to 92.47%. When the prenasal vowel is high and tense and does not bear the word stress, nasal insertion occurs at a rate of only 7-8% in total from the two categories.

Figure 2.2 Percentage of nasal insertion in different vocalic and stress contexts



Interestingly, variation in adaptation, which Smith (2006) calls doublets, appears in some examples, and the pattern is systematic. The examples in (8) show that the intervocalic nasal consonant in English is adapted with a nasal singleton or a nasal insertion in loanwords in SM. The dictionary corpus only provides one adaptation form for each word. The variation adaptation forms are verified by Google search, i.e. two types of transliterations can be searched for on Google.

(8) Variation in nasal insertion

English [ənV]	SM [VnnV] ~ [VnV]
Lympany	[lin.bən.niː] ~ [lin.pʰaː.niː]

Melanie	[mei.lan.niː] ~ [mei.lɤː.niː]
Tiffany	[tiː.fən.niː]/[tiː.fan.nei] ~ [tiː.fuː.niː]
Albany	[au.bən.niː] ~ [au.pwoː.niː]
Eleanor	[ai.ljan.nwoː] ~ [ai.liː.nwo]
Anthony	[an.toŋ.niː] ~ [an.sɻ.niː]
Gardiner	[tɕʲaː.tiŋ.naː] ~ [tɕʲaː.tɤː.naː]
Corona	[kʰɤː.lun.naː] ~ [kʰɤː.lɤː.naː]

We can see that in the examples given in (8), the English prenasal vowels are either a [ə] or a reduced vowel [ɪ]. In addition, the prenasal vowel is stressless; it bears neither the primary word stress nor the secondary stress. The examples also showcase that prenasal vowel quality and stress pattern matter to variable adaptation.

This section illustrates the corpus data and identified generalizations. I present that the English intervocalic nasal adaptation in Standard Mandarin is more complicated than onset adaptation. Intervocalic nasal adaptation is not a simple one-segment-to-one-segment mapping process. The corpus data show that the English intervocalic nasal can be adapted with, without, and with/without nasal insertion. The adaptation process is conditioned by the English prenasal vowel quality and the stress location in the word.

To trigger nasal insertion in SM loanwords, the English prenasal vowel has to be non-high, lax, and bear the primary stress. In other words, if the prenasal vowel is tense, is a diphthong, or is phonetically long, nasal insertion does not occur. As for stress location, if the post-nasal vowel bears the primary word stress, which also means the English syllabification is clear, e.g. *Boˈnita*, nasal insertion barely occurs in SM loanwords. For the source words that are adapted with two forms in SM loanwords, vowel quality and stress also seem to play an important role during the

adaptation process since the English prenasal vowel has to be either a [ə] or a reduced vowel [ɪ] and it also has to be stressless.

In the next section, I will propose an analysis that reasons out English intervocalic nasal consonant adaptation in SM loanwords with phonological and phonetic factors.

2.4 Proposed analysis

I propose that the "unnecessary" nasal insertion in SM loanwords is actually necessary to match the audio similarity of perceived English inputs. As the observed patterns in the corpus data, two main conditions trigger nasal insertion:

1. prenasal vowel quality (tenseness)/quantity (duration) and
2. stress location.

To fulfill the vowel type condition, the prenasal vowel in the English source word has to be a non-high lax/short vowel. To fulfill the stress location condition, the prenasal vowel needs to bear the primary word stress so the nasal consonant is ambisyllabic.

By inserting a nasal consonant, the SM output creates a closed syllable so that there is a better match of vowel duration with the short or lax vowel in the English source. Moreover, Solé's (1992, 1995, 2008) and Krakow's (1994) studies on vowel nasalization suggest that non-high vowels in nasal contexts, e.g. CVN in English, exhibit more nasalization than high nasalized vowels; therefore, inserting a nasal coda after a stressed non-high vowel produces a better match in phonetic detail since Mandarin does not have such an allophonic rule, i.e. the prenasal vowel in Mandarin is not phonologically nasalized. Prenasal vowels in Mandarin get nasalized by segment gestural overlap. The degree of overlap depends on the type of the following nasal. Duanmu (1990) argues that the Mandarin prenasal vowel is nasalized with a velar nasal coda. However, it is not nasalized when the nasal is alveolar. If Mandarin had a vowel nasalization rule, the prenasal vowel

should be nasalized with both nasal codas. Zee & Lee's (2001) acoustic study also shows that the ending nasal affects the prenasal vowel variably according to the vowel and nasal type. Their experimental results show that [n] and [ŋ] have an effect on the F1 and F2 values for [ə], [a], and [u] in syllables with the CVN structure, structure, but have a minimal effect on the and F2 values for the high front vowels [i] and [y].

Durvasula & Huang (2013) follow Krakow (1989, 1999) and show that the ambisyllabic nasal consonants pattern with word-medial codas by measuring the nasalization on the prenasal vowel and comparing the vowel nasalization to the single-linked nasal in syllable onset and coda positions. Therefore, I suggest that in the loanword adaptation process, Mandarin speakers perceive the phonetic details of the duration and nasality of the vowel in the English source, and insert an extra nasal consonant to better approximate the phonetic details.

However, as the examples in (5), (6), and (7) show, nasal insertion does not apply when the English prenasal vowel is either a tense vowel or a diphthong and when the vowel is the phonetically longest low back vowel, [ɑ] (House 1961; Umeda 1975) in trisyllabic words. One possibility is that these vowels may have already mapped the required SM syllable duration (Duanmu 2000/2007); therefore, the adaptation process does not undergo the insertion process. Another possible explanation can be based on vowel quality mapping from English to Mandarin. The peripheral vowels, [i], [u], and [a] are all faithfully adapted because they are auditorily dispersed maximally in the vowel space (Flemming, 2002/2013). Y. H. Lin (2008) also argues that the peripheral vowel is perceived with less confusion than mid vowels, and hence, having less deviation in loan forms is reasonable. In the current adaptation process, if the vowel is faithfully adapted as tense, in the CGVX structure, the X slot is also occupied by the tense vowel. Since the

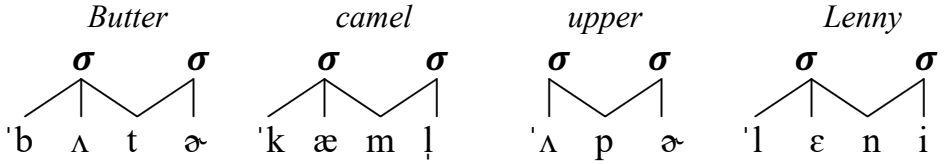
X slot is occupied, there is no other slot for the inserted nasal, i.e. Mandarin does not allow CGVVN syllable structure.

To fulfill the stress location condition, the prenasal vowel must bear the primary stress. Stressed syllables in English have longer durations than stressless ones. However, in SM, with the exception of neutral toned syllables, every syllable is roughly the same in syllable duration and syllable weight (Duanmu 2000/2007). Therefore, inserting a nasal coda helps preserve the longer perceived duration from the stressed syllables in English and preserve the syllable weight in SM by compensating for a lax vowel in English stressed syllables (cf. the analysis of consonant gemination in Cantonese by Yip (1993) mentioned in §2.2.3).

Since the corpus data were created by proficient bilingual dictionary editors and translators, we can assume that those Mandarin speakers have access to English phonological knowledge (c.f. Paradis & Lacharité, 1997). Therefore, I suggest that the insertion process can also be explained from the perspective of ambisyllabicity, which is a puzzling form of syllabification in English. This is different from what we see in many other languages where intuitions on how to divide syllables are clearer.

In the present case, the intervocalic nasal consonants are considered ambisyllabic in English because the nasal consonant leads to heavy vowel nasalization of its preceding vowel due to feature spreading. Gussenhoven (1986), Hayes (1995, 2009), and Kahn (1976) argue that ambisyllabic consonants are dominated by more than one syllable. In other words, an ambisyllabic consonant is dominated by two σ (see Figure 2.3).

Figure 2.3 Ambisyllabic consonants are dominated by more than one syllable



(Hayes, 2009, p. 1)

This representation would account for the ambiguous intuitions speakers have concerning the syllabification of such words. Based on the examples with representations, we can see that the stress falls on the syllable before the intervocalic consonant. According to Kahn and Hayes, the intervocalic consonants in the following examples are considered ambisyllabic. By looking at the examples in (9), we can see that the vowel before the ambisyllabic consonant can be either tense or lax. Kahn further observed that the allophonic tap [ɾ] of the aspirated oral stops is related to ambisyllabicity.

(9) Ambisyllabic consonants

a. [n] in pony [ˈponi] (tense)

b. [n] in Lenny [ˈlɛni] (lax)

c. [p] in happy [ˈhæpi] (lax)

d. [t] in later [ˈleitʰɚ] → [ˈleɾɚ] (tap)

Giegerich (1992) asserts that ambisyllabicity occurs if the intervocalic consonant is a permissible onset and it is immediately followed by a lax vowel. According to the Weight-Stress Principle, stressed syllables must be heavy. Duanmu (2010), therefore, suggests that in V_1CV_2C, when V_1 is a lax vowel and bears the primary stress, the C is linked to the V_1 as a syllable coda.[26] Fallows (1981) uses her experimental results to argue that vowels before ambisyllabic consonants

[26] This analysis violates the Maximal Onset Principle, which requires the intervocalic consonant to be linked to the onset of V_2.

are lax. In her experiment, the participants repeated the first syllable of disyllabic words. The results show a strong tendency that the first syllable takes the intervocalic consonants when the preconsonantal vowel is stressed and a lax vowel.

According to the patterns found in the corpus data, I adopt the proposals that the ambisyllabic consonant is doubly-linked to two syllables and the preconsonantal vowels must be stressed and lax.

In the current case, when the ambisyllabic consonant is a nasal, syllabification seems to be affected by the degree of vowel nasalization and the quality and the vowel duration on the prenasal vowel (cf. Hayes (2009) vs. Durvasula, Huang, and Merrill (2013), Duanmu (2010), Fallows (1981), and Giegerich (1992)).

The primary stress location decides whether the intervocalic nasal is ambisyllabic or not as well. Hayes argues that the division of English syllables is not always unclear, but rather, when a stressed vowel follows a consonant, syllabification is clear. The double-linked ambisyllabic nasal analysis and the subset prenasal lax vowel condition along with Hayes' analysis on clear syllable division can account for nasal insertion in SM loanwords. The derivation in Figure 2.4 illustrates how an intervocalic nasal is adapted with nasal insertion in a SM loanword. In Figure 2.5, the English intervocalic nasal consonant does not get adapted with an extra nasal in the SM loanword when it is followed by a stressed vowel.

Figure 2.4 The intervocalic nasal is considered ambisyllabic

Lenny [ˈlɛni] in English → lán.ní [lan.niː] in Mandarin

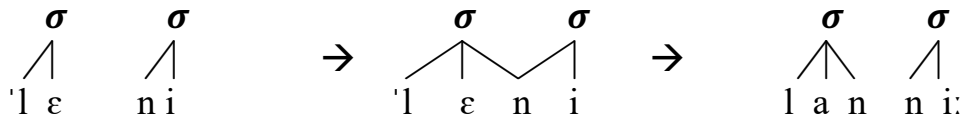
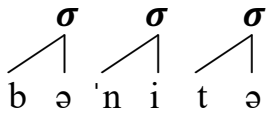
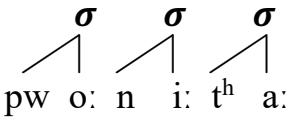


Figure 2.5 The intervocalic nasal is not considered ambisyllabic

Bonita [bəˈni.tə] in English



bō.ní.tǎ [pwoː.niː.tʰaː] in Mandarin



In Figure 2.4, we can see the derivation of the ambisyllabic structure in English and how the word *Lenny* is adapted into Mandarin. The [n] is double linked because English does not allow open syllables with a lax vowel, while the nasal feature is heavily spread to the prenasal vowel. These factors lead to nasal insertion in the loanword output in Mandarin. Figure 2.5 shows the nasal is not an ambisyllabic nasal because it is clearly syllabified to the onset of the syllable, while the stress falls on the postnasal vowel. The clear syllabification of the intervocalic nasal leads to no nasal insertion in Mandarin.

As for the variable adaptation (see (8)), I also attribute the variation to the vowel quality of the prenasal vowel in English. Variation in nasal insertion appears when the English prenasal vowel is a stressless schwa or a stressless reduced vowel [ɪ] in the middle of trisyllabic stressed-unstressed-unstressed English words. The fact that the stressless schwa or reduced vowel often triggers variation in nasal insertion can probably be accounted for by phonetic and phonological factors as well. The schwa is the least specified vowel phonologically, and is phonetically the shortest and most variable vowel in English. This is likely to make a [Cə] syllable a good candidate for duration compensation through the nasal insertion process; on the other hand, an unstressed syllable may not be prominent enough to make it necessary for nasal insertion in SM loanwords. The indeterminacy can then lead to adaptation variability.

This proposed analysis attributes the indeterminacy of nasal insertion in the outputs to different perceptual inputs.[27] This idea is based on the likelihood that Mandarin speakers are confused with the prenasal [ə] at the Perceptual Level (Silverman, 1992) since it is the phonetically shortest and the most variable vowel in English. Take the English word *Melanie* [ˈmɛːləniː] as an example. If [ə] is perceived as short, nasal insertion is then necessary to form a closed syllable and maintain the bimoraic syllable weight in SM and to have a better vowel duration match in SM loanwords; hence the adaptation form will be [mei.lan.niː]. On the other hand, if [ə] is perceived as [ɤː] in an open syllable, it forms a heavy syllable in the adaptation form [mei.lɤː.niː], so nasal insertion is not necessary. This is because if nasal insertion still appears, the loan form will be *[mei.lɤːn.ːni], in which the second syllable is a super heavy syllable and violates the SM phonotactic constraints.

2.5 Patterns found in another corpus

Besides the current corpus data and generalizations, Shih's (2013, 2019) SM loanword studies with a different corpus also suggest very similar data generalizations. His corpus is with proper nouns as well. All the words were collected from udn.com and chinatimes.com, two news websites from Taiwan. Among those English words, there are 233 cases with segment sequence of vowel-nasal-vowel. He observed that among the three English intervocalic nasals, /n/ gets more nasal insertion than /m/, and /ŋ/ barely gets nasal insertion in SM loanwords. Another observation of his corpus data is that in a sequence of V_1NV_2, nasal insertion appears in SM loanwords when V_1 is a lax vowel. Lastly, his data also show that stress location matters in the nasal insertion process. Nasal insertion occurs more frequent when V_1 bears the primary word stress. The difference in his

[27] Informally, one native speaker of SM at the 2014 Mid-Continental Phonetics and Phonology Conference informed me that she would only use the output form with nasal insertion. Another Mandarin speaker would use the one without nasal epenthesis. The author of this dissertation can use either form variably. This suggests that the indeterminacy or confusion in this case. The process of variable adaptation is tested with perception experiments in this dissertation.

2019 study is that the nasal insertion percentage is lower than that of the current study (56.33% vs. 92.47%). He also does not show variable adaptation patterns of intervocalic nasals.

The corpora used in this dissertation and Shih's are generated from different sources, United Daily News and China Times; however, very similar generalizations are identified on how English intervocalic nasals are adapted into SM loanwords. This suggests that the findings and the observed patterns of the current study are valid and the loan forms are still highly conventionalized.

2.6 Conclusion and discussion

In this chapter, I have presented that consonant adaptation in Standard Mandarin loanwords is not always a simple segment-to-segment matching process. Rather, as examined in this chapter, the adaptation can be conditioned by phonetic and phonological factors related to the source language and the recipient language and to how the borrowers may have constructed the input for the final phase of the adaptation process.

Specifically, I have shown that prenasal vowel types and stress location in English are the two main conditions that determine whether nasal insertion and variable adaptation apply in SM loanwords. I also suggested how the perceived inputs are represented in the adaptation process. In addition, the generalizations identified in the current corpora are also identified in other corpora. This further supports that my findings are accurate.

Miao (2005) shows that foreign nasals from Italian, German, and English are substituted by their corresponding nasals in Mandarin, i.e. /m, n, ŋ/. When deviations occur, the only feature likely to show variability is place. Changeability is found in coda positions due to SM phonotactic constraints and other sociolinguistic and sociocultural factors. Hsieh, Kenstowicz and Mou (2009) further claim that the adaptation of nasals changes the place of articulation based on the perception of the backness or F2 of the prenasal English non-high vowels. Their observations are in

conformity to Y.-H. Lin's (2008) claim that matching the backness of the input and output vowels is crucial in the vowel adaptation process. The current study not only confirms SM's nasal adaptation patterns in the previous studies but also identifies an additional pattern in which intervocalic nasals in English can be adapted with one and two nasals in SM loanwords depending on contextual factors, such as the prenasal vowel type and stress location in the donor language.

The so-called unnecessary nasal insertion is not random. I argue that it is actually necessary to make the input and output sound more similar in SM loanwords. Such repair can also be attributed to phonological and phonetic reasons. Phonologically, the English intervocalic nasal consonant between a stressed and an unstressed syllable can be analyzed as an ambisyllabic consonant since the prenasal vowel is nasalized. If this approach is adopted, one can suggest that Mandarin-English bilingual speakers possess phonological input representation of English ambisyllabicity in a doubly linked structure (cf. LaCharité & Paradis (2005) on phonological input in loanword adaptation), and hence adapt such a doubly-linked nasal with two nasals linked to two syllables in SM loanwords through nasal insertion.

If, on the other hand, SM speakers, especially those with low English proficiency, rely on the perception of the duration and nasality on the prenasal vowel, forming a closed syllable in the output through nasal insertion better matches the duration and nasality of the lax/short prenasal vowel.

The analysis presented in §2.4 is mainly based on the perceptual account, although it is conceivable to have a phonology-based analysis. My proposal requires crucial assumptions on what the perceived inputs are. I assume that at the Perceptual Level, those SM speakers who are not fluent bilinguals perceive and retain the phonetic details, such as the duration and nasalization of the prenasal vowel in English. Native SM phonology then comes in to modify the relevant

syllable to a grammatical one when necessary. By adopting Silverman's model to analyze the current data, I am able to take both phonology and phonetics into account.

Variable adaptation forms can also be attributed to the perceived input. Other than the anecdotal information mentioned in footnote 27, which confirms that both inputs with long vowel duration and short vowel duration for an English reduced vowel are possible, it was also brought to my attention that for some SM speakers the word *Cabana* analyzed in (7) can possibly be adapted as either [ka:.ba:.na:] or [ka:.ban.na:] depending on what the English prenasal low vowel input is, since in American English, for words like *Rihanna*, *Cabana*, and *Astana*, the prenasal vowel can be pronounced as either [æ] or [ɑ].[28]

This production difference may have influenced SM speakers' perception, leading to potential variable loanword forms in SM, e.g. *Rihanna* → [lei.ha:.na:] ~ [lei.an.na:]. The variation is predictable based on the proposed analysis since nasal insertion depends on what the perceived prenasal vowel is based on English vowel production.

Another issue concerns the origin of the source words is English. For example, the words, such as *Cabana* and *Astana*, are not originally English words. It is hard to tell whether SM speakers borrowed them from English or from the original source languages; however, it does not matter where the words come from since our analysis predicts that the perceived input varies according to what the source vowel is. I therefore further maintain that the construction of perceived inputs is crucial in understanding loanword adaptation since they affect what the actual outputs are.

Furthermore, people may argue that nasal insertion can simply be due to source language orthography or spelling. The examples given in §2.3.3 show that when the input is spelled with a nasal singleton, the Mandarin loanword output appears with two nasals. Therefore, I argue that

[28] Thanks to Moria Yip (personal communication (2014)) for pointing this out.

orthography and spelling may matter in intervocalic nasal adaptation, however, not majorly. Variable adaptation cases also show that English spelling does not play a crucial role in the adaptation process since all the examples with variable adaptation are spelled with only one nasal in English.

English intervocalic singleton consonants may be adapted as geminate consonants in loanwords systems such as Japanese (Kubozono et al., 2008), Finnish (Karvonen, 2005), and American Italian (Repetti, 2009, 2012), in which stress and vowel types also appear to be relevant. In terms of the implication for the broader context, the fact that similar patterns occur cross-linguistically suggests a common basis that underlies consonant insertion/gemination in loanword adaptation. This is even true in SM, which has no consonant gemination in its phonological system.

In this chapter, I have demonstrated that nasal insertion in SM loanwords is conditioned by vowel types and stress location and proposed that nasal insertion is principally motivated to improve the perceived similarity between the English input and the SM loanword output in terms of vowel duration and nasality. Based on my observation of the current corpus data, I conclude that this unnecessary repair is necessary due to the interaction between perception and syllable structure constraints of Mandarin. Depending on who the adapters are, English phonology may also play a role. Assuming the adaptors are proficient bilingual speakers of Mandarin and English, they have access to both English and Mandarin phonological knowledge. However, we need to note that the ambisyllabic nasal is considered ambisyllabic mainly because the nasal is heavily spread to its prenasal vowel, so the prenasal vowel bears strong nasal acoustic cues. The unexpected and variable cases for English [ɑ] and reduced vowels are hypothesized to have different perceived inputs constructed by SM speakers. In the next chapter, I will show experimental results that verify my proposed analysis in this chapter.

Chapter 3 Perceptual Experiment I: Intervocalic [n]

3.1 Introduction

In the previous chapter, I presented how English intervocalic nasals are adapted into Mandarin loanwords in my corpus data. It appears that to trigger nasal insertion in Mandarin loanwords, prenasal vowel quality and the primary word stress location play crucial roles. Based on the generalizations, I proposed an analysis with possible phonological and phonetic explanations, which explain why a nasal singleton can be adapted as a singleton and with nasal insertion in different phonological environments.

My major claims are:

1. The adapted loanwords are constrained by perceptual or phonetic similarity of the foreign input and the Mandarin loanword output. Perceptual similarity limits the number of possible Mandarin outputs, with and without nasal insertion. The adaptors create loanwords that share adequate similarity with the donor language.
2. Beside input-output perceptual similarity, the SM output should be constrained by the native phonology as well. After the perceptual similarity stage, the adaptors adjust the perceived phonetic cues and make them fit into SM native phonology.

To examine the validity of the proposed analysis about the role of perceptual similarity and the role of SM speakers' native phonology, perceptual similarity experiments were conducted and were run on two groups of participants with different language backgrounds: Mandarin monolingual and Mandarin-English bilingual speakers.

The main goals are:

1. to investigate whether online perception of solicited loanwords conform to the generalization identified in my corpus data, and
2. to explore whether or not SM speakers with different levels of English exposure or proficiency behave differently.

To minimize the interference of semantic factors and to maximize the perceptual similarity between the input and the output, the participants in both groups were told to ignore the meaning of the Chinese characters but to pay close attention to phonetic cues (sounds). Test items and filler items were pseudowords and were presented orally to participants as *new English proper nouns*, e.g. names of new cities or places. The experimental design and restrictions on phonological environments were based on the identified generalizations and findings in the corpora presented in Chapter 2, i.e. nasal insertion in Mandarin loanwords is conditioned by English prenasal vowel quality and the primary word stress location. Nasal insertion is anticipated to appear very frequently when the pseudo word's prenasal vowel is lax, non-high, and bears the primary word stress.

In this chapter, I present the experimental design, procedures, and results. I also revisit the proposed analysis for intervocalic nasal adaptation in Chapter 2. The organization of this chapter is as follows. In §3.2, I present the methodology of the experiments, including the background and language backgrounds of the participants, and predictions and hypotheses. In §3.3, I present the experimental procedures. Results generated from the monolingual and bilingual participants are presented in §3.4. General discussion is given in §3.5. It shows that the experimental results in general pattern with the generalizations observed in the corpora, though minor discrepancy appears. I draw a conclusion in §3.6.

3.2 Methodology

In order to test whether the observed loanword patterns in Chapter 2 mirror the Mandarin monolingual and Mandarin-English bilingual online adaptation patterns, a force choice perceptual similarity ABX task was conducted. The experimental design was different from traditional ABX tasks because neither A nor B was identical to the pseudo-English input X. The two possible Mandarin outputs A and B were created for adaptation of X. After the participants listened to a sound string of ABX or BAX, they decided which one of A and B was more perceptually similar to X and then made a choice between them. The same experiment was run on two groups of participants with different language backgrounds: monolingual Mandarin speakers and Mandarin-English bilingual speakers.

3.2.1 Participants

The experiment was run on two groups with different language backgrounds. In the following, I present the group size and participants' language backgrounds.

Mandarin monolingual group. 33 adult Mandarin monolingual undergraduate students volunteered to participate in the experiment. Their ages fell between 18 and 21 years old. They studied at National Chengchi University majoring in different subjects. None of them majored in English or linguistics. They were native Mandarin speakers born in Taiwan with normal hearing capacity. At the time of the experiment, they had no study abroad and/or living experience in any English-speaking country. Although Southern Min dialects are widely spoken in Taiwan, these participants these participants solely spoke Mandarin. Based on their self-reports, their families did not speak any dialect as well. Their English proficiency was assessed by self-reporting before the experiment and by an American native English speaker after the experiment.

To evaluate participants' English proficiency, the American English speaker had a short greeting conversation with the participants and asked them to read 6-8 pages of a story—*The Cat in the Hat*. The story was chosen to check whether the participants could differentiate between lax and tense vowels in English and whether they produce coda consonants in English. According to the English speaker's judgement, the participants could not differentiate between English lax and tense vowels well, especially in the casual conversation. They did better and paid attention to those vowels when they read the story aloud. After the interview, they received 300 NTD (roughly 10 USD) for participating in the study.

Mandarin-English bilingual group. 24 adult Mandarin-English bilingual undergraduate and graduate students majoring in different subjects volunteered to participate the experiment. Their ages ranged from 21 and 33 years old. At the time of the experiment, they were either studying or teaching at Michigan State University or had a corporate job in Michigan. They were native Mandarin speakers born in Mainland China with normal hearing ability.[29] They do not speak or use any Chinese dialect at home besides Mandarin. At the time of the experiment, they had lived and studied or worked in the U.S. for more than 3 years. They had to use English as their dominant language for the classes they were taking or teaching and also at work. Their English proficiency was assessed by a self-reported TOEFL score. Their TOEFL scores were all higher than 100 (the global average score is 78). The maximum possible mark for the TOEFL exam is 120. After the experiment, they received 15 USD for their participation.

The bilingual group did not have to read the story aloud to an English speaker because the TOEFL exam has speaking parts and was assessed by professionals.

[29] I did not recruit people from Taiwan because its population base is very small at MSU.

3.2.2 Prediction and hypotheses

Predictions. Based on the patterns identified in the nasal insertion corpus data, specific predictions of the experimental results are stated below.

With regards to the English intervocalic nasal adaptations, the experimental results would show the same or at least similar patterns to those observed in the corpus data, i.e. nasal insertion in Mandarin loanwords depends on the prenasal vowel quality and stress location in English. Nasal insertion would appear in loanwords in Mandarin when the prenasal vowel from the English input is lax and phonetically short, and it also has to bear the primary word stress, e.g. *ˈLenny*. In short, nasal insertion appears in such loanwords by fulfilling both the vowel type and stress location conditions.

On the contrary, if the prenasal vowel from the English input is tense, phonetically long, or a diphthong, the intervocalic nasal would be faithfully adapted. That means nasal insertion would rarely occur in loanwords in Mandarin, e.g. *ˈLina*. Although the word *ˈLina* obeys the stress location condition, it violates the vowel type condition. Nasal insertion rates would also be low when the syllabification in English is clear, i.e. when the main stress is on the post-nasal vowel, e.g. *Bo ˈnita*. The word *Bo ˈnita* violates the stress location condition.

Variable adaptation would occur when the prenasal vowel is a [ə] or a reduced vowel [ɪ], e.g. *Tiffany*. More examples of each condition can be found in §2.3.3.

Major hypotheses. Based on the generalizations and the proposed analyses in Chapter 2, I hypothesized that:

1. Nasal insertion would appear significantly more when the input prenasal vowels are nonhigh, lax, and/or phonetically short than those are tense and a diphthong or phonetically long.
2. When the English nasal is ambisyllabic, nasal insertion appears significantly more often than the nasal consonant with clear syllabification.
3. The unnecessary repair is phonetically driven. Ungrammatical syllable structure repair is not involved. Since it is phonetically driven, the experimental results of monolingual and bilingual speakers should be similar.

3.2.3 Materials: test items, possible outputs, and filler items

In this subsection, I will present the test items, the two possible Mandarin outputs, the filler items, the methods and equipment of which I created them for the task.

The English inputs were read out carefully and recorded by one female American native English speaker, from Illinois with training in linguistics. The possible Mandarin loanword outputs were produced and recorded by one single female Mandarin native speaker from Taiwan who only speaks Taiwan Mandarin as her native language and also has linguistics training. The stimuli were tokens in a three-word series. Each sound string consists of two possible adapted loanword forms in Mandarin and a pseudoword. The order of the words is {Mandarin Output A, Mandarin Output B, English Input X} and { Mandarin Output B, Mandarin Output A, English Input X }.

The devices used for recordings were a Blue Yeti USB microphone and a MacBook Air. The Blue Yeti microphone was on its cardio mode that only recorded sound sources directly in front of the microphone. The recording sample rates were 16 bit/48 kHz. The application used for the recordings was Praat (Boersma & Weenink, 2020). All the test items and filler items were recorded

in the phonology-phonetics laboratory, which belongs to the Linguistics Department at Michigan State University.

3.2.3.1 Test items

The test items were designed by following the patterns observed in the existing corpus. The corpus data show that nasal insertion strongly correlates to the prenasal vowel quality in English. Therefore, all the English tense and lax vowels that occupy the prenasal vowel position were tested. The corpus data also show that stress location affects the appearance of nasal insertion as well. Hence, pseudowords in which the primary word stress falls on the prenasal and postnasal vowel were tested as inputs. Test items for variable adaptations were all with a prenasal vowel [ə] in trisyllabic words and with the primary stress on the initial syllable. Another set of test items contrasting the prenasal vowel [æ] and the low back [ɑ] was tested as well. A full list of paired-up input and output can be found in the appendix (Table A.2).

In the current experiment, I only used the alveolar nasal [n] as the target because when compared to [m] and [ŋ], the intervocalic English [n] is adapted with nasal insertion most frequently with 83.19%. The inserted nasal is either identical to the source form or transformed to [ŋ] to agree on backness with its preceding vowel (cf. Hsieh et al., 2009).

3.2.3.2 Possible outputs

Following H. I. Wu (2006), C. Wu's (2006), and Wang's (2010) studies on tonal adaptation in loanwords in Mandarin, the primary stressed syllable is more likely to be adapted with the high level tone, tone 1, in Mandarin because high tones have similar features to stress in pitch.[30] Hence,

[30] Both C. Wu (2006) and H. I. Wu (2006) found that the stressed syllable in English most likely to be adapted with tone 1 in Mandarin. However, C. Wu (2006) observes that the high level tone/tone1 and the high falling tone/tone 4 are preferred for English stressed syllable adaptation. H. I. Wu (2006), on the contrary, observes that the high level/tone 1 tone and the rising tone/tone 2 are preferred, and that the high falling tone/tone 4 is the least preferred tone for stressed syllable mapping.

the syllable with the primary word stress in the input was assigned tone 1 in the given outputs. The tone patterns of the consecutive characters in the possible given outputs were the same if there was no systematic gap on Chinese characters, i.e. no character is assigned with the tone in Mandarin, e.g. English [ˈbɛnɪd]→Mandarin [pēi.níː.tɤ̌ː], [pān.níː.tɤ̌ː]. Tone 2 is assigned for [ní] in test items with [bVˈnita] structure. This tone assignment follows H. I. Wu's (2006) findings that stressed syllables whose onsets are sonorants or voiced stops tend to be associated with the rising tone, which is tone 2 in SM. In addition, it can be also influenced by the native lexicon, i.e. English syllable [ni] is mostly adapted as [ní] in Mandarin.

3.2.3.3 Filler items

There were two sets of filler items. One set was with a nasal consonant and this set also combined the test items for the vowel epenthesis experiment (see Chapter 5). The other set had 40 items without nasal consonant. The set without nasal consists of monosyllabic and disyllabic words, open syllable and closed syllable words. The primary word stress falls on either the first or the second syllable of the disyllabic words. The structures of the monosyllabic filler items were [p^hV]/[p^hVd], and [spV]/[spVd]. For example, pseudo words like [p^hi]/[p^hid], [spi]/ [spid] were part of the filler items. For the open syllable words, the vowel position was occupied by tense vowels, such as [i, e, u, o], one vowel in each word. Lax vowels were not included because English syllable structure does not allow lax vowel in open syllables. The closed monosyllabic syllable items had all lax and tense vowels in the V position.

There were also disyllabic filler items with stress falling on either the first or the second syllable, e.g. [ˈstidi]/[bəˈt^{h}id]. The filler items with the primary stress on the first syllable had a [ˈstVdi] structure, whereas when the primary word stress fell on the second syllable, the structure

appeared as [bəˈtʰVd]. All the lax and tense English vowels, one vowel each word, occupied the V position.

One of the two given outputs of the filler items was created by following Paradis & Tremblay's (2009) study, which suggests that the non-distinctive features of consonants are not important for Mandarin speakers. Hence, the stop consonants, /C/, and their allophones [C^h] mapped to /C^h/ in Mandarin. The other possible output counted against Paradis and Tremblay's claim. Hence, Mandarin speakers should be sensitive to allophonic features and adapt allophones in different ways, e.g. [t^h] → Mandarin [t^h]; [t] → Mandarin [t], instead of both [t^h] and [t] → [t^h]. A full list of paired-up input and output filler items can be found in the appendix (Table A.4).

In the following section, I will present the procedures of the experiment and introduce how the instructions were prompted to the participants, the software and the devices used for the experiment.

3.3 Procedures

3.3.1 The Monolingual group

The participants were tested in the Phonetics and Psycholinguistics Lab under the Graduate Institute of Linguistics at National Chengchi University in Taipei, Taiwan. The experiment was run on 3 participants simultaneously.

The current perceptual similarity experiment is quite similar to an ABX task. The difference is that in a traditional ABX task, A or B has to be identical to X. However, in the current experiment, neither A nor B is identical to X. The participants had to pick the output that was the most perceptually similar to the English input from A and B. Because this experiment is purely perceptual, Chinese characters and English spelling were not shown to the participants. They only

saw the option labels A and B on the screen, and they used the left arrow key to choose A and the right arrow key to choose B.

Before the experiment, there was a practice session. The participants were given instructions orally in Mandarin. All the participants were told at the beginning of the experiment that the experiment is about how they would borrow new words from English to Mandarin via listening. They were told that the words they would encounter later during the experiment would be newly created American place names. Besides the oral instructions, the participant also read a brief instruction on PsychoPy (Peirce, 2007) on the screen. The practice session had 10 trials distinct from the stimuli used in the experiment for analyses later, e.g. Mandarin [k^hən], [k^hən.t^hɤ˧], English Kent [k^hɛnt^h]. The words in the practice session included some low frequency English words, e.g. *leep*, *gad*, *molty*, and common English names, e.g. *Charlene*, *Kent*, *Derick* so the participants were trained for and practiced on what they needed to do. All the sound strings were embedded in PsychoPy and presented through a headset. The stimuli were presented through a headset from *AKG*, model number *K271 MK. II*. The interval between each word was 500ms. The practice session made sure the participants clearly knew what they would have to do later during the experiment. When they finished, they clicked on the spacebar to proceed to the real experiment. The trial items can be found in the appendix (Table A.1).

The instructions for the real experiment were provided in Mandarin visually on PsychoPy, and the stimuli embedded in PsychoPy (Peirce, 2007) were presented through the same headset. The participants made their judgements between the two possible Mandarin outputs via the left and right arrow keys on a keyboard. PsychoPy and the experiments needed were installed in a Windows system on a computer.

There were 270 three-word series items in the real experiment with ABX and BAX word order. There was a 10-second optional break after every 50 items, with 5 optional breaks in total. The task was about 35 min long. For each three-worded series, the participants heard the two Mandarin outputs first followed by its English input. The interval between each word was 500ms, the same as in the practice session. Then, on the screen, the participants were prompted to judge whether the given Mandarin output A or B sounded more similar to the foreign input in Mandarin. Clarifications were provided whenever requested. No one asked for extra help.

3.3.2 The bilingual group.

The participants were tested in the language computer lab at Michigan State University. The experiment was run on 1-4 participants simultaneously. The stimuli were presented through a headset. The procedure was the same as that of the monolingual group (see §3.3.1). The differences were only in the devices. The language lab at Michigan State University was equipped with Macintosh computers. The headsets in use were *Plantronic*, model number *.Audio^{TM} 355 STEREO HEADSET*.

3.4 Results

As presented in Chapter 2, the corpus data show that nasal insertion has strong correlations with English prenasal vowel quality and word stress location. English prenasal stressed lax vowels trigger significantly more nasal insertion than prenasal stressed tense vowels and diphthongs in loanwords in Mandarin. When postnasal vowels bear the stress, which also means that the intervocalic nasal is clearly syllabified to the next syllable, nasal insertion rarely occurs. Variable adaptation and the low back [ɑ] cases are also related to the prenasal vowel quality. Hence, with regard to the intervocalic nasal adaptation, the hypothesis was that the appearance of the inserted nasal in Mandarin loanword is due to speakers' perception of the prenasal vowel quality and how

they syllabify words, i.e. depending on the location of the primary word stress. The so-called unnecessary repair is in fact necessary.

This section presents the perceptual similarity experimental results. The results were collected from monolingual Mandarin and bilingual Mandarin-English speakers. Vowel type and stress location conditions that trigger and prevent nasal insertion in Mandarin were analyzed accordingly.

All the collected data were valid, and all the calculation of percentages and data analyses with different phonological conditions were completed with a combination of ANOVA and pairwise t-tests in the statistical software R (R Development Core Team, 2015).

3.4.1 Vowel type condition

Table 3.1 shows the percentages of nasal insertion preference of the monolingual Mandarin and bilingual groups when different types of prenasal vowels appear in English. We see that both groups performed very similarly. In other words, regardless of the participants' language backgrounds, the tenseness of English prenasal vowels affects the presence of nasal insertion in Mandarin loanwords.

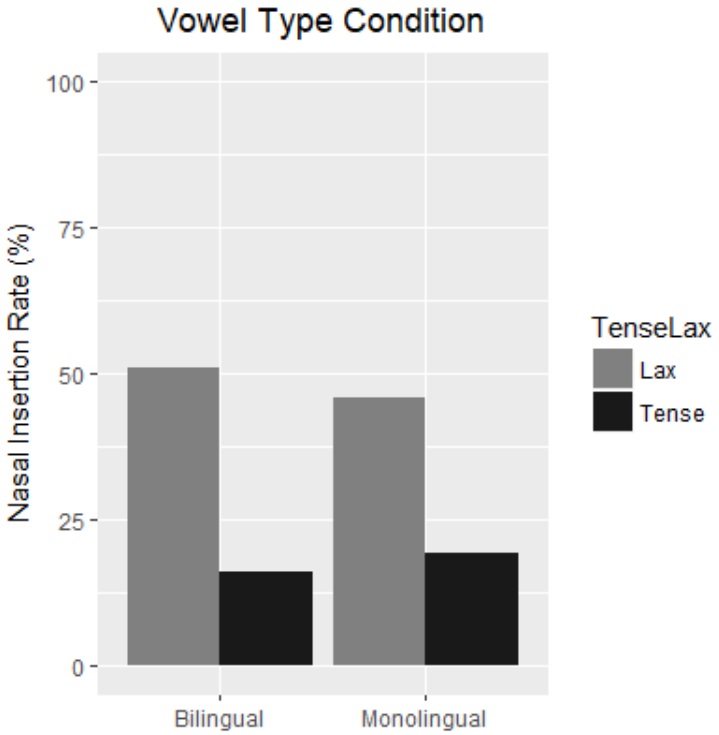
Table 3.1 The comparison, based on the prenasal vowel quality, of nasal insertion rate of the corpus data and the experimental results

Vowel type	Corpus data	Experimental results
Lax vowels	92.47%	Monolinguals:45.8%
		Bilinguals: 50.8%
Tense vowels	5.48%	Monolinguals: 19.3%
		Bilinguals: 16.1%

I compared the nasal insertion preference of the bilinguals and the monolinguals. Following my prediction based on the corpus data generalizations, t-tests of the vowel type condition reveal that the preference for nasal insertion is significantly higher in both monolingual [$t(32)=7.782$, $p<0.001$] and bilingual [$t(23)=7.582$, $p<0.001$] groups when the prenasal vowel is lax in English, although the percentage of lax vowel triggering nasal insertion in the corpus data is significantly

higher (cf. Figure 2.2). It can be still claimed that English prenasal vowel quality decides the presence of nasal insertion in Mandarin loanwords.

Figure 3.1 Nasal insertion preference of monolingual Mandarin speakers with English pre-nasal vowels lax and tense



In Figure 3.1, the two-way ANOVA analyses show that there is no significant interaction effect on nasal insertion rate ($F(1,55)=0.044$, $p=0.129$) between bilingualism and the prenasal vowel type. For the main effect, there is no significant difference between bilingual and monolingual speakers on nasal insertion rate ($F(1,55)=0.003$, $p=0.711$). However, there is a significant effect for prenasal vowel tenseness on nasal insertion rate ($F(1,55)=2.820$, $p<0.001$). We can see that both groups show nasal insertion rates that are significantly higher when the prenasal vowel is lax.

3.4.2 Stress location condition

For stress location conditions, according to the corpus data, nasal insertion appears in Mandarin loanwords when the prenasal vowel bears the primary word stress. On the other hand, when the

primary word stress falls on the postnasal vowel, which also means the syllabification is clear, nasal insertion rarely shows up. For example, the intervocalic nasal in *Denise* [dəˈniz] is adapted as [tiː.niː.sɻ], with one nasal in Mandarin. However, *Dennis* is adapted as [tan.niː.sɻ] with an extra nasal.

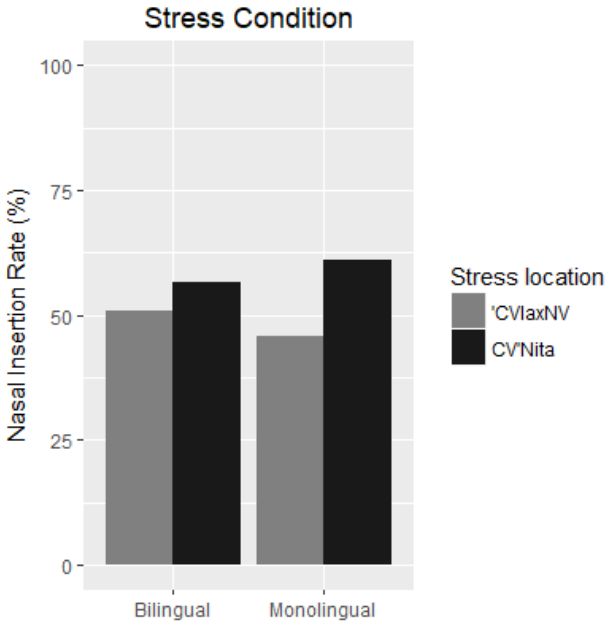
Figure 3.2 and Figure 3.3 show how monolingual Mandarin and bilingual Mandarin-English speakers adapt the intervocalic [n] with English word stress falling on prenasal and postnasal vowels.

Since we already knew from the results of vowel type condition from §3.4.1 that English prenasal tense vowels and diphthongs do not trigger nasal insertion in Mandarin as frequently as lax vowels and from the corpus data that when the stress falls on the postnasal vowel with a clear syllabification, nasal insertion rarely shows up in Mandarin loanwords, only ˈCV_{lax}NV and CVˈNita items were analyzed, and not ˈCV_{tense}NV and CVˈNita. That said, there is no need to compare ˈCV_{tense}NV and CV'Nita; the results would be similar because both conditions would not trigger much nasal insertion in the responses.

The two-way ANOVA analysis shows that there is no significant interaction between bilingualism and stress location in English inputs ($F(1,55)=2.787$, $p=0.101$). For the main effect, there is no significant difference between bilingual and monolingual speakers on nasal insertion rate ($F(1,55)=0.030$, $p=0.863$). However, there is a significant effect for stress location on nasal insertion rate ($F(1,55)=14.135$, $p<0.001$). Figure 3.2 shows that both groups have higher nasal insertion rates when the primary word stress falls on the postnasal vowel and a stronger tendency is shown in the monolingual group. We need to be aware that the results are opposites to the stress location condition in the corpus data. That is, I predicted CVˈNita would have a low nasal insertion rate since the syllabification is clear. However, the experimental results show that CVˈNita

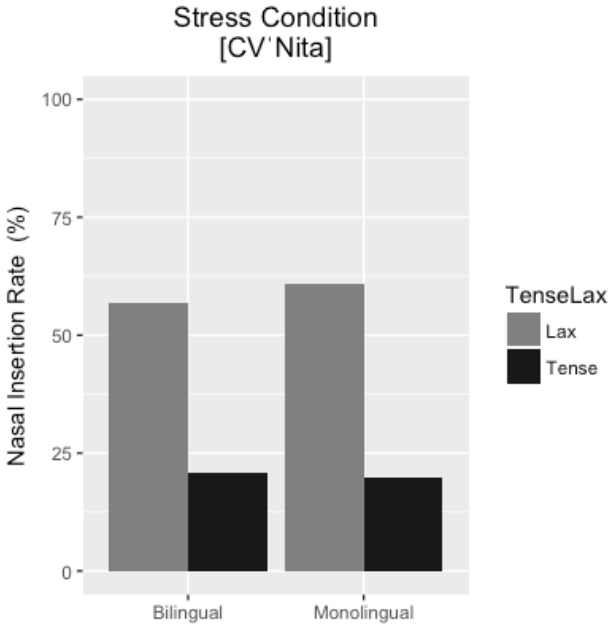
structure, which has a clearer syllabification in English, has a higher nasal insertion in both groups, and this tendency is stronger among the monolingual speakers. The results also indicate that the CV'Nita structure significantly triggers more nasal insertion in Mandarin than 'CV$_{tense}$NV.

Figure 3.2 The comparison of words with 'CV$_{lax}$NV and CV'nita structure. The primary word stress falls on either the prenasal vowel or the postnasal vowel



I also compared CV$_{lax}$'Nita and CV$_{tense}$'Nita to see whether vowel tenses would affect nasal insertion rate when the stress is on the postnasal vowel. Figure 3.3 shows that preference for nasal insertion is significantly higher when the prenasal vowel is lax in both groups ($F(1,55)=4.124$, $p<0.001$) and there is no significant interaction between bilingualism and the tenseness of English prenasal vowel ($F(1,55)=0.020$, $p=0.266$). Bilingual and monolingual groups do not show significant difference ($F(1,55)=0.006$, $p=0.563$) in nasal insertion. In other words, nasal insertion is preferred in both groups when the prenasal vowel is lax in English.

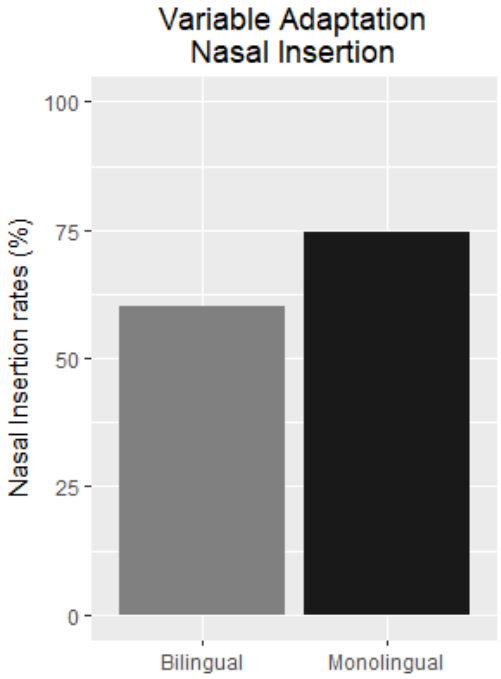
Figure 3.3 The comparison of words with CVˈnita structure. The prenasal vowels are lax and tense. The primary word stress falls on the post nasal vowel, e.g. [biˈnita] vs. [bɪˈnita]



3.4.3 Variable [ˈCVbəNi] adaptation

According to the corpus data, words with [ˈCVCəNV] tend to have two adaptation forms in Mandarin (see examples in (8)). Figure 3.4 shows how bilingual and monolingual speakers adapt the intervocalic nasal with [ə] as the prenasal vowel. The results show that the monolingual speakers prefer the outputs with nasal insertion significantly more than the bilingual speakers in the perceptual similarity task ($t(35.445)=2.622$, $p=0.013$). We can interpret that bilingual speakers tend to have variable adaptations. In all the responses from the bilingual speakers, 60.2% of the time they chose nasal insertion as the perceptually similar output, whereas monolingual speakers' nasal insertion rate is higher at 74.7%.

Figure 3.4 Bilingual and monolingual groups' preference on nasal insertion when the prenasal vowel is [ə]

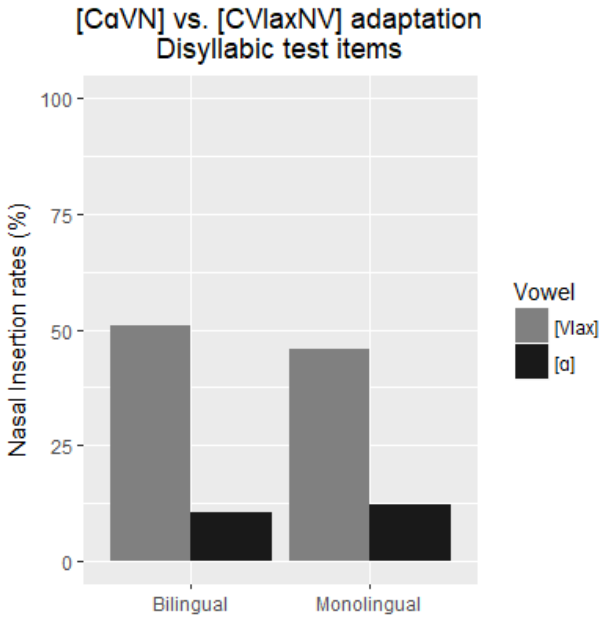


3.4.4 [CɑNV] vs. [CV$_{lax/tense}$NV] adaption

In the corpus data, when the prenasal vowel is low back [ɑ], nasal insertion never appears in Mandarin loanwords. I looked at how monolingual and bilingual speakers handle test items with [CɑNV] and [CV$_{lax/tense}$NV] structures.

Figure 3.5 shows both bilingual and monolingual groups do not prefer nasal insertion in Mandarin outputs when the English prenasal vowel is low back [ɑ]. The nasal insertion rate for the bilingual group is 14.7% and the monolingual group is 8%.

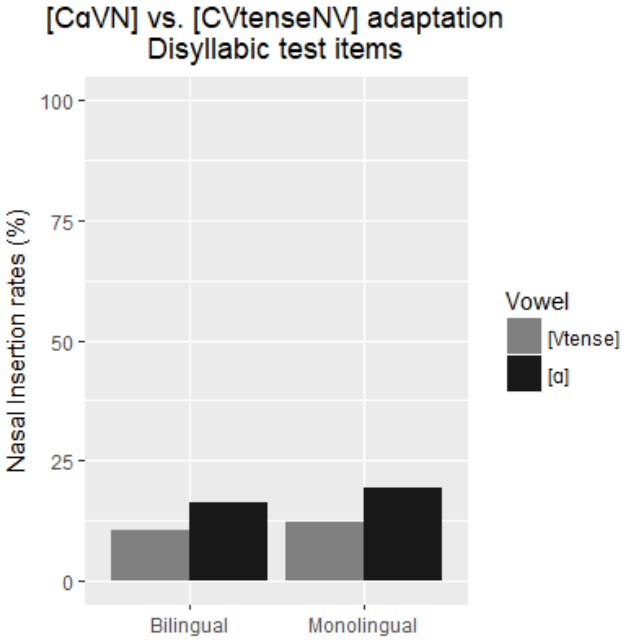
Figure 3.5 Comparison of nasal insertion rate when the English prenasal vowel is low back [ɑ] and all the other English lax vowels



The two-way ANOVA analysis reveals that there is no significant interaction between bilingualism and the quality of the English prenasal vowel ($F(1, 55)=0.996$, $p=0.322$). The analysis shows that nasal insertion is significantly not preferred in both monolingual and bilingual groups when the English prenasal vowel is low back [ɑ] ($F(1, 55)=118.396$, $p<0.001$). There is no significant difference between monolingual and bilingual speakers ($F(1, 55)=0.192$, $p=0.662$). The experimental results tell us that the low back [ɑ] behaves significantly differently from other lax vowels in English during intervocalic nasal adaptation process.

Figure 3.6 shows that similar to the corpus pattern, the low back vowel [ɑ] does not trigger nasal insertion in Mandarin loanwords like other tense vowels.

Figure 3.6 Comparison of nasal insertion rate when the English prenasal vowel is low back [ɑ] and all the other English tense vowels



The two-way ANOVA analysis reveals there is no significant interaction between groups with different language backgrounds and the prenasal vowel quality ($F(1, 55)= 0.037$, $p=0.847$). The preferences of nasal insertion for monolingual and bilingual speakers were similar ($F(1, 55)=0.349$, $p=0.557$). Both groups do not prefer inserting an extra nasal when the prenasal vowel is [ɑ] and other tense vowels in English. There is no significant difference in nasal insertion between [ɑ] and other English tense vowels ($F(1, 55)=3.079$, $p=0.08$).

3.5 General discussion

After analyzing the results from all participants with different language backgrounds, I will now discuss: i) the similarities and differences between the experimental results and the corpus data and, ii) the possible reasons for the differences.

In general, the experimental results from the monolingual and the bilingual groups are consistent with the analysis of the corpus data. The corpus data analysis shows that nasal insertion

accounts for 92.47% of English intervocalic nasal adaptation when the prenasal vowel is non-high lax (see Table 2.5). Whereas, the experimental results also show that English prenasal vowel quality plays an important role in nasal insertion in Mandarin loanword adaptation, although the rate is not as high as that of the corpus data. The experimental results differ from the corpus data in the respect of stress location condition. However, the differences are interpretable. Similar results from participants with different language backgrounds indicate that bilingualism does not play a crucial role in the intervocalic nasal adaptation process (cf. Peperkamp et al. (2008)). Hence, I further argue that nasal insertion is perception-based.

3.5.1 Vowel type condition

The experimental results from both groups show that the given Mandarin outputs with nasal insertion were selected by the participants as the more perceptually similar adapted form to the English ˈCV_{lax}NV inputs compared to those without.[31] When the English prenasal vowels are tense, nasal insertion is significantly less preferred in Mandarin loanwords.

Although the nasal insertion rate of the experimental data is significantly lower than it is in the corpus data (Bilingual: 50.8%, Monolingual: 45.8% vs. Corpus: 92.47%), these findings still support that the quality of English prenasal vowel renders the occurrence of nasal insertion in Mandarin loanwords. The difference in the nasal insertion rate can be attributed to how the participants handle the prenasal vowels (Lin, 2008b, 2012). Taking the prenasal vowel [æ] as an example, it can be adapted as [a_c], [je], [a], [ai], and [ja].[32] In the current experiment setting, the two given SM outputs of [æ] were either [a_c] without nasal insertion in an open syllable or [a] the fronted allophonic [a_c] with nasal insertion in a closed syllable. If the participant had adapted

[31] Chen and Lu's (2017) study "*The effect of duration and nasalization in the adaptation of English nasals by Mandarin speakers*", their perceptual similarity experimental results also show that lax vowels in English are more likely to trigger nasal gemination (in their term) than tense vowels.
[32] The variation can be due to speakers' perception or the phonotactic constraints of Mandarin.

English [æ] as [a], the form with nasal insertion was selected as the most perceptually similar form to the input. Another possibility is that the participants actually heard two nasals from the input due to the phonetic feature of the ambisyllabic intervocalic nasal, i.e. heavy vowel nasalization in the prenasal vowel. The participants might also misperceive one nasal as two.

The analysis proposed in Chapter 2 can account for the adaptation patterns shown in the experiments in that Mandarin speakers take the English prenasal vowel quality as one of the major cues for intervocalic nasal adaptation.

3.5.2 Stress location condition

The patterns observed in the experimental results of stress condition are not identical to the patterns observed in the corpus data. I first compared ˈCV_{lax}NV to CVˈNita. The experimental results do not pattern with the generalization observed in the corpus data. Presumably, CVˈNita test items should have very few responses exhibited with nasal insertion. According to Hayes (2009), such an intervocalic nasal is clearly syllabified as an onset due to the stress patterns. However, the experimental results indicate that ˈCV_{lax}NV and CVˈNita have very similar adaptation pattern, i.e. the results from both structures show that nasal insertion is preferred. This also means that the experimental results on stress condition are opposite to the stress condition pattern observed in my corpus data.

Figure 3.3 presents the comparison between CV_{lax}ˈNita and CV_{tense}ˈNita. For the CV_{lax}ˈNita test items, both monolingual and bilingual groups chose the outputs with nasal insertion as the more perceptually similar option. I suggest that this can be attributed to the fact that the English input recordings show clear nasalization of unstressed prenasal lax vowels. Figure 3.7 gives an example of how vowel nasalization is measured in one of the CV_{lax}ˈNita test items. Mandarin speakers from both groups perceive the short duration of the vowel with heavy nasalization. Hence,

they add another nasal consonant to fulfill Mandarin *μμ*-syllable constraints and the fine acoustic nasal cue on the prenasal vowel.

Figure 3.7 [bʊˈnita] as an example of vowel nasalization measurement on the prenasal vowel of the test items with CV_{lax}ˈnita structure

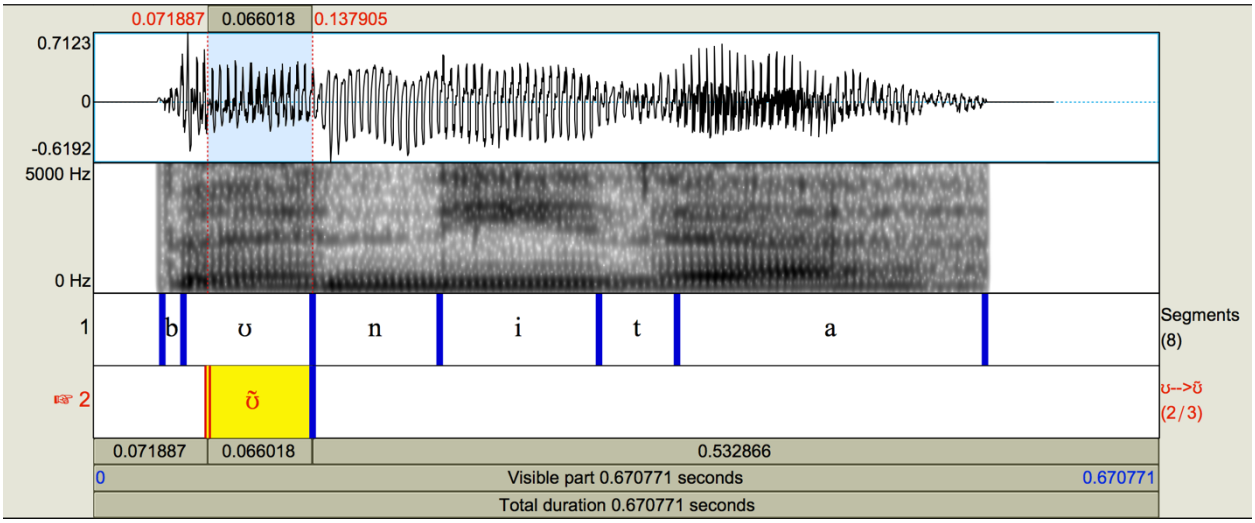


Table 3.2 shows the total vowel duration of the prenasal vowel, the duration of the proportion of the nasalized part within the prenasal vowel, and the percentage of vowel nasalization of the CV_{lax}ˈnita test items. Vowel nasalization indicates that both groups of speakers rely on perception cues to match vowel duration and nasality through nasal insertion.

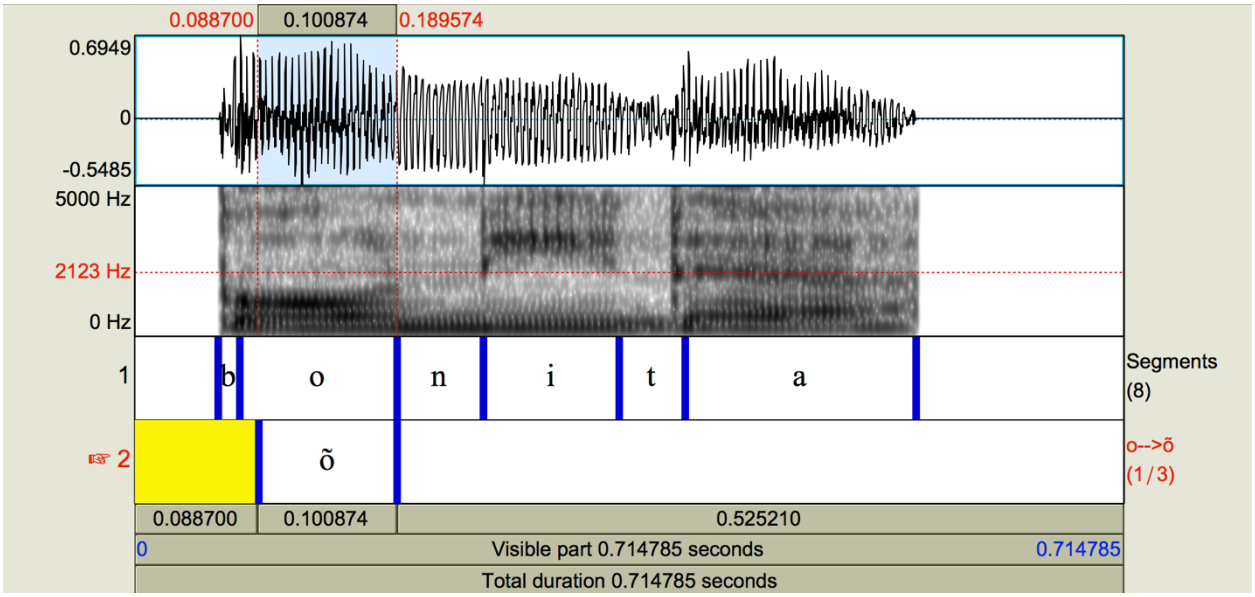
Table 3.2 The total prenasal vowel duration, the duration of the nasalized part in the prenasal vowel, and the proportion in percentage of vowel nasalization of the test item with CVˈNita structure

Test items	Vowel duration (ms)	Nasalization within the vowel (ms)	Ṽ/V
[bɪˈnita]	52	39	75%
[bʊˈnita]	83	66	79.5%
[bɛˈnita]	67	57	85.1%
[bɔˈnita]	123	108	87.8%
[bæˈnita]	120	105	87.5%

Similar to the corpus data, CV_{tense}ˈnita test items are not adapted with nasal insertion even though the prenasal vowel in the test items is nasalized (see below for a tense prenasal vowel

nasalization example). I argue that the prenasal tense vowel already fits into Mandarin phonotactics. Therefore, even though the prenasal vowel shows a large proportion of nasalization; there is no need to add another nasal consonant. If an extra nasal is added, an ungrammatical syllable, i.e. CV:N, will be formed in Mandarin. Hence, we can further conclude that when adapting English intervocalic nasals, Mandarin speakers weigh English prenasal vowel duration more than its nasal allophonic feature.

Figure 3.8 [boˈnita] as an example of vowel nasalization measurement on the prenasal vowel of the test items with CV_{tense}ˈnita structure

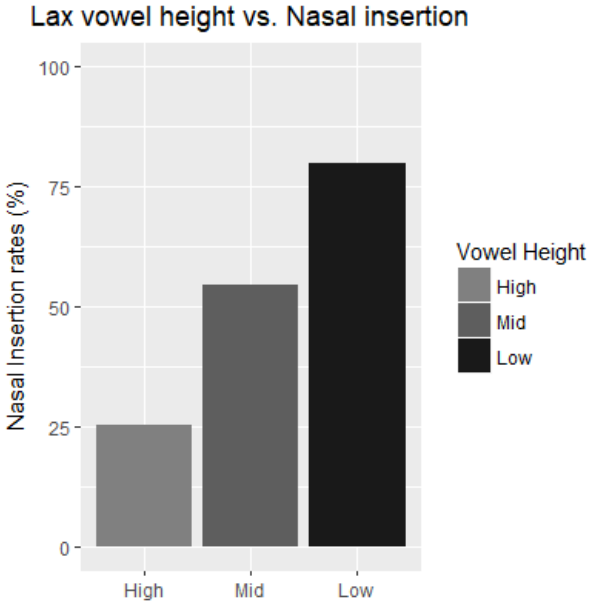


The corpus data also show that non-high prenasal vowels trigger more nasal insertion in Mandarin loanwords than high vowels. My experimental results also show this tendency, which presents that non-high (low[33] and mid[34]) lax English vowels trigger more nasal insertion than high vowels. English high lax vowels [ɪ] and [ʊ] tend to be adapted as the tense vowel [i] and [u] in

[33] Because low back [ɑ] never triggers nasal insertion in the corpus data and it rarely triggers nasal insertion in the experimental results, it is excluded in the analysis.
[34] To be consistent with the corpus data analysis, [ə] is excluded for the analysis. [ə] is analyzed under the variable adaptation category.

Mandarin. Nasal insertion does not apply to Mandarin loanwords even when they fulfill vowel type condition and stress location condition. These vowel adaptation patterns are observed in vowel adaptation in Mandarin loanwords in Y.-H. Lin (2008, p. 367-368).

Figure 3.9 Comparison of nasal insertion rate with different English prenasal vowel quality



I propose that the asymmetry of the nasal insertion rates among the tested lax vowels with different vowel height can be attributed to the duration of the nasalized proportion of the prenasal vowel.

Table 3.3 shows that in the same phonological context, ˈ$CV_{lax}NV$, the lower the vowel is the more nasalization appears in the prenasal vowel, and nasal insertion appears in SM loanwords more frequently. This is due to Mandarin speakers' perception of the nasality of the English prenasal vowel.

Table 3.3 The proportion of vowel nasalization in the prenasal vowel in ˈCV_{lax}NV test items

Prenasal lax vowel	Vowel duration (ms)	Nasalization within the vowel (ms)	Ṽ/V
[ɪ]	86	60	69%
[ʊ]	107	63	58%
[ɛ]	115	92	80%
[ɔ]	144	111	77%
[æ]	157	122	78%

3.5.3 Perception and adaptation of prenasal vowels

Table 3.1 and Figure 3.1 show that nasal insertion rates of the bilingual and the monolingual groups are 50.8% and 45.8%. From the given two outputs, we can interpret that nasal insertion and vowel lengthening were both in use during the adaptation process. The asymmetry in nasal insertion rates between the corpus and the experimental data can be attributed to how the prenasal lax vowels are modified by adapters. Similar results were reported in Chen and Lu (2017). They report that the nasal insertion response rate was slightly higher than 40% when the English prenasal vowel is lax and roughly 15% when the English prenasal vowel is tense. The experiment was run on monolingual Mandarin speakers. Their results also show that the prenasal vowel quality affects the appearance of nasal insertion in loanwords in Mandarin.

Due to the asymmetry between the vowel inventory of the donor language and the recipient language, vowel modification happens during adaptation adequately often. Nasal insertion and vowel lengthening are the two sound modification candidates that strongly shape the loanword output to be perceptually similar to its input. Based on the recent loanword phonology studies, the sound modification can be purely due to speakers' misperception (Peperkamp, 2005; Peperkamp & Dupoux, 2003b). Speakers' phonological knowledge is not involved, e.g. /ɪ/ is constantly perceived as /i/. It can also be that speakers' perception functions at the perception level when the input enters as a sound string, and then speakers use their native phonological knowledge to find

the most similar sound that matches the non-native sound, e.g. /ɪ/ is perceived as /ɪ/ but is modified to /i/ when entering into SM (Silverman, 1992).

Studies, e.g. X. Wang & Munro, 1999, on second language acquisition of English paired tense-lax vowel perception of Mandarin speakers show that lax vowel perception sensitivity, e.g. /i/-/ɪ/, and /u/-/ʊ/, can be dramatically improved after training. Ji, Berry, & Johnson's (2013) study on bilingual speakers' perceptual accuracy rate on English lax vowels show that bilingual speakers do not have major problems differentiating tense and lax vowels in English. In addition, the perception accuracy rate of front vowels in general is higher than back vowels. The average accuracy rate of [ɪ] is 78%; however, [ʊ] is only 60%. Hence, it seems that misperception cannot well explain the sound modification of English lax vowels in Mandarin because bilingual and monolingual groups have very similar performances. In addition, to some extent, the monolingual speakers had knowledge of English in classroom settings. Therefore, we can claim that the appearance of nasal insertion depends on how the adapters adapt the prenasal vowels and Silverman's model better explains the current loanword adaptation issue.

In an attempt to account for the lower insertion rate in the experimental results than the nasal insertion rate calculated in the corpus data, a few possibilities can be considered. The first is related to how the prenasal lax vowels are modified by SM speakers. As mentioned previously, vowels can be adapted variably (cf. Y.-H. Lin, 2008a, 2015). If the prenasal lax vowel is adapted as a tense vowel or a diphthong in Mandarin, nasal insertion cannot appear. Otherwise, the SM phonotactic constraints against no super heavy syllables, i.e. *CVːN, is violated.

Even though nasal insertion seems to happen by chance because the rate is close to 50% for the bilingual group, the results show that the contrast between lax and tense vowel is significant. The second explanation is related to the adaptation method, i.e. by reading or by listening with a

very short responding time. By reading, orthography can be one factor because English tends to double spell the consonants after a short or a lax vowel, e.g. *Danny* [ˈdæni]. However, through listening with a short responding time, speakers rely only on their perception; hence more sound modification methods appear. They need to consider whether they want to maintain the vowel quality to add an extra nasal to fulfill perceptual requirement on vowel duration and/or on nasality, or whether they just want to keep the nasal number from the source. The third explanation for lower nasal insertion rate in the experimental results comes from the number of the intervocalic nasal consonants that the Mandarin speakers perceive. This can be attributed to heavy vowel nasalization on the prenasal vowel and the number of nasal features from the source. The heavily nasalized prenasal vowel bears a nasal feature. Meanwhile, the intervocalic nasal consonant also has a nasal feature. When nasal insertion occurs, although nasal segment number does not match, the nasal feature number matches.

Same as the corpus data, nasal insertion is not preferred when the English prenasal vowel is low back [ɑ]. Nasal insertion should occur if we treat the low back [ɑ] as a lax vowel while it fulfills vowel type condition and stress location condition. The combination [ɑŋ] is also a possible syllable in Mandarin.[35] However, [ɑ] almost never triggers nasal insertion in Mandarin. In my analysis in Chapter 2, I proposed that [ɑ] is phonetically long in duration. Hence, it fills the X slot in C(G)VX. There is no need to insert another nasal consonant. In addition, [ɑ] is one of the peripheral vowels in the donor language and the recipient language. Without sound modification, it can be faithfully mapped from English to Mandarin. Therefore, extra repair, i.e. nasal insertion, is not necessary. Another possibility is that [ɑ] acts as a tense vowel in open syllables.

[35] The inserted nasal is not [n] here because the place of articulation of the nasal is decided by the backness of the English prenasal vowel.

Ladfoged and Johnson (2001) claim that [ɑ] in American English is a tense vowel in *spa*, which is not originated in American English.[36] British [ɑ] is also a tense vowel in *car, card*, in both open and closed syllables. Green (2001) proposes that [ɑ] in English can be lax and tense in different environments. He points out that all words in which [ɑ] appears in contexts otherwise restricted to tense vowels are either loanwords like *spa* and *mirage* or hypocoristics like *ma* and *pa*. Words in the current corpus data like *Cabana, Adana*, and *Astana* are foreign country names or exotic objects in English. Also, when the test items were recorded, the American English speakers were told that the words were all pseudowords. If Green's claims are correct, the prenasal [ɑ] is considered not only long in duration but also a tense vowel in the English source, hence nasal insertion does not appear in Mandarin.

3.6 Conclusion

To conclude, in general, the appearance of nasal insertion in the experimental data patterns with the corpus data. That is, the prenasal lax vowels in English tend to trigger nasal insertion in SM loanwords noticeably more than tense vowels. The insertion rate in the experimental data is not as high as it is in the corpus data. However, the asymmetry is interpretable. I propose that it can be attributed to how the prenasal lax vowels are adapted through perception. If the Mandarin speakers adapt the English prenasal vowel as lax and short, nasal insertion appears to form a grammatical syllable and a better phonetic match on English prenasal vowel duration and nasalization. When the participants selected the vowel lengthening outputs, it does not necessarily mean that they did not perceive the prenasal lax vowel or that they cannot distinguish lax vowels and tense vowels. According to (Ji et al., 2013; X. Wang & Munro, 1999), SM speakers can

[36] *Spa* was originally a town's name in Belgium.

differentiate lax and tense vowels in English after training. Hence, I propose that both groups actually perceived the lax vowels correctly.

In addition, adaptation methods also cause two different adapted forms. Smith's (2006) study on Japanese doublets shows that when the adaptation is done by reading, vowel epenthesis is always used to repair syllable codas; whereas, when the medium of borrowing is auditory, consonant deletion and vowel epenthesis both appear in Japanese loanwords. In the current study, the dictionary corpus is from 1988. It is reasonable to assume that, similar to Japanese loanwords, at that time, loanwords in general entered into Mandarin through reading materials rather than spoken English, since English education was not popular and people rarely had a chance to access foreign languages through public media. Following Smith's (2006) proposal, we can argue that by reading, the adapters perceived two nasals on the basis of English spelling or orthography; therefore, two nasals are represented in the underlying representation of Mandarin and there is no process when the underlying representation maps to the surface representation. However, phonologically, there is only one nasal when it is in an ambisyllabic position such as this, and many cases show one nasal in the English orthography but are adapted with two nasals in Mandarin (see the examples given in §2.3.3). There are also words with two nasals in spelling but that are adapted with only one nasal in Mandarin, e.g. *Minnie* → [miː.niː]. Hence, I argue that English orthography is not the major factor that causes nasal insertion in SM loanwords. Based on the experimental results and the corpus data, I argue that nasal insertion is due to speakers' perception even though orthography may play a role inside, i.e. how SM speakers perceive the prenasal vowel and the number of nasal features (Ṽ and N[+nasal]) in English.

Through a perception-only adaptation method in the current experiment, I conclude that similar to the corpus data, nasal insertion rate is significantly correlated to prenasal vowel quality. Prenasal

lax vowels cause significantly more nasal insertion in Mandarin loanwords than prenasal tense vowels. The lack of the stress effects exhibited in the corpus data and the relatively lower nasal insertion rate in the prenasal stressed lax vowel context in the experiment (50%~63%; cf. 90.8% in the dictionary corpus) are attributed to the auditory experimental setting, which likely leads to auditory variation (cf. Davidson, 2007, Smith, 2006) and less access to phonological representation such as metrical structure.

Mandarin speakers from different language backgrounds adapt intervocalic nasals similarly. This indicates that bilingualism does not play a crucial role. Although the stress pattern observed in the corpus data is not present in the experimental results, I demonstrate that the appearance of nasal insertion when the stress is on the postnasal vowel is due to the heavy nasality spread from the nasal consonant. I further suggest that intervocalic nasal adaptation relies on speakers' perception. Speakers from both groups rely on prenasal vowel quality to process intervocalic nasals. Phonological factors such as ambisyllabicity is not a main factor that determines nasal insertion in Mandarin loanwords.

Chapter 4 Coda [m] Adaptation: Corpus Data

4.1 Introduction

This chapter examines when and why the English coda [m] is or is not adapted with an epenthetic vowel (e.g. *Beckham* → [pei.kʰɤ:.han.mu:], *Walmsley* → [wei.mu:.sɤ:.li:] vs. *Columbia* → [kɤ:.lun.pi:.ʲa:]) and when the forms with and without vowel epenthesis both appear in Standard Mandarin loanwords based on my corpus data. Place names on "Google Maps" are also studied for the adaptation process.

A syllable with coda [m] is illicit in Standard Mandarin. To fulfill the Standard Mandarin phonotactic constraints, Standard Mandarin speakers, based on the corpora, employ two repair strategies: vowel epenthesis after the illicit coda [m], [m] → [mu:], and nasal place change [m] → [n]/[ŋ]. I propose an analysis based on Standard Mandarin speakers' perception and native phonology to account for three cases of Standard Mandarin loanword adaptation of English [m]:

1. when the English [m] is adapted with vowel epenthesis,
2. when it is adapted with nasal place change, and
3. when it is adapted variably between vowel epenthesis and nasal place change.

The corpus data show that the appearance of vowel epenthesis in SM loanwords associated with the coda [m] is conditioned by its phonological environment in English. I argue that vowel epenthesis is mainly driven by adaptors' knowledge of the native phonotactic constraints. Adaptors' perception and phonological knowledge both play an important role for cases that are adapted with [n] or [ŋ].

The organization of this chapter is constructed as follows. In §4.2, I briefly review adaptation of coda consonants in Standard Mandarin loanwords and cases of vowel epenthesis in the loanword systems of other languages. Other relevant issues that would affect adaptation of syllable repair

strategies are discussed as well. My corpus data and the generalizations of SM vowel epenthesis are presented in §4.3. In §4.4, I show similar adaptation patterns of English coda [m] observed in another corpus. In §4.5, I propose an analysis of the three adaptation patterns of the English coda [m]: vowel epenthesis, nasal place change, and variable adaptation between the epenthesis and nasal place change, and in §4.6, I discuss relevant issues of vowel epenthesis in Standard Mandarin loanwords. In §4.7, I draw a conclusion and discuss on [m] adaptation and contemporary loanword adaptation models.

4.2 Background

In loanword adaptation, when there is a mismatch between the donor and recipient languages, various repair strategies can be used to produce licit adapted forms, including epenthesis, deletion, and feature or segment change.

Vowel epenthesis is a common process to satisfy phonotactic and syllable structure constraints in many languages, e.g. Yoruba, Japanese, Shona, Samoan, and Sranan (Y. Kang 2011; Kyumin Kim & Kochetov, 2011; Repetti, 2012; Uffmann, 2006, 2007).[37] The following examples from Uffmann (2007) show that the epenthetic vowels are in two positions in general. First, to avoid onset consonant clusters, vowels are inserted in between the two consonants that appear in the onset position in the donor language. Second, the epenthetic vowel resyllabifies the coda in the recipient language. Thus it prevents illicit coda consonants in the recipient language.

(10) Epenthetic vowels in loanwords (Uffmann, 2007, p. 1)

Yoruba	k**í**láàsi	‘class’
Japanese	s**u**torail**u**	‘strike’

[37] Vowel epenthesis normally refers to mapping underlying representation (UR) to surface representation (SR). However, in loanword adaptation, it refers to the repair of the SR of the donor language that is ungrammatical in the SR of the recipient language through adding a vowel.

Tswana	k**e**res**e**mose	‘Christmas’
Shona	g**i**rin**i**	‘green’
Samoan	s**i**kaut**i**	‘scout’
Fijian	s**i**piinij**i**	‘spinach’
Kikuyu	ng**i**rath**i**	‘glass’
Rennellese	k**a**lap**u**	‘crab’
Haya	**e**s**i**p**u**rei	‘spray’
Luganda	ss**u**kur**u**	‘school’

If vowel epenthesis is simply for syllable structure repairing, consonant deletion is another logical option. Yet, deletion is rarely picked to be the repair strategy. Paradis and LaCharité (Paradis & Lacharité 1997; Paradis 1996) propose the Preservation Principle, in which they argue that the input information or materials must be preserved as much as possible. That is to say, based on the Preservation Principle, vowel epenthesis is generally preferred over deletion when the input structures violate the grammar of the recipient language. This has been widely examined in adaptations of word-initial consonant clusters (Fula, Japanese, Korean, Hauve, etc) and word-final codas and clusters (Japanese, Korean, Sesotho, etc). However, consonant preservation has more variability in the word-final position. There are languages that use deletion to repair word-final codas, such as Vietnamese and Thai. Some languages, for example, Burmese, and Fijian chose vowel epenthesis to repair word-initial consonant clusters; however, they adopt deletion for word-final codas. Vowel epenthesis and consonant deletion can also be applied in the same syllable position in one language. For example, in Fijian, *east* [ist] is adapted as [ˈisi] where [t] deletion applies; *wolf* [wɔlf] is adapted as [ˌoˈliva] where [a] is inserted. We need to be aware that Paradis and LaCharité suggest that the adapters are fluent or proficient bilingual speakers. Feature or

segment changes commonly apply when the two corresponding segments between the donor and recipient languages differ phonologically/phonetically or occur in different phonological contexts (Y. Kang 2011; Paradis & Lacharité, 2011, and references therein).

Nasal consonants in English have several adapted forms in SM loanwords. The most common form is a faithful mapping in syllable onset position, e.g. *Nate* → [nai.tʰɤː], *Mark* → [maː.kʰɤː]. Standard Mandarin allows [n] or [ŋ] but not [m] in syllable coda position; hence, English coda [m] cannot be faithfully adapted into SM loanwords. In order to fix the illicit coda, two repair strategies are commonly adopted: vowel epenthesis after [m] or [m] → [n]/[ŋ] nasal place change. Deletion of an illicit coda [m] almost never happens.[38] It seems that vowel epenthesis is the default strategy. However, nasal place change is in use almost all the time when [m] is followed by a homorganic consonant. Some cases in the current corpora also show variation between vowel epenthesis and nasal place change when the coda [m] is in word-medial coda position followed by an obstruent. Based on the corpus data, I observed that the phonological environments of English coda [m] decide which syllable repair strategy should be used and the presence of the epenthetic vowel in SM loanwords.

4.2.1 Adaptation of coda consonants in general

Standard Mandarin has very simple syllable structures. Onset and coda consonant clusters are not allowed (Duanmu 2000/2007), and only [n] or [ŋ] can occupy the syllable coda position. However, many languages allow all types of consonants in coda position. When the illicit codas enter into SM, the adaptations of foreign words displays variations between alternative phonotactic strategies in resolving foreign syllable structures that are incompatible with the SM phonology.

[38] One example I can provide here is a French cosmetic brand name *Lancôme* → 兰蔻 [lan.kʰou_]. Another example of nasal deletion is [n] in coda position, *Line* → 赖 [lai_]. The deletion of the latter one is due to the retaining of the prenasal diphthong and it fulfills the heavy syllable constraint. By deleting the nasal consonant, the syllable number can also be faithfully mapped.

From the English loanwords in (11) and (12), we can see that an English coda consonant can either be preserved through vowel epenthesis, as in (11), or simply deleted, as in (12).[39]

(11) Vowel epenthesis in adaptation of codas

English	SM
Bob	[pau.pwo]
Jazz	[tɕɥeː.ʂɻ]
Pete	[pʰiː.tʰɤː]/[piː.tɤː]
Scott	[ʂɻ.kʰɑu.tʰɤː]

(12) Consonant deletion in adaptation of codas

English	SM
Compaq	[kʰɑŋ.pwoː_]
Denmark	[tan.mai_]
Janet	[tʂən.niː_]
McDonald	[mai.tɑŋ.lɑu_]

For example, in *Bob* → [pau.pwo], the second English oral stop /b/ undergoes resyllabification through /o/ epenthesis, whereas the coda cluster /ɹk/ is deleted in *Denmark* → [tan.mai]. In some cases, the adaptation forms with illicit codas can be adapted with consonant deletion and vowel epenthesis. For example, *Cheetos* → [tʰɕiː.twoː] / [tʂɻ.twoː.sɻː], and *Adidas* → [ai.tiː.taː.sɻː] / [ai.tiː.taː]. Whether vowel epenthesis or coda consonant deletion applies in loanword adaptation, the purpose is to fix the illicit syllable.

[39] The examples given in (11) and (12) are from Miao (2005), (Lin, 2007, 2008b) and the corpora used in this study.

By now, we have seen that the illicit codas are commonly fixed by vowel epenthesis and consonant deletion. However, what contributes to the choice between epenthesis and deletion in coda position is another issue.

Next, I will present that consonant deletion and vowel epenthesis are adopted by two speaking communities of the same language—Mandarin.

4.2.2 Different repair strategies in two Mandarin communities

The goal of Yip's (2002, 2006) studies is to show that speakers who share a similar first language grammar but produce different loanword outputs. The target language used in her research is Mandarin, which is spoken in two different areas—Mainland China, and Taiwan. The following examples given in Yip (2006, p.995) show one input, however, that is modified with two repair strategies.

Table 4.1 Syllable repair strategies in a shared grammar of two communities

Source	**Mainland: retention**	**Taiwan: deletion**	**Target consonant**
Friedman	fuː.liː.tɤː.man	fuː.liː.man	d
Adidas	aː.tiː.daː.sɻ	ai. tiː.daː	s
Burt (Reynolds)	pwoː.tʰɤː	pi	t
Denzel (Washington)	təŋ.tsɤː.ər	tan.tswo	l
Gorbachev	kʰɤː.ər.paːtʰɕjau.fuː	kʰɤː. paːtʰɕi.fuː	r
Navratilova	naː.fuː.laːtiːnowː.waː	naː. laːtiːnowː.waː	v
(Rita) Hayworth	hai.hwaː.sɻ	hai.hwaː	θ
(Steven) Spielberg	ʂɻ.pʰiː.ər.pwo.kɤː	ʂɻ.pʰiː.pwo.	l, g

Table 4.1 illustrates that the same source word can be adapted with two loan outcomes in two Mandarin speaking regions. Consonant retention with an epenthetic vowel after is the preferred strategy applied to loanwords in Mainland China, whereas, consonant deletion is adopted quite often in Taiwanese Mandarin loanwords.[40]

[40] The variable adaptation of *Cheetos*, [tʰɕiː.tʷo] and [tʂɻ.tʷoː.sɻ] ealier, gives an opposite example of Taiwan and Mainland Mandarin adaptation forms from the aspect of coda consonant retaining. The loan form with vowel epenthesis, [tʂɻ.tʷoː.sɻː], was used in Taiwan among people born in 1980-1990. However, nowadays both Taiwan and

From the point of view of syllable structure, SM speakers from the two areas should share similar phonological grammar. Mandarin spoken in both areas does not allow oral stops and [m] in coda position. Hence, she further argues that the dialectal differences between Mainland Mandarin and Taiwan Mandarin would not predict any difference in ability to perceive the excrescent coda. She argues that the repair must be phonological.

Yip has two proposals. First, she argues that SM speakers never encounter coda consonants other than /n/ and /ŋ/ or unsyllabified consonants in their native grammar. Therefore, SM native grammar does not encounter segment insertion and deletion issues. Foreign inputs are the first time a decision needs to be made about the dilemma of coda consonant retention or deletion. The initial decisions are random, because Mandarin speakers' phonological grammar has never encountered segment insertion and deletion puzzles. Later on, within a given speech community, this initiates a new grammar, and a pattern emerges.

She also argues that this proposal has problems. For example, the cross-linguistic preference for retention (Paradis and LaCharité, 1997) suggests segment retention is universally more preferred than deletion, although in some languages deletion is preferred, e.g. in Hmong, word-final coda are categorically deleted (Golston & Yang (2001)) and in Jahai, voiced stops get deleted in nasal homorganic environments ('*cattle*' lembu → [l.muʔ]) (Burenhult (2001)). Another problem is that native constraint ranking and loanword constraint ranking order in different ways, i.e. in Maori, deletion is preferred in its native phonology; however, epenthesis is preferred in loanword phonology (Yip 2002).

To solve the theoretical problems, she proposes a set of MIMIC constraints, which can be freely ranked high or low. MIMIC constraints serve to faithfully adapt the percept to output in grammar.

Mainland use, [t^hɕi:.t^wo], the form without vowel epenthesis.

In her proposal, the percept includes some reflection of most of the non-native segments, but it may differ from the percept of a native speaker of the donor language. The input to the phonology is the already transformed percept. The grammar makes further changes when necessary. This grammar may have access to perceptual information, particularly the relative salience of acoustic cues.

If the MIMIC constraints are ranked high, the loanword output will be more like the foreign input, however, illicit syllable structure may appear in the recipient language. If they are ranked low, the grammar of the output will be more similar to or the same as the recipient language. See the adaptation of English word *Titanic* in Table 4.2 for an example.

Table 4.2 Possible Mandarin responses of the English word *Titanic*

Constraint ranking	**SM output**	**Status of the target consonant [k]**
OK-σ low, MIMIC high	Tita[nik]	[non-native, retention of C]
OK-σ high, MIMIC high	Tita[ni:.k^{h}ɤ:]	[retention of C/vowel epenthesis, Mainland]
OK-σ high, MIMIC low	Tita[ni:]	[deletion of C, Taiwan]

We see that when the OK-σ low is ranked low and MIMIC constraint is ranked high, although the output in SM is fully faithful to the input, the retained coda [k] violates the SM OK-σ constraint, and therefore, the adaptation form is less native Mandarin like. On the other hand, ranking MIMIC constraint in different places in SM grammar contributes to different grammatical outputs in the two Mandarin speaking communities.

We need to note that Yip argues that the output that keeps all the segments is more faithful to the input. However, Silverman (1992) argues that perceptually weak segments get deleted in Cantonese loan adaptations.

4.2.3 Consonantal perceptibility and syllable repair strategy

Besides the phonological explanations proposed by Yip, other than data analysis of the existing datasets, Miao (2005) runs online production and perception experiments to show that perception

also plays a crucial role in loanword adaptation. Based on P-map hypothesis (Steriade 2009), her cross-linguistic corpus data analysis suggests that when Mandarin speakers encounter syllables from foreign languages that are not permissible, i.e. codas other than [n] and [ŋ] and consonant clusters, to repair such ill-formed syllables, the decision on segment deletion or consonant preservation is made by the perceptibility of the consonant in different phonological contexts.

According to the corpus data, Miao argues that consonants tend to be preserved in the recipient language when they are in a perceptually prominent position in the source language. Consonants in a stressed syllable are more likely to be preserved than those in a stressless syllable; consonants after a tense vowel tend to more likely be preserved than those after a lax vowel (cf. Y. Kang (2003)); consonants in syllable onset position are more frequently retained than those in syllable coda position (cf. Loggins (2010)).

In addition, Miao also argues that different classes of consonants have different perceptibility. That is to say when a consonant is more perceptible, it is more likely to be preserved. For example, her corpus data show that fricatives have a higher retention rate than stops/plosives. Nasals never get deleted. This also means that fricatives and nasals are more perceptible than stops/plosives. Another pattern observed in her corpus data is that segments in certain types of clusters have stronger perceptual cues than in others. For example, the final obstruent in sonorant-obstruent clusters is more distinctive than in obstruent-obstruent clusters. In nasal-obstruent clusters, a voiceless obstruent (e.g. [np]) in the cluster-final position is more perceptible than a voiced obstruent (e.g. [nb]). In nasal-obstruent coda clusters, the final sibilant or fricative (e.g. [nf]) is more distinctive than final stops (e.g. [nb]). Her findings in Mandarin loanwords are similar to Kenstowicz's (2007) study on Fijian. In Fula loanwords, obstruent-obstruent sequences are repaired by consonant deletion of the second obstruent; whereas, sonorant-obstruent sequences are

usually repaired by vowel epenthesis. Based on the corpus data, Miao argues that consonant type and the phonological context of the consonant decide whether the illicit syllable should be fixed by vowel epenthesis or consonant deletion.

Miao conducts an online perceptual similarity judgment task and production (in this order) experiments to test whether the generalizations and her proposed analysis are valid and to check whether the perceived similar forms also appear in production grammar.[41]

The experimental data were solicited from 10 Mandarin-English bilingual speakers. The English input structure is with C_1VC_2 structure, where C_1=/l, m/, V= /i, ʌ/, and C_2=/b, p, d, t, g, k/. Each input appeared 3 or 4 times and was paired with a different Mandarin output. For example, the English word /lip/ was paired up with /liːpʰuː/, and /li.puː/, /li/, and /lim/. The participants had to listen to each pair and give a similarity score on a scale of 1 to 3.

The results suggest that the Mandarin participants from Mainland China prefer vowel epenthesis to consonant deletion when they encounter illicit syllables. The results also indicate that vowel epenthesis is less marked than deletion in syllable structure repairing. The results also suggest that voicing and aspiration deviate more than manner feature, nasality, e.g. /lit/ → [liː.tʰɤː] or [liː.tɤː] but /lit/ → *[lin]. Among [liː.tʰɤː], [liː.tɤː], [liː] and [lin], [liː.tʰɤː] is more preferred than [liː.tɤː], [liː] and [lin] (See below).

Miao's two production experiments share the same participants (from Mainland China), test items, and filler items with the perceptual similarity judgement task. In the first production experiment, the participants have to transcribe the English words into Pīnyīn after they listen to them. The results are summarized as follow (Miao, 2005, p. 144):

[41] The experiment methodology will be discussed in discussion section.

1. Vowel epenthesis is the only syllable repair strategy.
2. The epenthetic vowel shares the same [±labial] feature with the preceding consonant, e.g. [b, p, m] in coda position are repaired with a [+round] vowel, such as [u, o]
3. Segmental mapping displays variability in voice-aspiration features, but never in nasal features.

In her second production experiment, the participants were asked to listen to the English words and to write down the transliteration forms for the test items in Chinese characters. The same as the first production experiment, vowel epenthesis is the only repair strategy when the SM speakers encounter illicit coda. The epenthetic vowel agrees with the [±labial] feature of its preceding consonant and segmental mapping shows similar types of deviation of voice-aspiration in the perception experiment and the first production experiment. Another finding is that one single loanword may be adapted with different characters.

The experimental results from the perception similarity judgement task and the two production experiments show similar patterns with the corpus data. The concluding remarks of her study is that the adaptors tend to be better attuned to some particular consonant features and this also suggests that not all the features were weighted the same in perception or primary in phonology. Her argument opposes Yip's (2006) suggestion that such repair has to be phonology based. However, her argument supports Paradis & Lacharité's (1997) argument that vowel epenthesis is universally preferred over deletion.

I suggest that the fact that vowel epenthesis is the only repair strategy that appeared in Miao's production experimental results is because of the order of the two experiments (first perceptual similarity, then production). Although the results from the two types of experiments are similar, the order matters. Given that the subjects were primed by the previous perceptual experiment, we

cannot expect that they would have unbiased reactions to the production study. In addition, the participants in her study were all bilinguals with high English proficiency. Segment preservation can be predicted. Hence, after they heard possible outputs in the perception experiment, they were also probably biased to use vowel epenthesis in the production experiments. In addition, they are from Mainland China. They have probably been exposed to loan forms repaired with vowel epenthesis frequently (cf. Yip, 2006). Therefore, the vowel epenthesis rate was 100% in Miao's production study.

Kenstowicz's (2007) study on English loanwords in Fijian also claims that perception or consonant perceptibility affects how the illicit coda is adapted. Fijian is an open syllable language. Consonants in coda and clusters need to be repaired during loan adaptation. Fijian loanwords show similar syllable repair strategies to SM. Vowel epenthesis is the major strategy to remove the marked syllable structure. However, consonant deletion emerges in some circumstances as well. Examples of English words repaired with vowel epenthesis and consonant deletion are given in (13) (Kenstowicz, 2007, p. 329).

(13) Vowel epenthesis in Fijian loanwords from English.

word-initial	steak	sitéki
	class	kalási
word-medial	telegram	tàlikarámu
	whisky	wìsikí
word-final	film	fiːlímu
	ounce	òː.nísi

(14) Consonant deletion in Fijian loanwords from English.

word-final	barracks	bà:.rékì
	billiards	bìli.átì
	somersault	sàmi.sólo

Based on the corpus data, Kenstowicz observes that:

1. a single final consonant is consistently adapted with an epenthetic vowel. Consonant deletion appears in many cases in word-final consonant clusters.
2. when consonant deletion appears in word-final clusters, it is always the second consonant that gets deleted.
3. when the two consonants are obstruents, deletion applies more. When the first consonant is a sonorant, epenthesis applies more.

Kenstowicz proposes that the disparity of coda consonant and consonant cluster adaptation is due to the weak perceptual cue from the second consonant in the cluster and that the simplex coda has a stronger chance to bear the formants from its preceding vowel. This has been also observed in other open syllable languages, e.g. Cantonese (Silverman, 1992). The difference among consonant clusters, obstruent-obstruent, and sonorant-obstruent, adaptation can be explained with phonetic or perceptual factors as well. Like vowels, sonorants have formant structures to better cue the following consonant to be repaired by vowel epenthesis rather than deletion. This is also observed in Cantonese loanwords (Silverman 1992). In Cantonese loanwords, stops are adapted with vowel epenthesis only when the preceding segment is a vocoid.

4.2.4 Channel of borrowing affects syllable repair strategy

Besides phonological and phonetic factors, Miao (2005), Smith (2006), and Y. Kang (2011) also argue that the channel of borrowing, i.e. whether borrowing through spoken vs. written

channels, and the related influence of orthography have been proposed to affect the adaptation pattern (Dohlus 2005 on French and German mid front rounded vowels adaptation in Japanese, Smith 2006, Vendelin & Peperkamp 2006 on English words in French, Detey & Nespoulous 2008 on French consonant cluster adaptation in Japanese, Friesner 2009 on loanwords in French speaking community in Montréal).[42] Miao points out that adaptation by reading the source languages shows notably more consonant retention. Her corpus data from English, German, and Italian show that coda consonants from German and Italian in most cases are preserved and resyllabified with an epenthetic vowel, whereas coda consonants from English are adapted with epenthesis or deletion. This is due to the fact that German and Italian loanwords are mostly adapted via reading. Different strategies are applied to English coda adaptation because English loanwords are conducted through oral speech more than borrowing from German and Italian.

4.2.5 Phonetically or phonologically driven?

By now, we have seen how coda consonants are adapted into Chinese languages. According to different corpus datasets, the illicit coda can be resyllabified with an epenthetic vowel, or it can be truncated. In world-final consonant cluster adaptation, the second consonant can be variably adapted with deletion or vowel epenthesis depending on the context. This can be attributed to the weak perceptibility of the second consonant and the type of the first consonant in the cluster (Kenstowicz, 2007; Miao, 2005).

In loanword adaptation, vowel epenthesis is widely found as the preferred strategy to repair the illicit syllable in the recipient languages, e.g. Shinohara (1997), Katayama (1998) on Japanese, and Kenstowicz (2007) on Fijian. However, the reason for vowel epenthesis in production is worth

[42] Kang provides a Korean example showing that in 1930s Korean, non-preconsonantal /s/ in English loanwords was variably adapted as lax /s/ or tense /s'/, the latter written as geminate <ss> in Korean orthography. Whether the English /s/ was written with a single or double <s> had a significant effect on the choice between the two adaptation patterns.

discussing since the epenthetic vowel is an excess segment only in the output representation. This subsection discusses the different nature of vowel epenthesis in loanword adaptation in previous studies.

Japanese only allows moraic nasal and the first half of a geminate in coda position. Itô & Mester (1995) use loanword data to show that when Japanese speakers encounter complex codas, they tend to use vowel epenthesis to fix the illicit structure. However, Dupoux et al. (1999) use experimental results to argue that the epenthetic vowel between the foreign CC structure in Japanese loanwords is entirely attributed to perception mistakes. In their experiments, participants were Japanese and French speakers. They created nonce words that formed a continuum ranging from trisyllabic tokens like [ebɯzo] to disyllabic tokens like [ebzo] by progressively removing acoustic correlates of the vowel from the original recording. The participants from both groups were asked to judge the presence of [ɯ] in the CC cluster of nonce word like [ebzo] and [ebɯzo].

Results from the Japanese group show that even when there was no acoustic cue of [ɯ] in the test items, Japanese speakers still judged the vowel was presented. In contrast, the French group was sensitive to the duration/existence of [ɯ]. In their ABX discrimination task, the Japanese group had difficulties to tell apart the test items with and without an epenthetic vowel; whereas, the French group did better on the discrimination task. Another thing that Dupoux et al. point out is that [ɯ] is phonetically short and it gets devoiced and shortened in Japanese; therefore, compare to other vowels, e.g. [i] in Japanese, [ɯ] causes more illusory perception.

Y. Kang (2003) also provides a detailed case study of vowel insertion in postvocalic word-final position in Korean loanwords from English, showing that when the native Korean phonotactic constraints are not violated, vowel epenthesis appears variably in postvocalic word-final position. Therefore, vowel epenthesis in such cases in Korean cannot be attributed to the native phonology.

She suggests that the variable adaptations can be attributed to the perceptual similarity between the English inputs and the produced Korean loanword outputs. Coda consonant release in English and Korean is asymmetric: Coda consonants in English may or may not be released due to their allophonic rules, whereas coda consonants are never released in Korean. Therefore, when the input is perceived in two ways, Korean speakers adapt the words in two ways—with and without vowel epenthesis. When the coda consonant in English is not released, there is no vowel epenthesis in Korean loanwords, and vice versa. She further claims that the appearance of vowel epenthesis, rather than being a phonological repair, may be a means of preserving phonetic details of the source language.

Peperkamp, Vendelin, & Nakamura (2008) identify the asymmetry of word-final nasal adaptations from English and French in Japanese loanwords. English word-final codas are adapted as a moraic nasal in Japanese loanwords, e.g. *pen* → *peN* (N = moraic nasal), whereas French word-final nasals are adapted with a following epenthetic vowel [ɯ], e.g. *Cannes* → *kannu*. They provide experimental evidence to explain that the asymmetry stems from the phonetic differences in the realization of word-final [n] release in English and French, and consequently to the way in which English and French word-final [n] are perceived by native speakers of Japanese. They further argue that loanword adaptations originate in perceptual assimilation that maps the non-native sounds and structures at the perceptual level onto the phonetically closest native ones without directly involving phonology.

However, the argument that vowel epenthesis is purely due to perception is debatable. Rose and Demuth (2006), Smith (2006), Uffmann (2006, 2007) and Paradis and Lacharité (1997) suggest that speakers' perception cannot solely account for all the vowel epenthesis cases in loanword adaptation.

Rose and Demuth's (2006) study on English and Afrikaans loanword incorporation into Sesotho focuses on the process of vowel epenthesis in word-initial and word-medial consonant clusters.[43] They argue that although both phonological and phonetic factors play a role in loanword adaptation, except for [s] initial consonant cluster adaptation, vowel epenthesis in loanwords from English and Afrikaans in Sesotho is mainly phonologically driven. Most of the epenthetic vowels depend on the phonological contrastive features of the surrounding consonants or vowels. The low back /ɑ/ rarely gets through the vowel copying process because it has no coronal-labial contrast in low dimensions in Sesotho. Rose and Demuth, therefore, use the theory of Contrastive Specification (proposed by Rice & Avery (1993)) to analyze the corpus data. The patterns observed in cluster repairing are straightforward. The place of articulation of the epenthetic vowel is copied from the feature of the first consonant in the cluster only when the consonant feature is contrastive. For example, to repair a labial-liquid sequence, the epenthetic vowel copies the [+round] from the left because [+labial] is a contrastive feature. To repair a coronal-liquid sequence, the epenthetic vowel is a coronal [ɪ] because coronal is a contrastive feature. However, when the first consonant is velar, instead of copying the dorsal feature from the left side, the epenthetic vowel is copied from the right side. For example, *knip* [knip] → [kinipi]. Velar consonants do not determine the quality of the epenthetic vowel because the dorsal feature is not contrastive in Sesotho. The placeless low back /ɑ/ gets copied in only two phonological environments: i) when the initial consonant is velar, which has no contrastive feature to spread to the epenthetic vowel; ii) when there is no available vowel on the right hand side of the epenthetic site and the initial consonant is a liquid, which is also underspecified with coronal feature. This is because /ɑ/ is an unspecified vowel in the language. They then further conclude that the selection of the epenthetic vowel in

[43] Rose and Demuth (2006) does not include word-final vowel realizations because it involves morphological factors of both the source and the recipient languages.

Sesotho depends on the specification of labial and coronal features of the surrounding consonants or vowels. Segments which are without specified features cannot not decide the quality of the epenthetic vowel. Vowel epenthesis in Sesotho loanwords can be explained by segment representation factors of Sesotho rather than phonetic factors or the default vowel strategy.[44]

Uffmann's (2006, 2007) study with corpus data on vowel epenthesis in Shona, Sranan, and Samoan loanwords stands against the phonetic-based model. He also argues that the epenthetic vowel is not just about the vowel quality and the default vowel account cannot account for all vowel epenthesis processes since vowel epenthesis can be done by vowel harmony and consonantal assimilation. Similar to Rose and Demuth's (2006) argument, the epenthetic vowel can receive all or some features of the surrounding segments. Although in all three languages that are under investigation look like they have a default epenthetic vowel according to which vowel is inserted most frequently, other phonological terms, i.e. vowel copying and consonant feature spreading, determine the quality of the epenthetic vowel as well. Similar to Rose and Demuth's study, the vowel epenthesis can be done via vowel copying and consonant feature spreading. In addition, Uffmann also observed that not all features are spread or copied equally. He further explains that high and front vowels are more likely to spread than low back vowels, and coronal and labial features spread more frequently than dorsal features. The default vowel appears to be the epenthetic vowel when spreading exceeded a certain language-dependent markedness threshold.

Smith (2006) provides evidence in English loanwords in Japanese to argue that using only a perception-based method is too restrictive to explain all cases of vowel epenthesis in loanword adaptation. Instead, phonological grammar also plays a role. As mentioned in Dupoux et al.,

[44] Only vowel epenthesis after [s] is explained with phonetic factor in Rose and Demuth (2006)

Japanese does not allow codas and consonant clusters. To repair such illicit structures, either vowel epenthesis or consonant deletion should apply. Smith shows that in many cases, one input can be repaired in both ways. She names them doublets. For example, English *pocket* → [pok.ke_]/[po.ket.to]. We can see that the ill-formed syllable is repaired by both strategies at the same time. She also observed that in general, the loanwords repaired with deletion are more likely to have an output repaired with vowel epenthesis. In addition, how words are borrowed, i.e. via auditory input or orthography, also affects the adaptation results. Auditory inputs lead to more deletion than orthographic inputs. Therefore, she argues that in those doublets, the form that is repaired with consonant deletion is due to perceptual similarity between the input and the output; whereas, the form repaired by vowel epenthesis is not. Perceptual similarity cannot account for all vowel epenthesis cases in Japanese loanwords because there are examples that show perceptual deletion (cf. Rose 1999) as well.

This section not only gives a background of how coda consonants are generally adapted in Mandarin, but also gives a background of how illicit codas are repaired with different methods within one grammar, how ungrammatical structures are fixed under phonological or phonetic mechanism, and how adaptation methods also influence the loanword outputs. In the next section, I will show how English coda [m] is repaired in SM loanwords in my corpus data and the patterns I observed.

4.3 How English coda [m] is adapted to Standard Mandarin?

4.3.1 The corpora

Three different corpora were used in this study. One comes from the Appendix I of *A New English-Chinese Dictionary*, the same as the one used for nasal insertion. The second one contains major American city names with English to Chinese transliterated forms from Google Maps

(Google Maps, 2015). The dictionary corpus has around 2400 British and American male and female names. The Google Maps corpus consists of 1,921 major city and state/province names of the United States and Canada. The third one consists of data I collected from public media, e.g. movies, newspapers, and magazines. In total, around 500 [m] in different syllable positions were examined.

Instead of just using the list in the dictionary and the self-collected data from the public media, I added Google Maps as another source because the dictionary corpus with the self-collected data do not have enough data for [m] in homorganic environments, such as [mb], [mp], [mf], and [mv]. Having enough data with this type of consonantal combination make my generalization more concrete.

In Chapter 2, I proposed that the existing loanword data are created by proficient Mandarin-English bilinguals because the data were generated by dictionary editors and professional translators. What types of proper nouns, how they are transliterated, and how the transliteration process affect the output in Google Maps will be discussed here.

Google's research team tackles the problem of transliterating from several source languages into several target languages by pivoting through an explicit intermediate phonetic representation. Brawer, Jansche, Takenaka, & Terashima (2010) have a case study on Google Maps of world maps in Japanese, Mandarin, and Russian. They suggest that based on phonetic or acoustic similarity between the sound strings of the source language and the recipient language, a large part of the transliteration can be automated by computer programming. This means that the place names presented in different languages in Google Maps are generated by computer programming.

The transliterated labels in Google Maps are not limited to place names. Many of them have a complex internal structure and contain names of people, e.g. street names, and organizations,

Washington Street. Labels in Google Maps also contain common nouns like city or river, which are not always transliterated. For example, there are meaning-based loan forms, such as *Grand Rapids* → 大(grand) 急流 (rapids) 城 (city). The research team focuses on those labels that are purely transliterated, i.e. sound-based loanwords.

Their investigation on Mandarin loanwords shows that all transliterated forms target a small subset of common Chinese characters.[45] To be more specific, fewer than 250 characters are used in the borrowed place names. When used in transliteration, these characters only denote sounds; their meanings are ignored. This confirms Lin's (2007) observation that some Chinese characters are used for the sound-based adaptation repeatedly of foreign proper nouns and the character meanings are mostly ignored. Lin also suggests that it is easier for people to process loanwords and separate them from native lexicons by using only a limited set of Chinese characters.

The Google research team follows the transliteration patterns identified in *Names of the World's Peoples* (1993), in which 58 languages of foreign names are transliterated based on the original pronunciation and spelling of the source language. Taking English as a source language for example, the transliteration is shown in a table with consonant and vowel combinations and with loanword specific Chinese characters, e.g. consonant [b] and vowel [i] together create 比 [pi:]$_{214}$, [m] in coda creates 姆 [mu:]$_{214}$. Table 4.3 provides an idea of what a transliteration table looks like.

Table 4.3 A self-created transliteration table for creating the outputs 比 [pi:]$_{214}$ and 姆 [mu:]$_{214}$

IPA	b	m
Vowel	布[pu:]$_{51}$	姆[mu:]$_{214}$
i, ɪ, j	比[pi:]$_{214}$	密[mi:]$_{51}$

[45] This dissertation only reviews their findings on Mandarin loanwords.

English spelling and pronunciation sometimes do not have an identical match. Hence the consonants and vowels are presented with IPA symbols. Transliteration amounts to a greedy leftmost-longest rewriting of the input string according to the table. This means that every segment tends to be retained and transliterated. This also means that the illicit coda and consonant clusters are repaired with vowel epenthesis, since if an illicit coda and segments in clusters need to be retained, excess vowels have to be added. Other than the Google research team, the National Academy Education Research in Taiwan uses their own consonant-vowel combination table to transliterate foreign scholars' names as well.

Different transliteration tables are used for different source languages because different segment phonetic features appear in different languages. According to the introduction section of *Names of the World's Peoples* (1993), these tables are created by bilinguals of the source languages and Mandarin Chinese. The Google research team suggests that although most of the place names can be modularized by programming based on the transliteration tables and other techniques, some intricacies are not easy to deal with.[46]

We can assume that whether the current transliteration on Google Maps are automated or not, bilingual speakers and phonetic similarity between the donor language and the recipient language play a role in the transliteration.

Now, we have an idea of how the existing corpora are created, especially Google Maps. Next, I will present how English coda [m] is adapted into Mandarin in different phonological environments.

[46] This is a conference presentation; the researchers did not specify what other techniques they use and what intricacies they encounter in the process. My assumption is that some fine acoustic cues may be missing if the program tends to keep all the segments in the source.

4.3.2 The corpus data and generalizations

By looking only at English coda [m], the main data from the corpora can be categorized into three types and each type occurs consistently under specific phonological environments. The data collected from different sources were analyzed together because the same patterns merge in the same phonological environments among words from different sources.

1. adapted forms with nasal place changes in SM loanwords, [m] → [n]/[ŋ],
2. those with vowel epenthesis, [m] → [mu], and
3. those that are variably adapted between nasal place change and vowel epenthesis.

Vowel epenthesis appears in SM loanwords when the English coda [m] is in word-final and word-medial non-homorganic environments. The examples in (15) illustrate how [m] in word-final and word-medial coda position in both monosyllabic and disyllabic words is adapted.

(15) English SM

a. [m] in word-final coda position in monosyllabic words.

Jim	[tɕiː.muː]
Kim	[tɕiː.muː]~[tɕin.muː]
Sam	[ʂan.muː]
Tim	[t^{h}iː.muː]
Tom	[t^{h}ɑŋ.muː]
Rum	[lɑŋ.muː]

b. [m] in word-final coda position in disyllabic words.

Abram	[aː.puː.laː.muː]
Beckham	[pei.k^{h}ɤː.han.muː]
Beerbohm	[piː.əɹ.p^{w}oː.muː]

Hingham [ɕin.əː.muː]

Salem [saː.lɤː.muː]

c. [m] in word-medial coda position in disyllabic words.

Armstrong [aː.muː.sɻː.tʂuɑŋ]

Beamsville [piː.muː.sɻː.wei.əɹ]

Camlin [kʰaː.muː.lin] ~ [kʰan.muː.lin]

Camrose [kʰaː.muː.lwoː.sɻ]

Plimsoll [pʰiː.liː.muː.swoː.əɹ]

The examples in (16) show that in either word-medial ((16)a) or word-final coda ((16)b) position, vowel epenthesis does not apply when [m] is followed by a homorganic obstruent.

(16) English SM

a. [m] in word-medial homorganic contexts [b/p/f]

Amboy [an.pwoː.jiː]

Columbia [ke.lun.piː.jaː]

Campus [kʰan.pʰuː.sɻ]

Humphrey [xan.fuː.lai]

Olympia [ao.lin.pʰiː.jaː]

Pampers [paŋ.pao.ʂɻ]

Tempa [tʰan.paː]

b. [m] in word-final homorganic contexts [p/f].

Camp [kʰan.puː]

Tempe [tʰan.pʰei]

Triumph [tai.an.fən]

The examples in (17) show that when the pre-[m] vowel in English is long or a diphthong, vowel epenthesis still applies even though [m] is followed by a homorganic obstruent.[47]

(17)

English	SM
Bloomfield	[puː.luː.muː.fei.əɹ.tɤː]
Shaumberg	[ʂau.muː.pɑu]

The examples in (18) show that variation occurs when English coda [m] is followed by a non-labial stop. In this context, [m] can be adapted with or without vowel epenthesis in loanword outputs.

(18)

English	SM
Binghamton	[pin.han.muː.tun]~[pin.haɴ.tun]
Camden	[kʰaː.muː.təŋ]~[kʰəɴ.tun]
Hamden	[han.muː.tun]~[haɴ.tun]
Palmdale	[pʰaː.muː.tai.əɹ]~[pʰaɴ.tai.əɹ]
Rumlow	[lɑŋ.muː.lwo]~[lɑŋ.lwo]
Sumter	[saŋː.muː.tɤː]~[saŋ̩.tɤː]

In the corpora, there are 279 cases of [m] in coda position. When English coda [m] is in word-medial and word-final non-homorganic contexts, the average vowel epenthesis rate in SM loanwords from the dictionary and from social media is 75.66%, whereas it is 82.7% from the Google Maps. Vowel epenthesis never occurs in SM loanwords in all the corpora when the coda [m] in English is in a homorganic environment and preceded by a monophthong. Table 4.4 and Table 4.5 show the counts and percentages of the appearance of vowel epenthesis in different phonological environments in different corpora.

[47] There are only 2 cases appear with this pattern.

Table 4.4 English coda [m] triggering vowel epenthesis in SM loanwords: word counts and percentage from the dictionary and social media

Phonological environments	Vowel epenthesis counts
Word-final	66/85 (77.64%)
Word-medial	28/38 (73.68%)
Homorganic (monophthong)	0/26 (0%)
Homorganic (diphthong)	N/A: no show in the corpus

Table 4.5 English coda [m] triggering vowel epenthesis in SM loanwords: word counts and percentages from Google Maps

Phonological environments	Vowel epenthesis counts
Word-final	24/30 (80%)
Word-medial	41/48 (85.41%)
Homorganic (monophthong)	0/52 (0%)
Homorganic (diphthong)	2/2 (100%)

In addition, I also observe that when [m] in English is ambisyllabic or in word final position, nasal insertion occurs, e.g. *Sammy* → [ʂan.mi:], *sauna* → [saŋ.na:], *Sam* → [ʂan.muː] and the place of the inserted nasal, in most cases, agrees in backness with its preceding vowel in English (cf. Hsieh, Kenstowicz & Mou 2009). Moreover, the epenthetic vowels are all [+round], [u] in most cases, and [o] in just two words.

4.4 Patterns observed in another corpus

One of the corpora used for English coda [m] adaptation is from an English-Mandarin dictionary, which was widely used in Taiwan. I also looked at a corpus generated by (Xīnhuá News Agency) from Mainland China. Xīnhuá News Agency is the biggest and most influential media organization in China and it is a ministry-level institution subordinate to the Chinese central government as well (Wikipedia).

This corpus consists of about 50,000 transliterated foreign words.[48] In these 50,000 words there are 2,074 words that have [m] in different syllable positions and in different phonological

[48] I call them foreign words because some spellings do not appear in English, e.g. [m] in word-initial consonant

environments.[49] See the following table for coda [m] adaptation in word-final, word-medial coda positions, word-initial consonant clusters, and homorganic environments.

Table 4.6 The counts of English coda [m] triggering vowel epenthesis in SM

Phonological environments	Vowel epenthesis raw counts
Word-final	1029/1029
Word-medial	485/485
Homorganic (monophthong)	19/557
Homorganic (diphthong)	3/3
Total	2074

Figure 4.1 The percentage of vowel epenthesis rate that English coda [m] is adapted with an epenthetic vowel in SM loanwords (Data from Xīnhuá News Agency)

In general, the observed patterns in the Xīnhuá News Agency corpus are very similar to the corpora used in the current study (see Table 4.4 and **Error! Reference source not found.** for comparison.). Word-medial and word-final codas are highly repaired with vowel epenthesis in SM loanwords.

clusters. In addition, some vowels are spelled as ö and ü, which are not typical English vowel spelling.

[49] [m] in syllable onset position is not included since they are always faithfully adapted.

Table 4.7 The comparison of vowel epenthesis rate in different syllable positions and phonological environments between the corpora used in the current study and the corpus from Xīnhuá News Agency

Phonological environments	Vowel epenthesis rate (Dictionary and self-collected data)	Vowel epenthesis rate (Xīnhuá News)	Vowel epenthesis (Google Maps)
Word-final	77.64%	100%	80%
Word-medial	73.68%	100%	85.41%
Homorganic (monophthong)	0%	3.4%	0%
Homorganic (diphthong)	N/A	100%	100%

Although vowel epenthesis appears when [m] is in homorganic environments with a lax prenasal vowel, the frequency is quite low, only 3.4%. Similar to the data from the dictionary, Google Maps, and self-collected loanwords from social media, vowel epenthesis is applied when [m] is in homorganic environments with a tense prenasal vowel. In both current corpora and the Xīnhuá News Agency corpus, cases of [m] in homorganic environments with a tense prenasal vowel are rare, only 2 in the current corpora and 3 in the Xīnhuá News Agency corpus.

The corpora used in this dissertation and the corpus from Xīnhuá News Agency are generated from different sources and are created by different people also from two Mandarin speaking communities sharing the same phonological grammar; however, similar generalizations are identified. The same patterns from another corpus indicate that the findings and the observed patterns of the current study are dependable.

We need to note that the transliteration of the Xīnhuá News Agency corpus is also based on the consonant-vowel combination chart as what the Google research team uses. We also need to note that, although Google Maps and the Xīnhuá News Agency corpus uses a chart to generate the data, the adaptors do not fully rely on the chart. Otherwise, there should be an epenthetic vowel after [m] when it is in homorganic environments because I previously mentioned that transliteration amounts to a greedy rewriting of the input string which begins at the first segment.

This means that every segment tends to be kept in the output. However, [m] is not adapted with [u] or [o] when it appears in homorganic environments in the source.

In the following section, I provide an account of the adaptation patterns of English coda [m] in SM loanwords from phonological and phonetic perspectives.

4.5 Proposed analysis

To fix illicit coda [m], there are three possible solutions: vowel epenthesis ([m] → [mV]), consonant deletion ([m] → ϕ), and nasal place change ([m] → [n/ŋ]). According to the corpora, among the possible repair strategies, although the illicit coda can be repaired by [m] deletion, such repair strategy is almost never chosen. Based on the Preservation Principle (Paradis, 1996, p. 3), under the bilingual-adaptor hypothesis, I propose this is due to the need for segment preservation (Paradis, 1996; Paradis & Lacharité, 1997). The segment information is maximally preserved when the illicit syllable is repaired through vowel epenthesis, even at the expense of adding a vowel and at the expense of a mismatch of syllable numbers. In other words, in general, vowel epenthesis should be preferred over deletion or nasal place change. This is true to the corpus data. Vowel epenthesis rates vary from 83.68% to 85.41% for the word-medial coda [m] and the word-final coda [m]. Deletion never occurs because it violates the Preservation Principle the most. Cases repaired by nasal place change are noticeably less frequent than those repaired by vowel epenthesis because only the less phonologically weighted place feature, [+labial], is deleted during the adaptation process; however, the manner feature, [+nasal] is always preserved. Resyllabifying the coda [m] to the onset position of the epenthesized vowel in SM loanwords not only preserves the manner feature but also the place feature of [m] from English. Malformation of syllables yields preservation of the existing segments through insertion of a vowel, but not deletion of the existing segment in the donor language.

I propose that vowel epenthesis is not led by speakers' perception. Peperkamp et al. (2008) show that English and French nasals in Japanese loanwords behave differently. Japanese speakers do not adapt English [m] with an epenthetic vowel. They use a moraic nasal instead. However, vowel epenthesis appears for nasals that originated from French. Peperkamp et al. (2008) argue that this discrepancy is due to a strong vocalic-like release after nasals in French but not in English. We can apply this English phonetic fact to [m] adaptation in Mandarin loanwords. Vowel epenthesis is not due to [m] release, because English nasals rarely have a vocalic-like release in production. Hence, we can further suggest that vowel epenthesis is not perception-based. However, it is phonologically driven.

Perceptual similarity explains why nasal place change is strongly preferred when [m] in the English input is in homorganic environments. When [m] is followed by a labial consonant, i.e. in a homorganic environment and preceded by a lax vowel in English, vowel epenthesis almost never appears in the existing SM loanword corpora. This can be attributed to weak or no audible release of [m]. In English, a stop-obstruent sequence is produced with a gestural overlap (e.g. [m.p]/[m.b]/[m.f]), such that there is weak or no audible release for the first stop (Browman & Goldstein, 1990; Henderson & Repp, 1982). Hence, vowel epenthesis never occurs in such homorganic environments and nasal place change always applies to fix the illicit coda [m].

According to the pattern observed in the corpora, it is interesting to note that prenasal vowel quality seems to affect the occurrence of vowel epenthesis after [m] in SM loanwords. We see that when English coda [m] is in homorganic contexts, vowel epenthesis never occurs, e.g. *Columbia* → [kɤː.lwən.piː.jaː]. In all these cases, the prenasal vowel is always lax. However, the corpus data also show that when the English pre-[m] vowel is long/tense or a diphthong, even when [m] undergoes homorganic condition, e.g. English [CVVmpV] → SM [CVV.muː.pVː], epenthesis still

occurs. I suggest that SM speakers prefer to match the vowel duration as the priority to fulfill the μμ-syllable constraint (Duanmu, 2000/2007; Y.-H. Lin, 2007) and meanwhile, they also want to retain the [m] from the input. By inserting a vowel after [m], the English long vowel/diphthong will occupy the rime slot in Standard Mandarin and leave the [m] with no place to fit in, since a super heavy syllables such as *[CVVm.pVː] is not allowed in Mandarin. Therefore, the [m] has to be resyllabified to the onset position with an epenthetic vowel in the following syllable, i.e. [CVV.muː.pVː]. In these cases, vowel epenthesis not only fixes the illicit consonant sequences, such as [mp] in SM, but also preserves the segment [m] and the nasal and labial features; meanwhile, the prenasal vowel is faithfully adapted. Another possible output when the English inputs undergo homorganic tense/diphthong condition can be [CVVmpV] → SM [CVN.pVː]. However, this is never the case in the corpus data. We can attribute this to the extremely small corpus data size for this condition. In addition, the prenasal vowel may not be as faithful and the Preservation Principle is not fully obeyed. For example, the word *Shaumberg* is adapted as [ʂaʊ.muː.baʊ] in the corpus data. If the output is [ʂɑŋ.baʊ], which also follows the phonotactic constraints of Mandarin, the prenasal vowel would be changed from [aʊ] to [ɑ] and [m] cannot be faithfully preserved. In other words, the input materials are not preserved as much as possible.

Variable adaptations only occur when [m] is in word-medial coda position following with an obstruent, e.g. *Camden* → [kʰaː.muː.təŋ]~[kʰən.tun]. I propose that variable adaptations occur as a result of various degrees of perception in regard to nasal place features. The perception of nasal place feature also depends on the following consonant. Hence, speakers are undetermined with the place feature. Ohala & Ohala (1993) suggests that consonant assimilation owes a great deal to acoustic-auditory rather than articulatory factors. They argue that although nasal consonants are a class that are very different from other stops, their place cue is measurably less salient than other

oral obstruents. I suggest that when the input is perceived with the bilabial feature, then vowel epenthesis occurs. If the bilabial feature gets ignored due to being perceptually less salient, then only the manner feature is retained in the output. For the current case, m + obstruent, perceptually speaking, the place feature of [m] is likely to be eliminated or weakened by the following obstruent. Hence, only the manner feature is retained in the Mandarin outcome, which is the form without vowel epenthesis. Such phenomenon is also demonstrated in Malécot (1958) and Ohala (1990) that listeners judge nasal in heterorganic environments as one place of articulation, and it is from the second segment, not the nasal.

Other than the perceptual similarity, vowel epenthesis can be explained by phonological syllable repair as well because vowel epenthesis in Mandarin loanwords are different in nature from Korean stops variable adaptations. Korean allows simple stops in coda position; whereas, Mandarin only allows [n] and [ŋ]. Therefore, variable adaptations in Korean occur when the phonotactic constraint is not violated. Hence, the process is phonetic centered. However, vowel epenthesis in Mandarin loanwords fixes the illicit coda. It can be argued for phonological reasons, i.e. syllable repair, segment retention, and feature retention.

4.6 Discussion

In the previous section, I proposed phonetic and phonological factors that may or may not trigger vowel epenthesis after [m] in Mandarin loanwords. However, it is puzzling whether vowel epenthesis in this process is phonological or perceptual centered. This section discusses vowel epenthesis from phonological and phonetic perspectives:

Phonological perspectives:

1. Mandarin syllable structure/phonotactic constraints
2. The Preservation Principle of Paradis and LaCharité (1996, 1997)
3. The quality of the epenthetic vowel

Phonetic perspectives:

1. Nasal place deviation in the data and [m] in homorganic environments
2. Vowel epenthesis after coda [m] and after other oral consonants
3. Variable adaptation in word-medial coda position

4.6.1 Syllable structure and Mandarin phonotactic constraints

In loanword adaptations, it is not uncommon that well-formed syllable structures in the donor language are ill-formed in the recipient language. For example, complex onsets and simplex/complex codas are permissible in English, however they are not permissible in Mandarin. Therefore, such structures must undergo the phonotactic constraints of the recipient language, Mandarin in the current study. Since /n/ and /ŋ/ are the only two licit codas in Mandarin, they are expected to be borrowed into Mandarin loanword identically. However, this is not always true (See discussion later). The bilabial nasal /m/, which is prohibited in coda position in Mandarin, needs to be adjusted to meet Mandarin syllable structure and phonotactic constraints through modifications. Similar to other coda consonant adaptations (cf. Miao 2005), vowel epenthesis is preferable in most cases when English coda [m] enters into the Standard Mandarin loanword system.

To fit the impermissible syllable to Mandarin phonology, consonant deletion is another repair strategy. T.-E. Kim's (2014) study on preservation and deletion in Mandarin loanwords investigates the cause of these two repair strategies. Her corpus has 1,218 words and the source

varies from a dictionary to internet portals and to previous loanword studies. She argues that Mandarin speakers' perception of the saliency of the segments and native phonology both affect the adaptation results.

Kim's study, very similar to Miao's (2005) study, shows that in general, adaptors prefer the strategy of vowel epenthesis over consonant deletion when repairing coda plosives, fricatives, and affricates. The segment preservation rate is higher when repairing affricates and fricatives than plosives. As for coda nasals, the two licit codas [n, ŋ], and the illicit coda [m], deletion rate is only 0.61%. According to the corpus patterns, Kim suggests that perceptually salient consonants, e.g. fricatives, affricates, and nasals, tend to be preserved through vowel epenthesis. Table 4.8 shows the general coda segment preservation rate and the preservation rate of different coda consonants in T.-E. Kim (2014).

Table 4.8 The ratio of preservation of English word-final consonant

Consonant type	Preservation rate (%)
Plosives	76.18%
Fricatives	82.80%
Affricates	89.21%
Nasal	99.39%
Overall	85.52%

The coda nasal preservation rate in Table 4.8 includes all three nasal, [m], [n], and [ŋ], adaptations. Table 4.9 shows comparison of the English coda [m] adaptation patterns found in the current corpora and Kim's corpora.

Table 4.9 Comparison of English coda [m] adaptation patterns in the current corpus data to Kim's corpus data

	Current corpus data	Kim's (2014) corpus data
[m] → [mV]	72.16% (145/201)	45.71% (16/35)
[m] → [n]/[ŋ]	21.35% (43/201)	26.3% (5/19)
[m] → Ø	0%	0%

Both datasets show that English coda [m] maps to [muː] in most cases. 93.75% and 99.9% of the time the selected Mandarin character is 姆. The epenthetic vowel of the two exception cases in my corpora is 默 [mwoː], e.g. *Amherst* → [ai.mwoː.xɤː.sɻː.tʰɤː]. We can see that whether the adaptors select [muː] or [mwoː], the inserted vowel always bears the [+round] feature (cf. Uffmann, 2007). Although Kim does not specify other epenthetic vowel(s) for adapting coda [m], I would assume that the inserted vowels other than [uː] and [oː] may be due to semantic factors or character selection because part of her data are brand names. In addition, similar to my observation of the current corpus data, Kim also points out that nasal place change is not an uncommon repair strategy.

Kim proposes that deletion of coda plosives and deviation of consonantal features are not only due to weak perception but that semantic factors and Mandarin orthography also play a role inside. However, the meaning of the selected characters is considered after perception similarity and after the native phonological constraints are taken care of. The following table shows the percentage of coda consonant deletion that is due to semantic and Mandarin orthographic factors.

Table 4.10 The English word-final consonant deletion percentages that are influenced by semantic factors and Mandarin orthography

Consonant type	Segment deletion due to semantic factors (%)
Plosives	59.46%
Fricatives	38.89%
Affricates	100%
Nasal	25%

(T.-E. Kim, 2014)

Table 4.10 shows the percentages of different types of consonant repaired by deletion caused by semantic factors among all the deletion cases. If we looked at Table 4.8 and Table 4.9, we can see that deletion does not usually happen. When it occurs, it can be attributed to semantic factors and Mandarin orthography. There are only 4 cases containing nasal deletion. Among these 4 cases, one of them is due to the meaning of the selected Mandarin character.

Both vowel epenthesis and segment deletion repair syllable malformations. Deletion may be due to perception of consonant types and syllable positions. In addition, among all the deletion cases, many cases can be attributed to semantic factors.

4.6.2 The Preservation Principle Paradis and LaCharité (1996, 1997)

English coda [m] repaired with an epenthetic vowel [u] in the corpus data can also be accounted for by the Preservation Principle proposed by Paradis and LaCharité (1996, 1997). The Preservation Principle makes sure to protect the input and resists segment loss. To repair illicit structures, for example, CC in the word-initial or in the word-coda positions, vowel epenthesis and deletion both form a grammatical output. We will get CVC after vowel epenthesis and C after consonant deletion. Both strategies lead to phonological constraint satisfaction equally. However, vowel epenthesis is preferred over deletion because it satisfies the phonological constraints and maximally preserves the segmental information simultaneously. Their study is based on a corpus consisting of 11,348 loanwords from five languages with 15,686 segmental and ill-formed syllables. Among the malformations, 12,320 (78%) of them are adapted via segment preservation. Only 559 (3.6%) ill-formed cases are repaired by consonant deletion. They further conclude that the segmental information in the recipient languages is maximally retained.

Similar to Paradis and LaCharité's findings, to repair the adapted coda [m] from English, deletion is nearly never picked because it does not help preserve any segmental information, neither place nor manner, whereas nasal place change only helps retain features that are perceptually salient, which is manner for [m]. Under the hypothesis that loanword adaptations are done by proficient bilingual speakers, the Preservation Principle predicts that the loan forms preserve the information that exists in the donor language as faithfully as possible, even at the expense of adding information. That is, in the case of English coda [m] adaptation, in order to

preserve all the input information of the English coda [m] and to obey the Mandarin phonological constraints, SM speakers add another vowel. The following table shows what segmental features are preserved through deletion, nasal place change, and vowel epenthesis.

Table 4.11 Preserved segmental information through different repair strategies

Repair strategy	Segment	[+nasal]	[+labial]
[m] → Ø			
[m] → [n/ŋ]	✓	✓	
[m] → [muː]	✓	✓	✓

Table 4.11 shows what segmental information is preserved when the ill-formed English coda [m] appears in Mandarin loanwords. We can see that when the illicit coda [m] is repaired by deletion, none of the features from the donor language are retained in Mandarin. When nasal place change occurs in Mandarin, the nasal segment is preserved and meanwhile, the [+nasal] feature is preserved. When the ill-formed syllable is repaired through vowel epenthesis, the nasal consonant is faithfully preserved; hence, the manner and place features are preserved in Mandarin loanwords. This means segment information is maximally preserved by vowel epenthesis. By following the definition of the Preservation Principle, vowel epenthesis is the optimal repair strategy since it preserves all the segmental information and satisfies the Mandarin phonological constraints, although an extra vowel is added. However, we need to note that the form with the maximal segmental information is not necessarily the most perceptually similar one because inserting a vowel leads to a change of syllable number, e.g. *Tom* → [tʰɑŋ.muː]. Syllable number changes from one in English to two in Mandarin. In Mandarin, it means one more character will be added.

4.6.3 Quality of the epenthetic vowel

Uffmann (2007) categorizes vowel epenthesis in different loanword systems into three groups:

1. Default segments
2. Vocalic spreading
3. Consonant assimilation

Default segments. The default epenthetic vowel is language specific. It is the phonetically shortest and perceptually most confusable vowel (Steriade 2009) in the language. For example, the default epenthetic vowel in Japanese loanwords is [ɯ] (Park, 1986; Shinohara, 1997; Katayama, 1998); in English there is sometimes a schwa observed in consonant clusters, though consonant clusters are permissible in English, e.g. *Arm* [aɹəm] (Hall 2006). Kenstowicz (2007) also claims that the default epenthetic vowel in Fijian loanwords is the phonetically shortest [i] and that the inserted vowel never bears the primary word stress. As for SM, all vowels are almost equal in length so there is no default vowel for vowel epenthesis.

Phonologically, the default epenthetic vowel is the least specified vowel according to the underspecification theory (Archangeli 1988, Itô & Padgett 1995, Pullyblank 1988 on Yuroba, Abaglo & Archangeli 1989 on Ganbe). The mid vowel [ə] is the least specified vowel in SM. Due to the phonotactic constraints of Mandarin, [ə] cannot appear in an open CV syllable. However, due to its allophonic changes in different phonological environments, it can be argued as the default vowel for epenthesis (see discussion in ***Consonant assimilation*** below).

Vocalic spreading. The epenthetic vowel can be copied from the preceding or following vowel, e.g. the epenthetic vowel in Sranan is the same as the one that exists in the word (Uffmann 2007). Paradis (1996) also finds that in Fula, the epenthetic vowel is determined by the nearest vowel or vocoid in the word. This is not likely related to vowel epenthesis in SM native phonology and loanword adaptation. Every syllable represents one character. Vowel copying is not a phonological phenomenon in SM.

Consonant assimilation. I argue that vowel epenthesis after [m] in Mandarin loanwords falls into the consonant assimilation realm. The two epenthetic vowels after [m] are [u] and [o]. As mentioned before, [u] is the most common epenthetic vowel after [m]. Although [o] also appears, there are only two cases in the current corpus data. It does not matter which of the two vowels is inserted to fix the ill-formed syllable; they all receive the labial feature from the preceding consonant [m]. Such assimilation process is also found in loanword systems crosslinguistically.

Hyman (1970) shows that [u] is inserted in labial contexts in Nupe. Smith (1977) shows that the default epenthetic vowel in Haya is [i]; however, [u] takes place in the labial environments. Within the SM loanword system, the most common vowel that is inserted after other labial consonants, i.e. [b, p, v, f], also receives the labial feature of the preceding consonant, e.g. *Bob* → [pao.pwo], *Gap* → [kai.p^{h}uː]/[kai.pwoː], *Dove* → [tɤː.fuː], *Jeff* → [tɕjeː.fuː]. Hence, the epenthetic vowels are rounded vowels, for example, [u] and [o] in most cases. This is observed in the current corpora as well.

It seems that vowel epenthesis in SM does not fall into the default segment category and the inserted rounded vowel is assimilated by its preceding consonant [m]. One other analysis I propose is that the epenthetic vowel is [ə] underlyingly and it changes or assimilates to different surface representations in different phonological environments.

The default epenthetic vowel should be the least specified in the recipient language. The mid vowel [ə] is the least specified and the most malleable vowel in Mandarin. I propose that when vowel epenthesis occurs in Mandarin loanwords, the default vowel [ə] changes to its allophones in different contexts. See (19) below for the related distribution of /ə/. This analysis explains why labial coda consonants are sometimes repaired by [o] and it also explains why the epenthetic vowels are different after different consonants.

(19) The distributions of [ə]:

a. [o] in a diphthong followed by [u], and in syllable final position preceded by the glide [w], e.g. 都 [tou]55 ‘all’ and 波 [pwo] ‘wave’

b. [ɤ] in an open CV syllable, e.g. 歌 [kɤː] ‘songs’

English coda [m] is nearly 100% adapted with [u] to form a licit syllable in Mandarin. I claim that [u] is chosen due to consonant assimilation. However, some English coda [m] and other labial English coda consonants, such as [b], and [f], are adapted as [pwo] and [fwo], e.g. *Hebrew* → 希伯来 [ɕiː.pwo.lai], *Jeffrey* → 杰佛瑞 [tɕje.fwo.ɹwei]. We can leave the matter of the orthography aside because 布 [puː] and 福 [fuː] are also commonly used in loanword adaptation.[50] If we assume that [ə] is the underlying epenthetic vowel and also take the distributions of [ə] into account, the surface form in loanwords is [woː]. The reason that [uː] is chosen more often than [woː] may be due to [Cuː] being perceptually more similar than [Cwoː]. If [woː] is picked, not only is the vowel epenthesized, but also an extra glide is inserted. This analysis can also explain why alveolar and velar codas are adapted with the mid back unrounded vowel [ɤː]. The mid vowel [ə] is inserted underlyingly, and it changes to [ɤː] in open CV syllables, e.g. *Grant* → 格兰特 [kɤ̲ː.lan.tʰɤ̲ː], *Jack* → 杰克 [tɕje.kʰɤ̲ː].

English coda [m] being adapted with a rounded vowel in SM loanwords can be explained by the need to satisfy phonotactic constraints. Vowel epenthesis prevails over the other two because the existing loanwords are created by bilinguals. The bilinguals tend to preserve all the segment information from the donor language.

[50] The labial voiced fricative [v] is not included because it is adapted as [w] in most cases.

Besides the phonological reasons, perception of the fine acoustic cue could play a role in the process as well. In the following section, I will discuss how perception also affects the adaptation results.

4.6.4 Nasal place deviation and [m] adaptation in homorganic environments

The corpus data follow the Preservation Principle prediction and show that vowel epenthesis is preferred in most cases. However, in the data, and many cases outside the current corpora, some cases of coda [m] are replaced by [n] or [ŋ], which are the only two permissible codas in SM; for example, *Adam* → [jaː.taŋ], *[jaː.taŋ.muː], *Harlem* → [xa.lin], *[xaː.li.muː]. SM speakers will not judge that they are wrong, but they would say they are not conventional.

By changing the place of articulation of coda nasal [m], the syllable structure can be fixed as well; however, segmental information is only partially preserved. When such deviations occur, the manner feature, [+nasal], is always preserved, whereas place feature deviates. Y.-H. Lin (2011) also points out that although [n] is licit in coda position in SM, an English coda [n] sometime changes to [ŋ] in SM loanwords or vice versa (also see Miao (2005)). According to Y.-H. Lin (2011) and the current in use dataset, we can see that the place feature of nasal consonants can be either retained through vowel epenthesis or deviated through nasal place change. The changeability on the place feature suggests that not all features are equally perceptual salient or of the same weight phonologically (c.f. Ohala & Ohala (1993)).

To be more specific, manner features are more perceptually salient and more phonologically weighted. In addition, compared to non-nasal consonants, nasal consonants are the most common form of place assimilation in world languages (Ohala & Ohala 1993, p. 241). Nasal place deviation in loanword adaptations can be attributed to the property of the ease of place assimilation of nasals. Ohala (1993) suggests that nasal place change is attributed to acoustic-auditory rather than

articulatory factors. He also suggests that nasal consonants are highly distinct from other consonants because the place cues of nasal consonants are not as salient as oral stops. Kawahara and Garvey (2014) also suggest that typologically, the place feature of nasals assimilates with the following consonants easier than with other plosives. They use perceptual data with nasal stops, voiceless and voiced stops, and combine them with different places of articulation, bilabial, alveolar and velar, to show that the place contrasts in nasals are perceptually weaker than the place contrasts in oral stops; therefore, speakers are more willing to neutralize the place of the nasal consonants. Due to the perceptually less salient place feature of [m], coda [m] is sometimes adapted as [n] or [ŋ] in Mandarin loanwords.

In the corpus data, when [m] is in the homorganic environments, such as [mb], [mp], [mv], and [mf], vowel epenthesis nearly never occurs in Mandarin loanwords. To repair, it changes to either [n] or [ŋ]. Now we know that the deviation is due to weak perception of nasal place. I argue that the tendency of weak perception of nasal place can be especially strong in homorganic environments, when the place of [m] fully or partially overlaps with the following consonant. The nasal place is decided by the backness of the English pre-nasal vowel. This tendency is especially strong when the English prenasal vowel is low because of rime harmony in Mandarin (cf. Hsieh et al. (2009) and data in Chapter 2).

4.6.5 Adaptation of coda [m] and other oral codas

Although, except for [n] and [ŋ], codas are not allowed in Mandarin, obstruent codas get deleted more than nasal codas (e.g. *Scotland* → [suː.kɤːlan]/*[suː.kɤː.tʰɤː.lan.tɤː] vs. *Sydney* → [ɕiː.niː]/*[ɕiː.tɤː.niː]). The examples show that obstruent codas are repaired by deletion, although the forms repaired by vowel epenthesis are also grammatical.

I propose that for nasal retention, consonant sonorancy plays a role during the adaptation process. The major difference between oral and nasal stops is sonorancy. Nasal retention in loanwords suggests that [+sonorant] consonants are more likely to retain. By following the sonority hierarchy below, we can see that nasals are ranked higher than stops by two levels.

(20) Sonority hierarchy (more sonorous → less sonorous) (Lin, 2007, p. 110)

Vowels (low, mid, high) > Approximants > Nasals > Fricatives > Stops/affricates

This argument can be supported by coda cluster adaptation examples. For example, *cast* → [kʰaː.sɤː] and *Alexis* → [aiː.liː.saiː.sɤː]. When adapting the coda consonant clusters of fricative-obstruent/obstruent-fricative sequences, the obstruent often gets deleted. This is because fricatives have a high frequency so they are more sonorous than the obstruents, hence, more perceptual salient. Another reason can be that obstruents in such position are not released or with weak non-audible release; hence the listeners do not perceive it as an important cue. However, in syllable onset position, all consonants in the cluster tend to be preserved via vowel epenthesis, e.g. *Steve* → [ʂɤː.tiː.fuː].

Nasal consonants are [+sonorant] phonologically; hence, they are more perceptually salient than other oral consonants. The perceptual saliency makes nasal consonants rarely get deleted in Mandarin loanwords. As for coda [m] adaptation, the [+nasal] feature is always retained. It can be repaired by vowel epenthesis to have both the place and the manner feature preserved. It can also be repaired by changing the nasal place to either [n] or [ŋ]. As discussed previously, the deviation on place is due to its weak perception in the syllable coda positions.

4.6.6 Variable adaptation in word-medial coda position

The findings with regard to variation in consonant adaptation seem to be inconsistent. This can be discussed from phonological and phonetic/perceptual perspectives. Phonologically, vowel

epenthesis and nasal place change both repair the illicit coda [m] from English. If the existing loanwords are created by fluent bilinguals, the epenthetic vowel helps preserve all the features and segments from the donor language, although with the expense of adding an extra segment. Nasal place change also repairs the syllable by retaining only the [+nasal] feature; however, the less salient place feature is changed. This confirms what I discussed in §4.6.4. Which permissible nasal in Mandarin is chosen is decided by the backness of the prenasal English vowel (see Chapter 2 for details). Hsieh, Kenstowicz, and Mou (2009) argue that variation in nasal coda when preceded by a low vowel is best accounted for by appeal to perceptual saliency of the F2, the backness of the English prenasal vowel.

The variable adaptations of English word-medial coda [m], similar to other consonant adaptations, can be related to where the English coda [m] is located. Miao (2005, p. 150-1) mentions that when the stops are in coda position, there is some degree of variation in adaptation in English voiceless stops to SM voiceless stops, either aspirated or unaspirated, due to the perceptual weakness and /or variation in stop releases of English coda stops. However, [m] in coda is never fully deleted because it is a sonorant. Besides the feature of consonant itself, Logging (2010, p. 94, 109) also points out the need to consider syllabic position and/or contextual cues, since it is likely that in less prominent positions, the effects of perceptual cues may show up. However, this cannot explain why variable adaptations rarely appear when [m] is in word-final coda position in the corpus data.

Two possible explanations are provided to explain variable adaptation. One is related to adaptation methods, and the other one is related to speakers' perceptions. The two loan forms are borrowed into SM via different channels (cf. Smith, 2006 on doublets of Japanese loanwords). As I mentioned in the corpus sections §2.3.2 and §4.3.1, loanwords in Mandarin can be adapted

through reading the original spelling with a consonant-vowel combination chart and through listening. The latter is more likely to cause variable adaptation.

From the view of perception, nasal place deviation is due to weak perception of place. Ohala & Ohala (1993) also suggest that nasal place assimilation owes a great deal to acoustic-auditory factors. Hence, in the adaptation process, if the adaptors perceive the nasal and its place of articulation, vowel epenthesis appears in the loan form. In contrast, if the adaptors ignore the relatively weak place feature of [m], then only the manner feature will be preserved. Hence, [m] changes to one of the licit coda nasals in Mandarin. Presumably, adaptation can be variable between and within speakers. That is, different speakers treat the nasal place feature differently and one person can also perceive the nasal place in various ways based on the quality of spoken inputs.

4.7 Conclusion

Based on the corpus data, this chapter provides a detailed contextualized analysis of how coda [m] is adapted into SM loanwords. According to the corpus data, vowel epenthesis generally occurs in Mandarin loanwords when the English [m] is in word-medial and word-final positions. However, this is not always true. When [m] is in homorganic environments and the prenasal vowel is lax, vowel epenthesis almost never appears in the outputs. This is observed in both word-medial and word-final positions, e.g. *Olympia* → [au.lin.piː.jaː], *[au.liː.muː.piː.jaː] and *Camp* → [kʰan.pʰuː], *[kʰan.muː.pʰuː]. However, when the prenasal vowel is long or a diphthong, vowel epenthesis appears even when the coda [m] is in homorganic contexts, e.g. *Bloomfield* → [puː.luː.muː.fei.əɹ.tɤː]. In addition, when English coda [m] is in word-medial position and followed by a non-labial obstruent, forms with and without vowel epenthesis appear in the Mandarin

loanword system, e.g. *Camden*→[kʰaː.muː.təŋ]~[kʰən.tun]. The patterns identified in the current corpora are also observed in the Xīnhuá News Agency corpus.

The adaptation process can be explained with phonological and phonetic factors. However, it is best explained by the phonological based approach (Paradis, 1996; Paradis & LaCharité, 1997; LaCharité & Paradis, 2005) and the perceptual similarity approach (Silverman, 1992; Yip, 1993; Steriade, 2009; Kang, 2003; and Kenstowicz 2005).

The camp of phonological based approach assumes that loanwords are dominantly created by bilingual speakers and all the segment features are maximally preserved. Based on this assumption, this model well explains the illicit coda [m] repaired by vowel epenthesis and as well as when [m] is in homorganic environments with prenasal vowel lax, although only the nasal feature of [m] is preserved. The word-medial and word-final coda [m] repaired with vowel epenthesis shows that the segmental features of [m] are fully retained. As for [m] in homorganic environments, if we followed the hypothesis of the Obligatory Contour Principle (OCP) that consecutive identical features are banned in underlying representations, then there is only one labial feature linked to the two adjacent labial consonants in the English input. Hence, all the input features are preserved in the SM loanword outputs.

The phonological based approach can also explain the variable adaptation cases from a syllable repair perspective as well. Whether the English coda [m] is adapted with vowel epenthesis or it changes its place of articulation to [n] or [ŋ], the illicit syllable appearing in SM is repaired by the SM phonotactic constraints. In addition, the phonologically heavier feature (compared to the place feature), the manner feature, is preserved in the Mandarin loanword outputs.

On the other hand, the perception based approach only well explains the adaptation when [m] is in homorganic environments and those that are adapted with two forms. In homorganic

environments, vowel epenthesis is not chosen because of the overlap of articulatory gestures between the two labial consonants. Mandarin speakers, hence, may only perceive the more salient [+nasal] feature and ignore the labial feature of [m].

For variable adaptation cases, the nasal place feature is variably preserved when the coda [m] is followed by another obstruent. Variation can be due to the words entered through speaking and listening (cf. Smith, 2006). Hence, perception plays a crucial role inside. The perception-based approach cannot well explain the cases that are repaired by vowel epenthesis. Although vowel epenthesis can be due to perception illusion (cf. Dupoux et al., 1999), based on the corpus data and the identified patterns, vowel epenthesis is more like a syllable structure repair by bilingual speakers (cf. Preservation Principle (Paradis, 1996; Paradis & Lacharité, 1997)). We need to be aware that retaining all the segments from the source language does not necessarily mean the loanword outputs are perceptually more similar than those repaired with deletion or articulatory place change because the epenthetic vowel in loanwords does not exist in the source and adding a vowel leads to syllable number mismatch.

As for the perceptual similarity approach, given that the sound-based loanword outputs are created to be as close to their inputs as possible, an output with perceptually minimal modification would be preferred over the one with perceptually non-minimal modification. If we assume that the input is an acoustic signal and apply this idea to English coda [m] adaption, deletion is nearly never chosen because it causes a bigger perceptual difference between the input and the output than vowel epenthesis and nasal place change.

With the same assumption, Silverman's two scansion model seems to explain why vowel epenthesis is preferred. At the Perceptual Level the native segment constrains the representation of the English coda [m]. At the Operative Level the perceived [m] undergoes the true phonological

operation, triggered by the Mandarin phonotactics constraints. Since the data are created by proficient bilinguals who tend to maximally preserve the features of [m], vowel epenthesis is chosen as the syllable repair strategy. However, Silverman's model cannot explain why the weak labial feature of [m] is almost always preserved at the Perceptual Level.

As for the adaptation in homorganic environments, [m] is nearly never adapted to [muː]. Wright (2004) states that "the acoustic signal is produced by articulations that are continuous and overlapping to a greater or lesser degree; therefore, the resulting acoustic cues vary with context" (p. 36). Combining Wright's conclusion and Silverman's multiple scansion model, we, therefore, can assume that at the Perceptual Level, the bilingual adaptors perceived the nasal and labial features of [m]. However, the labial features from [m] and the following labial consonant are greatly overlapped. The labial feature of [m] is less perceptually salient than its nasal feature; hence, at the Operative Level, only the nasal feature and the labial feature of the next labial oral consonant are mapped to Mandarin. Moreover, the nasal place is decided at the Operative Level by the native Rime Harmony constraint (cf. Duanmu, 2007; Hsieh et al., 2009).

Based on the different existing corpora, we can conclude that although English coda [m] adaptation involves phonetic and phonological nativization. However, I argue that it is mainly phonologically driven. Orthography plays a role, but minimally. The channels of how the foreign words enter into the Standard Mandarin loanword system also decide whether the ill-formed syllable should be repaired by vowel epenthesis or nasal place change.

Vowel epenthesis is the default syllable repair strategy. It undergoes the true phonology of Mandarin phonotactic constraints. When [m] appears in homorganic environments, from a perception perspective, I argue that the adaptors still perceive [m]. However, perception decides which phonological repair strategy makes the outputs more similar to the inputs. From a

phonological perspective, the two labial segments are linked to one labial feature in order to not violate the OCP. Hence, in the loanword outputs, there is only one labial feature preserved, which is from the onset in the input.

The next chapter will present perceptual experimental results of how English coda [m] is adapted in Mandarin loanwords.

Chapter 5 Perceptual Experiment II: Coda [m]

5.1 Introduction

In Chapter 4, I presented how English coda [m] is adapted into Mandarin loanwords in corpus data. I also proposed an analysis with possible phonological and phonetic explanations, which explains why vowel epenthesis, nasal place change, and variable adaptation happen in different phonological environments.

My major claims are:

1. The adaptation of coda [m] is constrained by perceptual or phonetic similarity of the foreign inputs and the Mandarin loanword outputs. Perceptual similarity limits the number of possible Mandarin outputs. The adaptors create loanwords that share adequate similarity with the donor language, and
2. Besides input-output perceptual similarity, the SM outputs should be constrained by the native phonology as well. After the perceptual similarity stage, the adaptors adjust the perceived phonetic cues and make them fit into SM native phonology.

In order to test whether the observed loanword patterns in Chapter 4 mirror the Mandarin monolingual and Mandarin-English bilingual online adaptation patterns, perceptual similarity experiments were conducted and run on Mandarin monolingual speakers and Mandarin-English bilingual speakers. My main goals were:

1. to investigate whether online perception of solicited loans conforms to the generalization identified in the corpus data, and
2. whether or not SM speakers with different levels of English exposure/proficiency behave differently.

Test items and filler items are the same as those used in intervocalic nasal adaptation. The test items for nasal insertion are treated as filler items here. There is also a set of filler items without nasal consonants. The experimental design and restrictions on phonological environments were based on the identified generalizations and findings in the corpora presented in Chapter 4. The following phonological environments of [m] were tested:

1. word-medial coda position,
2. word-final position,
3. homorganic environments with a prenasal lax vowel, and
4. homorganic environments with a prenasal tense vowel or diphthong

In this chapter, I present the experimental results and revisit the proposed analysis presented in Chapter 4. The organization is as follows. I present the methodology, prediction and hypotheses in §5.2. Participant information will not be presented in detail in this chapter. Detailed information can be referred back to §3.2.1. I present the experimental procedures in §5.3. In §5.4, I present experimental results. General discussion is given in §5.5, which shows that in general, the experimental results in general pattern with the generalizations observed in the corpora. I draw my conclusion in §5.6.

5.2 Methodology

5.2.1 Participants

Participants are the same as those who participated in the nasal insertion experiment. There are 33 participants in the Mandarin monolingual group and 24 participants in the Mandarin-English bilingual group. The monolingual group was run in National Taiwan Chengchi University and the bilingual group was run in Michigan State University. See §3.2.1 for detailed information of participants' language backgrounds and how their English proficiency was assessed.

5.2.2 Prediction and hypotheses

Predictions. Based on the patterns identified in the nasal insertion corpus data, specific predictions of the experimental results are stated below.

Regarding the English coda [m] adaptations, the patterns identified in the experimental results would be the same or very similar as those identified in the corpus data, especially for the results from the bilingual group, i.e. vowel epenthesis with English coda [m] adaptation depends on its syllable position and phonological environments. I predict that vowel epenthesis would often appear in Mandarin loanwords when English coda [m] is in word-medial and word-final position, e.g. *Wilmslow* and *Beckham*. However, when English coda [m] is in homorganic environments and when the prenasal vowel is a lax monophthong, vowel epenthesis would rarely appear for syllable repair in Mandarin loanwords, e.g. *Columbia* and *Trump*. However, when the prenasal vowel is long or a diphthong, even in homorganic environments, vowel epenthesis should still apply, e.g. *Bloomfield*. The [m] is resyllabified to the onset position with an epenthetic vowel of the next syllable in Mandarin. Variable adaptation emerges when coda [m] is followed by an obstruent, e.g. *Camden*. More examples for the process can be found in §4.3.2.

Major hypotheses. Based on the generalizations and the proposed analyses in Chapter 4, I hypothesized that:

1. Vowel epenthesis would appear more than nasal place change when English [m] is in word-medial and word-final position. The bilingual group would show a stronger vowel epenthesis tendency than the monolingual group, following the Preservation Principle.
2. When [m] is in homorganic environments with a prenasal monophthong lax vowel, vowel epenthesis rate would be significantly lower than nasal place change.
3. English coda [m] repair is phonologically driven. Bilinguals and monolinguals may have different syllable repair strategies.

5.2.3 Materials: test items, possible outputs, and filler items

The English inputs were read aloud carefully by a female native American English speaker from Michigan with linguistics training. The possible Mandarin loanword outputs were produced by one single female native Mandarin speaker from Taiwan who does not speak any Chinese dialect and who also has linguistics training. The stimuli were tokens in a three-word series. Each sound string consists of two possible adapted loanword forms in Mandarin and a pseudo word. The order of the words is {Mandarin, Mandarin, Input}.

The devices used for recordings were a Blue Yeti USB microphone and a MacBook Air. The Blue Yeti microphone was on its cardioid mode that only records sound sources that are directly in front of the microphone. The recording sample rates were 16 bit/48 kHz. The application used for the recordings was Praat (Boersma & Weenink, 2020). All the test items and filler items were recorded in the phonology-phonetics laboratory under the Linguistics Department at Michigan State University.

5.2.3.1 Test items

The test items were designed by following the patterns or the generalizations observed in the corpus data.

The test items had English coda [m] in word-medial coda ([ˈlimdi]), word-medial homorganic coda with prenasal lax ([ˈlɪmbi]) and tense ([ˈlimbi]) monophthongs and diphthong [aʊ] ([ˈgaʊmbi)), and word-final coda ([ˈlidim]/[lim]) positions. Syllable number varies between one and two for word-final coda test items. The first syllable bears the primary stress when the test item is disyllabic (a full list can be found in the appendix (Table A.3)).

The tenseness of the preconsonantal vowel in the inputs affects the vowel epenthesis rate in Korean loanwords, i.e. English preconsonantal tense vowel triggers more vowel epenthesis (c.f. Y. Kang, 2003). All the English inputs in the current study also had all the lax, tense vowels, and one diphthong [aʊ] occupying the prenasal vowel position. Among all the English diphthongs, [aʊ] was picked because it is the only diphthong found in the corpus that precedes [m] under the homorganic condition, e.g. *Shaumberg* → [ʂaʊ.muː.baʊ].

A set of monosyllabic pseudo words with the grammatical alveolar nasal consonant in coda position was tested. This set of test items was paired with another set of monosyllabic test items that end with [n] in coda position. The results would allow us to see whether the participants tend to have vowel epenthesis due to consonant release.

5.2.3.2 Possible outputs

Each test item has two possible Mandarin outputs. One adopted nasal place change repair strategy, and the other used vowel epenthesis. Tone 2 was assigned to the stressed syllable in disyllabic and the monosyllabic test items. The tone for [mu] combination always bears tone 3 since besides the two [mò] cases found in the corpora, [mǔ] is the only possibility found. H. I. Wu

(2006) also noted that the epenthetic vowels in Mandarin loanwords are usually associated with tone 3. This may be because tone 3 in Mandarin is with the lowest pitch, hence, the least perceptually salient. For example, the participant heard sound strings like {SM[li2mu3di], SM[lin2di2], ENG[ˈlimdi]}, and {SM[li2mu3], SM[lin2], ENG[lim]}.

5.2.3.3 Filler items

There are two sets of filler items. One set was with nasal consonants, and the other set was without. The set with nasal consonants consists of the test items in the nasal insertion experiment. The set without a nasal consonant has 40 items (a full list can be found in the appendix (Table A.4)).

5.3 Procedures

The experiment was run on PsychoPy (Peirce, 2007). All the participants were told at the beginning of the experiment that the experiment is about how they would borrow new words from English to Mandarin via listening. They were told that the words they would encounter later during the experiment would be newly created American place names. The participants had to pick the output that was the most perceptually similar to the English input from A and B. Because this experiment is purely perceptual, Chinese characters and English spellings were not shown to the participants. They only saw option labels A and B on the screen and they used the left arrow key to choose A and the right arrow key to choose B. Before the participants started the real task, they had to go through a practice session. The words in the practice session included some low frequency English words, e.g. *leep*, *gad*, *molty*, and common English names, e.g. *Charlene*, *Kent*, *Derick* so the participant were trained for what they needed to do. The procedure and the instruction given to the participants are the same as the procedure of the experiment on nasal insertion. Refer to §3.3 for detailed information.

5.4 Results

I compared vowel epenthesis rates after [m] and [n] in monosyllabic words. This comparison gives us information about whether the participants took the experiment carefully. The results also show whether participants would add another vowel when it is unnecessary, i.e. after coda [n], a licit coda in Mandarin.

Figure 5.1 Vowel epenthesis rate of monosyllabic words when the coda is [m] and [n]

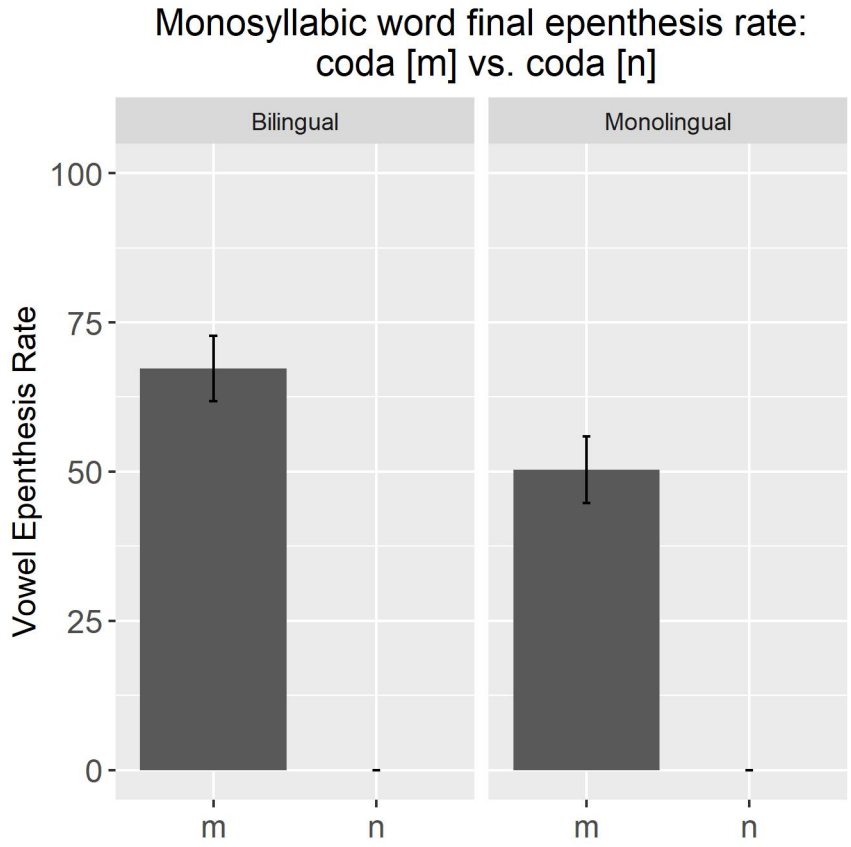


Figure 5.1 shows that speakers from both groups use vowel epenthesis to fix the illicit coda [m]. ANOVA reveals that there is a significant effect of bilingualism. The results indicates that the vowel epenthesis rate of the bilingual group is significantly higher than that of the monolingual group [t(53.904)=2.182, p=0.03]. There is a highly significant effect of nasal type [F(1,

110)=210.797, p<0.001]. There is significant interaction between bilingualism and nasal type [F(1, 110)=4.492, p=0.04]. The results indicate that:

1. Bilingual speakers tend to preserve the coda [m] and repair it with vowel epenthesis.
2. Monolingual speakers seem to not have a repair strategy preference, i.e. vowel epenthesis and nasal place change are both in use and are adopted by chance.
3. When there is no need for repair, both groups never add an extra vowel.

5.4.1 Results from the monolingual group

Based on the generalization identified in the corpus data, I looked at [m] in four different environments—word-final and word-medial coda positions, and homorganic environments with monophthongal and diphthongal prenasal vowels in the perceptual similarity experiment data. The results show that speakers with different language backgrounds use different strategies to repair ill-formed syllables. Moreover, similar to the corpus data, SM speakers use different strategies to repair the ill-formed coda when it appears in different phonological environments.

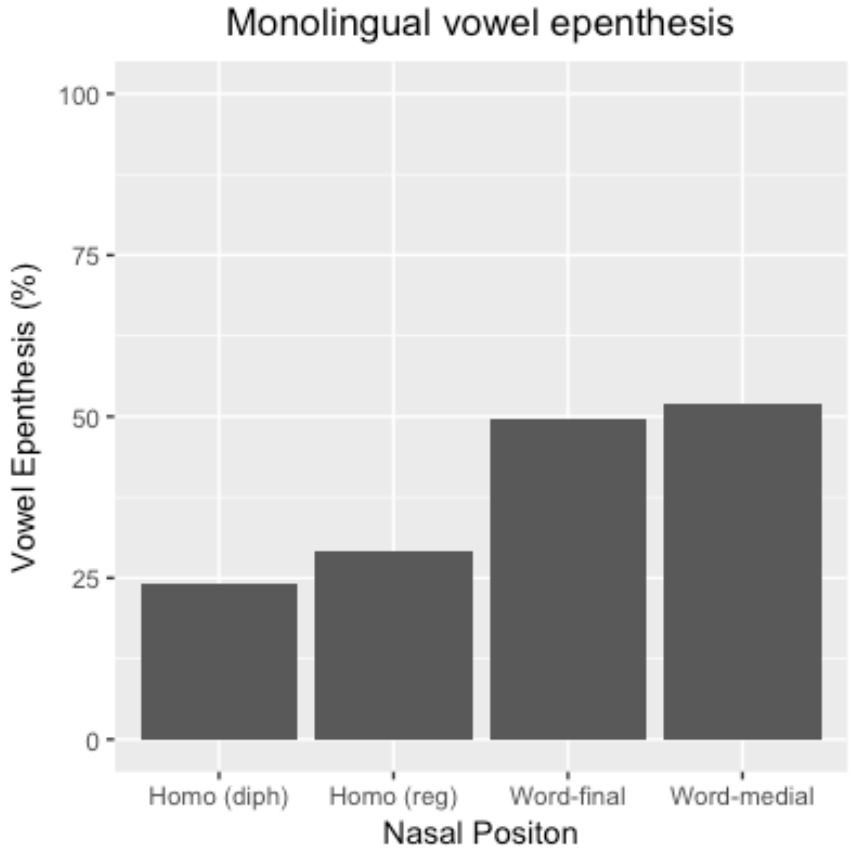
Table 5.1 presents the monolingual groups' vowel epenthesis rate in percentages when English coda [m] is in different phonological environments.

Table 5.1 Vowel epenthesis rate in percentages of the monolingual experimental results

Phonological environments	Vowel epenthesis from monolingual experimental results
Word-final	49%
Word-medial	51%
Homorganic (prenasal vowel lax)	29%
Homorganic (prenasal vowel long)	24%

Figure 5.2 provides a better vision of the vowel epenthesis preferences of monolingual results when English coda [m] is in word-medial and word-final positions and homorganic environments.

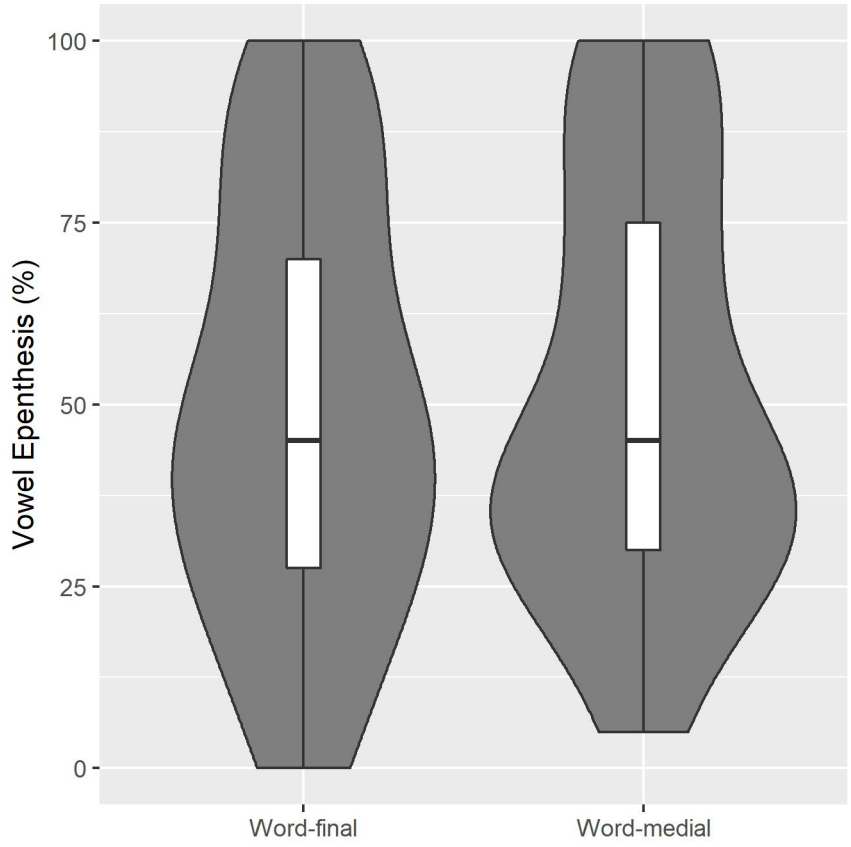
Figure 5.2 Vowel epenthesis rates of English coda [m] in different phonological environments from the monolingual group



T-tests were run to compare the preference of monolingual speakers for vowel epenthesis separately for homorganic environments vs. non-homorganic environments. The t-tests reveal that the preference for vowel epenthesis is significantly higher in the non-homorganic environments (the right two bars) than in the homorganic environments (the left two bars) [$t(32)=5.65$, $p<0.001$]. The vowel epenthesis rates of the monolingual group in Mandarin between English word-medial (51%) and word-final (49%) coda are not significantly different [$t(32)=1.06$, $p=0.55$]. If we look at the results more closely, we can see that the monolingual speakers do not strongly prefer epenthesis as the repair strategy when [m] is in word-medial and word-final position in English. The vowel epenthesis rate is roughly at 50%. This indicates that monolingual speakers seem to

have no preference on syllable repairing strategies, as long as the syllable is grammatical in SM. In the graph above we can only see the percentage numbers of how monolingual speakers handle the illicit [m] in word-medial and word-final positions. However, we cannot see the distribution of the data. The following violin plot shows the data distribution of vowel epenthesis among the monolingual speakers.

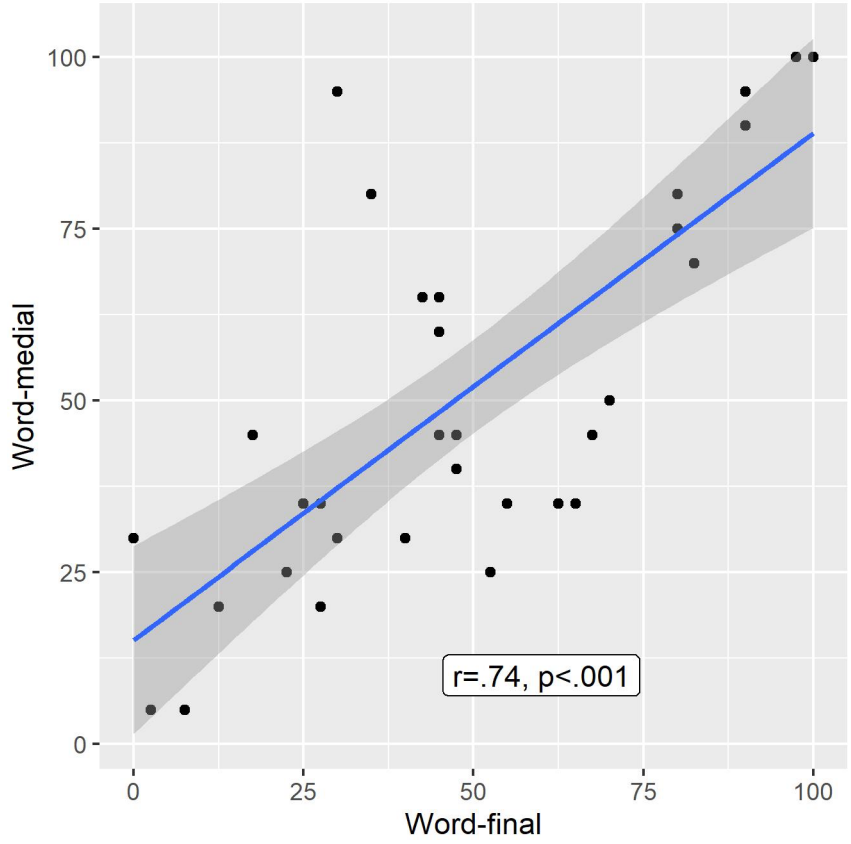
Figure 5.3 The data distribution of vowel epenthesis among the monolingual speakers when [m] is in the word-medial and word-final positions.



This violin plot shows the relationship of illicit coda [m] positions to vowel epenthesis. The box plot elements (the horizontal short bars in the boxes of the violin plots) show the medians of the word-final and word-medial are exactly the same. They are both 45. The mode numbers of the word-final results is 45 and 35 for the word-medial position results. The mean of the word-final group is 49.97, whereas the mean of the word-medial groups is 51.82. If we view the graph

horizontally, we can see that both mean numbers fall on the right side of the medians and are very close to 50. This further explains that the monolingual speaker do not have a preferred syllable repair strategy. They adopt vowel epenthesis and nasal place change by chance in both coda positions. There is no agreement of using vowel epenthesis or not to repair the illicit coda [m] among the monolingual participants. However, when monolingual speakers encounter coda [m] in the word-medial and word-final positions, there is intrapersonal consistency. This means that each monolingual individual tends to adopt the same strategy to repair [m] in the word-medial and word-final coda positions. See Figure 5.4 for the correlation between the adaptations of the word-medial and word-final coda [m] among the monolingual speakers ($r=0.74$, $p<0.001$).

Figure 5.4 The correlation of adaptation of [m] in the word-medial and word-final coda positions among the monolingual speakers



As for coda [m] in homorganic environments, the results show that nasal place change is preferred in general. The monolingual speakers do not show a significant difference [t(32)=1.10, p=0.277] in vowel epenthesis rates between the homorganic conditions with a lax prenasal vowel and with a tense/long and those with diphthongal prenasal vowel.

5.4.2 Results from the bilingual group

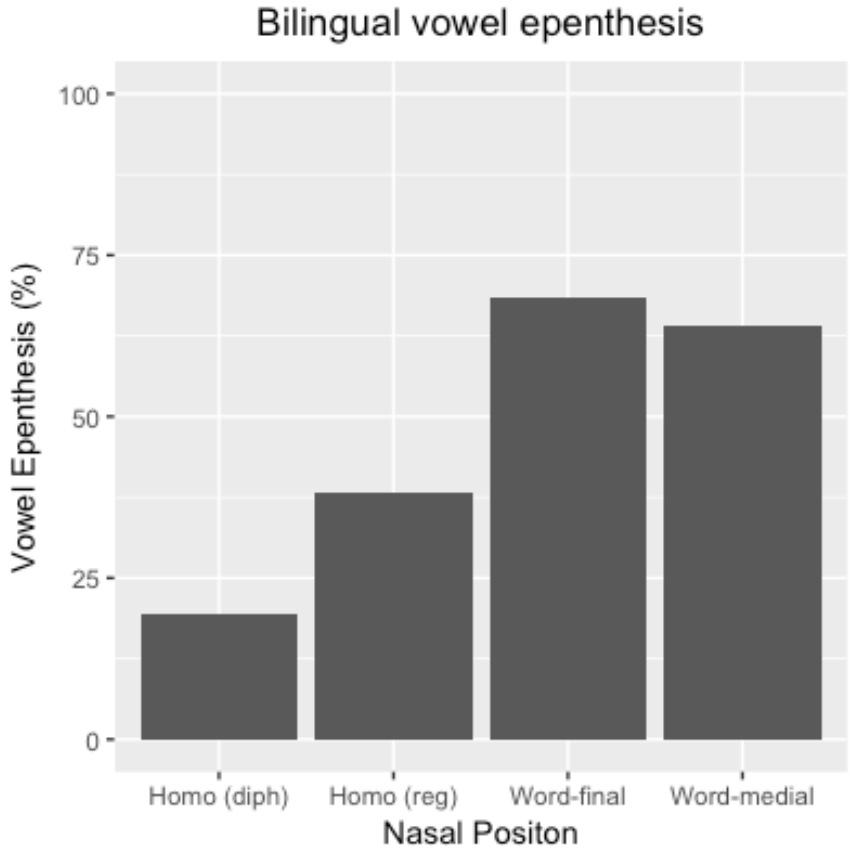
Table 5.2 presents the bilingual vowel epenthesis rate in percentages when English coda [m] is in different phonological environments.

Table 5.2 The comparison of vowel epenthesis rate in percentages of the bilingual experimental results and the corpora data

Phonological environments	Vowel epenthesis from bilingual experimental results
Word-final	68%
Word-medial	64%
Homorganic (prenasal vowel lax)	33%
Homorganic (prenasal vowel long)	19%

Figure 5.5 shows vowel epenthesis preferences of bilingual results when English coda [m] is in word-medial and word-final positions and homorganic environments.

Figure 5.5 Vowel epenthesis rate of English coda [m] in different phonological environments from the bilingual group



T-tests were run to compare the preference of bilingual speakers for vowel epenthesis separately for homorganic environments vs. non-homorganic environments. T-tests reveal that the vowel epenthesis preference is significantly higher in the non-homorganic group than in the homorganic group [$t(23)=7.53$, $p<0.001$]. The preference for vowel epenthesis rate in Mandarin between English word-medial and word-final coda is not significantly different [$t(23)=1.062$, $p=0.299$].

We can draw an interim conclusion here. In general, the experimental results from both groups show that compared to non-homorganic contexts, nasal place change is the preferred repair strategy in homorganic environments.

To sum up, a comparison of the vowel epenthesis rates among the corpora, the bilingual and monolingual experimental results is given in Table 5.3.

Table 5.3 Comparison of the vowel epenthesis rates among the bilingual/monolingual experimental results and the corpora data

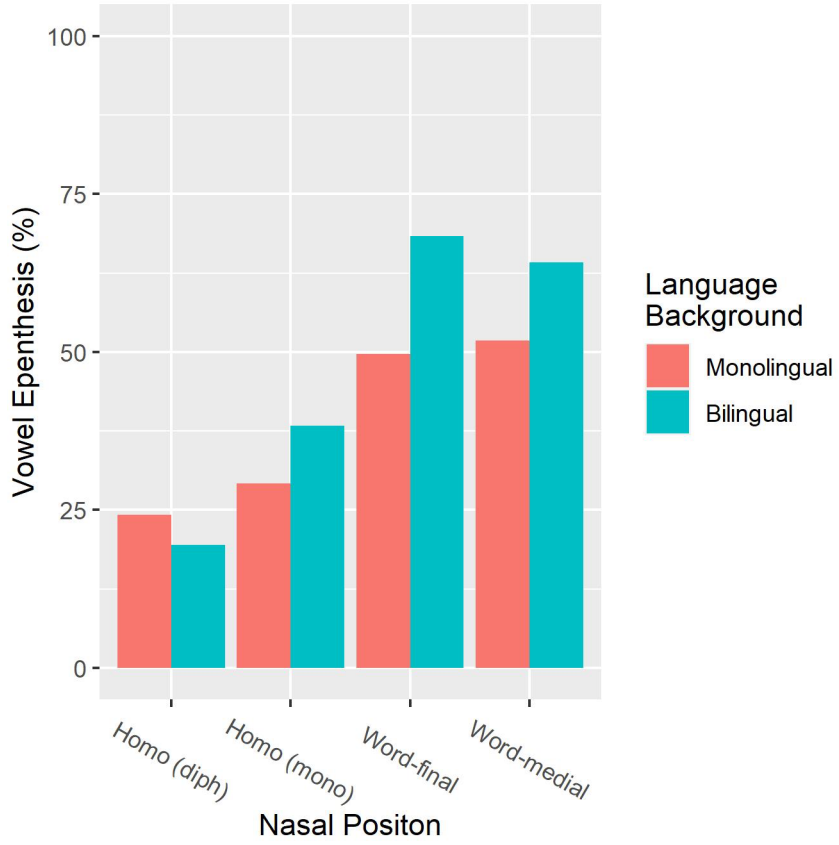
Phonological environments	Bilingual VE %	Corpora VE%	Monolingual VE%
Word-final	68%	72.16%	49%
Word-medial	64%	79.55%	51%
Homorganic (lax monophthong)	33%	0%	29%
Homorganic (diphthong)	19%	100%	24%

Overall, both homorganic conditions disfavor vowel epenthesis in the experimental results. The results of the homorganic diphthong environments are different from the corpora data. However, we need to be aware that there were only two examples found in the corpora for the homorganic condition with a prenasal diphthong and long vowel.

The experimental results suggest that in general, a sequence of [m] followed by a homorganic consonant inhibits vowel epenthesis. In word-final and word-medial non-homorganic conditions, the bilingual speakers' results are more similar to the corpora patterns in favor of vowel epenthesis, whereas the monolingual speakers chose vowel epenthesis at the chance level.

Figure 5.6 presents a comparison of the results drawn from the monolingual and bilingual groups with [m] in all phonological environments.

Figure 5.6 Comparison of bilingual and monolingual results of vowel rates of coda [m] adaptation in different phonological environments in the source



T-tests reveal that the vowel epenthesis preference is significantly higher in the non-homorganic group than in the homorganic group in both bilinguals [$t(23)=7.53$, $p<0.001$] and monolinguals [$t(32)=5.65$, $p<0.001$]. I also compared the vowel epenthesis preference overall for bilinguals vs. monolinguals. The Welch test reveals that bilinguals show a greater preference for vowel epenthesis than monolingual speakers [$t(49.744)=-2.27$, $p<0.05$] in non-homorganic environments. The bilingual experimental group shows higher preference ([$t(23)=3.26$, $p<0.05$]) for vowel epenthesis in the homorganic (monophthong) condition than in the homorganic (diphthong) one. However, this difference is not significant in monolinguals [$t(32)=1.10$, $p=0.277$].

5.5 Discussion

After analyzing the results from all participants with different language backgrounds, I will discuss:

1. the similarities and differences among the experimental results and the corpus data,
2. the similarities and differences among the monolingual and bilingual groups, and
3. factors proposed in other studies, such as prenasal vowel quality and syllable number, that would influence vowel epenthesis in the current experiment.

In general, the experimental data and the corpus data are similar. Both data sets show that vowel epenthesis is the preferred repair strategy when [m] is in non-homorganic coda positions. However, if we look at the data closely, bilinguals and monolinguals behave differently in non-homorganic conditions. The bilingual group prefers vowel epenthesis to nasal place change to repair ill-formed syllables. One of my major hypotheses is that [m] coda repair is a phonological process. Bilingual speakers follow the Preservation Principle and tend to retain all the segments and their features in the inputs. Although the percentage is not as high (72.16% vs. 68% in word-final position, 79.55% vs. 64% in word-medial position), I still claim that bilingual speakers prefer vowel epenthesis for syllable repair. The findings of the experimental results support the phonology-based approach and also support the hypothesis that loanwords are created by bilingual speakers (Paradis & Lacharité, 1997). I propose that the difference in percentages between the corpus and experimental data can be attributed to different adaptation methods. The current experimental data are generated from an auditory experiment, therefore there is more variation.

My corpus data were more likely to be created by proficient Mandarin-English bilingual speakers. The channels of how the foreign words entered into Mandarin are not always clear and can be from word to word. Foreign words could be adapted through reading and/or spoken contexts.

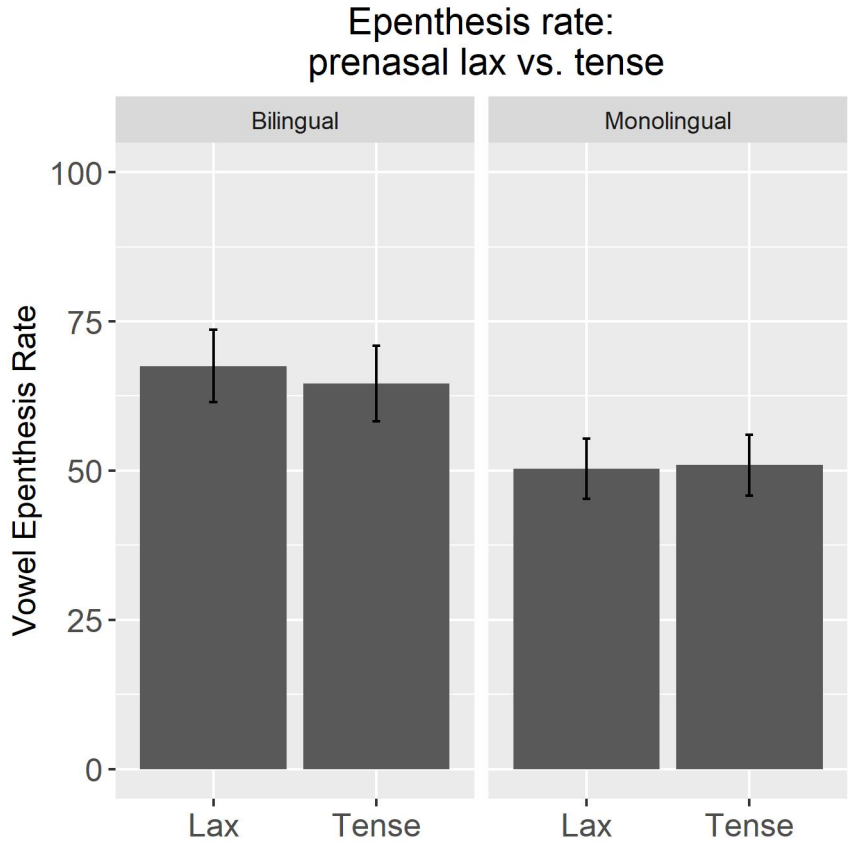
Even through reading, it is likely that proficient bilingual speakers have a phonological representation in their brain. This is evidenced by the provided sound transcription in the dictionary. The data from Google Maps were created through a consonant-vowel combination table and computation of fine acoustic cues (see detailed information in § 4.3.1) that tend to retain all the segments in the non-homorganic environments. Hence, illicit codas (not only coda [m]) are mostly repaired with vowel epenthesis. However, the stimuli in the current experiment were presented only in an auditorily/spoken context. According to Smith (2006) and Y. Kang (2003), it is more likely that two or more adaptation forms will show up when adaption is through an auditory context and when the influence of orthography is lessened. Smith suggests that auditory borrowing tends to frequently lead to illicit oral coda deletion because it is more acceptable for speakers to ignore some less salient acoustic cues, e.g. weak/non-audible consonant release. The results of the current study indicate that auditory borrowing causes the deletion of the place feature of [m] because phonologically, the nasal manner feature is weighted heavier than its place feature (Lin, 2009, 2011; Miao, 2005). Phonetically, nasal place is weak in perception (Malécot, 1958; Ohala & Ohala, 1993). Malécot (1958) and Ohala (1990) compare heteroganic nasal clusters N + stop and found out that the place percept is dominated by the stop but not nasal. Through auditory adaptation, when the output is not with an epenthetic vowel, nasal place deviation can be attributed to its weak phonetic cues.

As for monolingual speakers, the experimental results indicate that although speakers are aware of the ill-formed syllables, as long as they are repaired, it does not matter which repair strategy is adopted. This leads to vowel epenthesis rates for word-final (49%) and word-medial (51%) positions that are no better than chance. However, selection of repair method shows intrapersonal consistency. Which repair strategy is adopted is not random. That is, each individual

uses the same repair method to fix the coda [m] in non-homorganic environments. This can be attributed to lacking experience of consonants in coda position (cf. Yip (2006)). Therefore, the data show that there are individual differences. This can also be attributed to the design of the test items. The current experiment design for the word-medial coda position only has [m.d] combination. If [m] is followed by other types of consonants, such as approximates, nasal, fricatives, and stops with different voicing features, the results may show a clearer tendency.

I also looked at whether prenasal vowel quality influences vowel epenthesis in non-homorganic environments. Y. Kang's (2003) study on Korean loanwords suggests that vowel epenthesis in postvocalic word-final position is related to the tenseness of the preconsonantal vowel. However, this is not true for illegal nasal coda repair in Mandarin loanwords. Figure 5.7 shows that tenseness of the prenasal vowel does not significantly influence vowel epenthesis rates in both groups when [m] is in word-medial and word-final positions (bilingual group [$t(23)=0.796$, $p=0.43$], monolingual group [$t(32)=0.184$, $p=0.85$)]). ANOVA tests reveal that bilingualism significantly affects vowel epenthesis rate [$F(1,110)=7.542$, $p=0.007$]. Bilingual speakers prefer vowel epenthesis; whereas monolingual speakers are indecisive in between vowel epenthesis and nasal place change. There is no significant effect on prenasal vowel tenseness [$F(1,110)=0.025$, $p=0.87$] and there is no interaction between bilingualism and prenasal vowel type [$F(1,110)=0.098$, $p=0.75$]. This indicates that prenasal vowel quality is not a critical cue to triggers vowel epenthesis in either group.

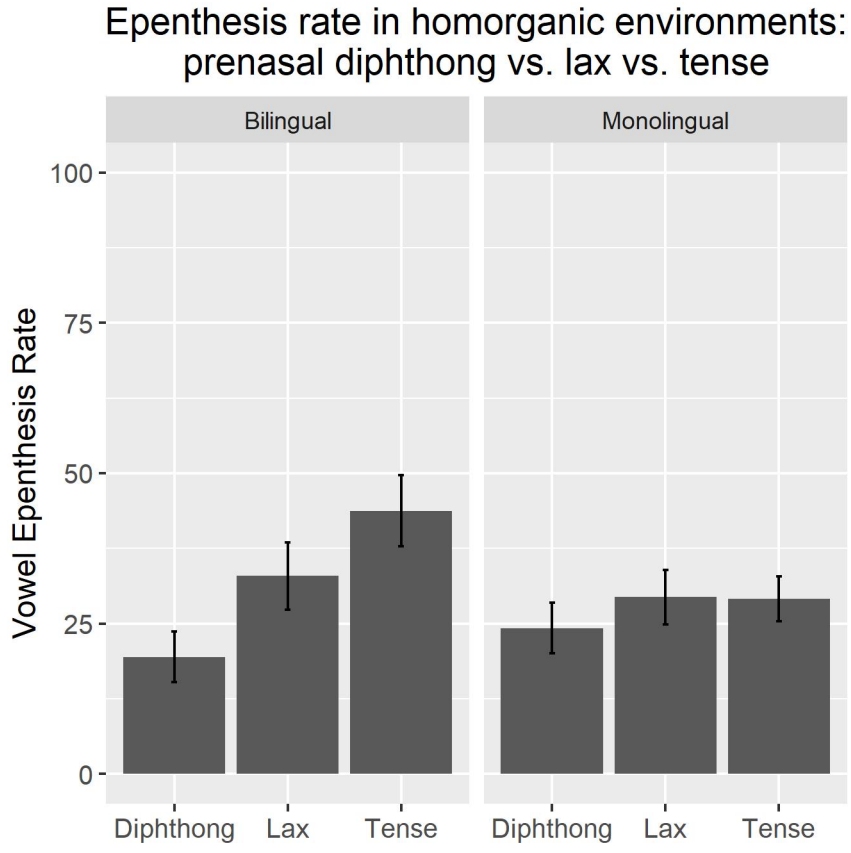
Figure 5.7 Vowel epenthesis rates of bilingual and monolingual groups with different prenasal vowel quality



The corpus data show that the prenasal vowel quality has influence on vowel epenthesis in homorganic environments. When the prenasal vowel is a lax monophthong, vowel epenthesis never appears in Mandarin loanwords. The experimental results also show that the prenasal vowel quality influences the appearance of vowel epenthesis in homorganic environments, especially for bilingual speakers. Figure 5.8 below shows vowel epenthesis rates of both groups with different prenasal vowel types, i.e. diphthong, lax monophthong, and tense monophthong. ANOVA tests reveal that prenasal vowel type significantly affects vowel epenthesis rates [$F(2,165)=4.081$, $p=0.02$]. Bilingualism does not have a significant effect on vowel epenthesis in homorganic environments with different types of prenasal vowels [$F(1,165)=1.349$, $p=0.25$] and there is no

interaction between bilingualism and prenasal vowel type [F(2,165)=2.153, p=0.11]. Post-hoc tests reveal that prenasal diphthongs and tense vowels behave significantly differently on vowel epenthesis in homorganic environments. Prenasal diphthongs and lax vowels also behave significantly differently on vowel epenthesis rates in homorganic environments. Tense and lax vowels do not behave significantly differently.

Figure 5.8 Vowel epenthesis rates of bilingual and monolingual groups in homorganic environments with different prenasal vowel types

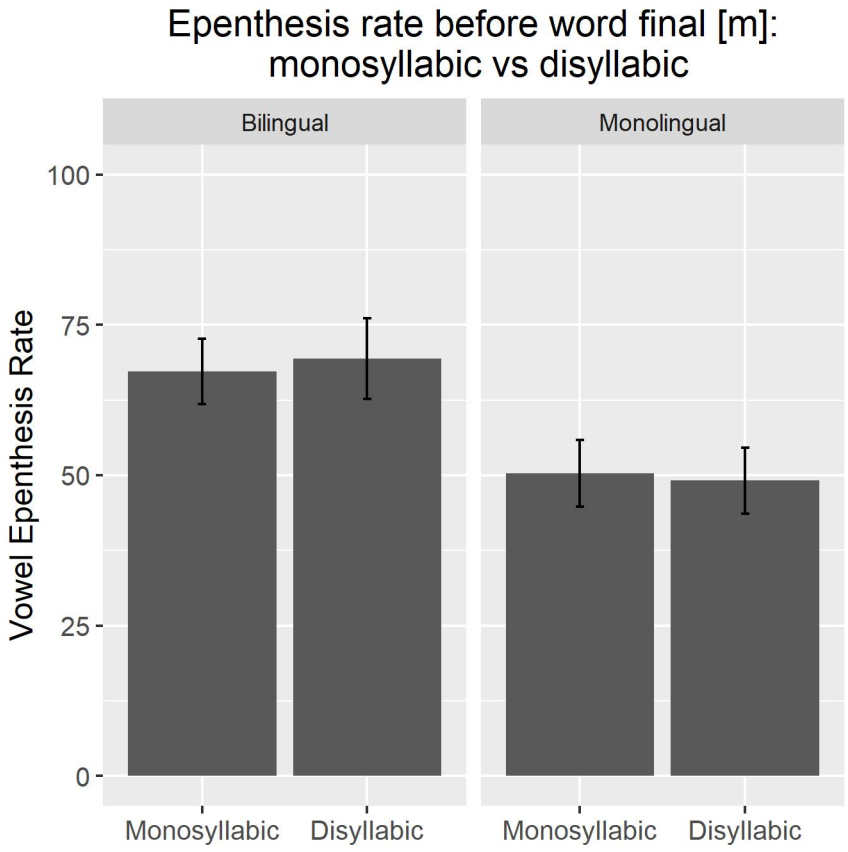


The results show that in all the homorganic contexts, with different prenasal vowels, the bilingual group has, in general, higher vowel epenthesis rates, except for the prenasal diphthong cases. On the graph, we can see that the vowel epenthesis rate does not fluctuate much among monolingual speakers' responses with different prenasal vowel conditions. However, prenasal

vowel quality affects vowel epenthesis rates among bilingual responses. Prenasal tense vowels trigger most vowel epenthesis among bilingual speakers but they behave differently from diphthongs. This experimental finding is different from the corpus data. In the corpus, prenasal tense and diphthongs behave the same. They trigger 100% vowel epenthesis. However, we need to note that there is only one prenasal tense vowel case and one prenasal diphthong case in the corpus. The experimental data provide more information of how coda [m] is adapted in such phonological contexts.

In addition, I looked at whether syllable number has an effect on choosing a syllable repair strategy. Figure 5.9 shows vowel epenthesis rates of both groups in non-homorganic environments in monosyllabic and disyllabic words. ANOVA tests reveal that vowel epenthesis rates are significantly affected by bilingualism [$F(1, 110)=10.013$, $p=0.002$]. The vowel epenthesis rate of the bilingual group is significantly higher than the monolingual group. There is no significant effect of syllable number [$F(1, 110)=0.001$, $p=0.98$]. This indicates that vowel epenthesis rates are not affected by syllable number in both groups.

Figure 5.9 Vowel epenthesis rates of bilingual and monolingual group with different syllable number in the test items



5.6 Conclusion

This chapter presents the perceptual experimental results, which show how coda [m] is repaired when it enters into Standard Mandarin. The data were collected from Mandarin monolingual and Mandarin-English bilingual speakers. The tested phonological environments (word-medial, word-final codas, and [m] in homorganic environments) were identified in the corpus data. In addition, monosyllabic items with [m] in coda position were tested. The results indicate how speakers with different language backgrounds respond to illicit nasal coda based on their perception.

The results have two major implications. First, English coda [m] adaptation is contextualized. Second, participants with different language backgrounds adopt different syllable repair strategies. Mandarin-English bilingual speakers tend to use vowel epenthesis when they encounter [m] in the

word-medial and word-final positions. Slightly different from the corpus data, bilingual participants also show some vowel epenthesis preferences when [m] appears in homorganic environments with the prenasal vowel lax, which is not present in the corpus data. This minor difference further confirms that the bilingual participants have English phonology and spelling rule knowledge. The vowel epenthesis responses show that the bilingual speakers know that [m] is followed by another oral labial consonant. They tend to preserve all the segments from the input and map them to the Mandarin representation, while simultaneously making the Mandarin representations satisfy the phonological constraints. By only listening to the test items, they know [m] precedes another labial segment and they tend to retain it with an epenthetic vowel.

When monolingual speakers encounter such illicit structures, they do not have a strong tendency to use epenthesis or nasal place change to repair the syllable. Vowel epenthesis and nasal place change are adopted at nearly chance levels. However, each individual uses the same method to repair the illicit structures within-person. When [m] appears in homorganic environments, vowel epenthesis is less preferable by monolingual speakers than bilingual speakers. This indicates that monolingual speakers pay more attention to syllable repairing than feature retaining. The segment is retained either way.

In addition, I also presented whether vowel epenthesis is related to syllable number and the prenasal vowel quality (lax, tense, diphthong) in English. The results show that regardless of syllable number and prenasal vowel quality, bilingual speakers prefer vowel epenthesis as a repair significantly more often than monolingual speakers. This is also true in all the homorganic environments.

I provide experimental evidence of how [m] is adapted into SM loanwords. I also demonstrate that consonant adaptation in SM loanwords is not always a faithful segment-to-segment matching

process. Rather, as exemplified in this chapter, the adaptation can be conditioned by phonetic and phonological factors related to the donor language and the recipient language and how the borrowers may have constructed the input for the final phase of the adaptation process. Specifically, I have shown that the phonological environments of [m] in English constitute the main condition that determines whether vowel epenthesis applies in SM loanwords, and I have suggested how the English inputs may have been perceived by SM speakers.

Given the overall similarity between the generalizations in the corpora data and the bilingual responses, I suggest that for the bilinguals, vowel epenthesis is the preferred syllable repair strategy for segment and feature preservation (Paradis & LaCharité 1997). Although the adapted form with vowel epenthesis is less phonetically similar to the English input in the number of syllables, the advantage of the vowel epenthesis strategy is that both nasality and labiality of [m] are preserved. On the other hand, the monolinguals tend to keep the perceptual similarity of syllable number between the input and the output by retaining nasal codas. Since the place contrasts in nasals are perceptually weak (Kawahara & Garvey 2015), the match between coda [m] and coda [n/ŋ] is perceptually more similar than the match between a coda [m] and a syllable [muː]. Therefore, vowel epenthesis is less preferred by the monolinguals. We can further assume that perceptually, the form with an excess vowel is less similar to the input than the form that is repaired by nasal place change.

Nasal place change is generally preferred in the homorganic conditions so as to maintain perceptual similarity, since English [m.p]/[m.b]/[m.f] are produced with a gestural overlap (Henderson & Repp 1982, Browman & Goldstein 1990). In addition, such a repair strategy creates a better mapping of the underlying feature representation.

Unlike the patterns in my corpus data, bilingual and monolingual speakers less strongly prefer vowel epenthesis in the homorganic condition along with a prenasal long vowel. However, the bilingual data still show that prenasal tense vowels trigger vowel epenthesis the most (see Figure 5.8). This could be attributed to the fact that this specific set of data from the corpora is based on only two words, which are not enough to understand the whole picture. This set of experimental data provides more information on how CVVm in English is adapted into SM loanwords. In addition, it also reveals that bilingual and monolingual speakers handle this structure differently. Bilingual speakers tend to faithfully map the manner and place features of [m]. Whereas, monolingual speakers tend to faithfully map syllable number. My corpus data show that prenasal tense vowels and diphthongs trigger vowel epenthesis 100% of the time in Mandarin loanwords. However, this set of experimental data shows that tense vowels and diphthongs behave differently among bilingual speakers. I attribute the discrepancy to variable vowel adaptations in Mandarin loanwords in general (cf. Lin (2008b)). Adaptation of English [au] to SM [a]/[ɑ] is not rare at all. Usually, both diphthong and monophthong forms appear in the SM loanwords, e.g. *Downey* → [tau.niː] ~ [tʰɑŋ.niː], and *Downton* → [tau.tun] ~ [tʰɑŋ.tun]. I suggest that this is because the second part of the diphthong is shorter than its first half. Hence, it gets ignored or has low perceptual saliency which results in it not showing up in the output.

The results from the experiment also support Smith's (2006) and Davidson's (2007) claim that there is variability in auditory loanword adaptations, since perceptual cues are affected by the variable release of English coda consonants in different phonological environments (Malécot 1958, Selkirk 1982, Crystal & House 1988, Davidson 2011) and by weak perception of nasal place. This seems to suggest that phonological considerations other than necessary syllable repairs are suppressed in favor of perceptual similarity in the perceptual experiment setting.

To conclude, along with the experimental results, I argue that coda [m] adaptation is phonologically based. The perceptual similarity experiment results from speakers with different language backgrounds show that bilingual speakers still follow the Preservation Principle to keep manner and place feature significantly more frequently than monolingual speakers. Bilingual speakers also show a tendency for vowel epenthesis in homorganic environments with prenasal lax vowels (although not as frequently in the corpus data). This indicates that they possessed knowledge of English phonology. They know that in N + stop contexts, the N is assimilated to the following stop. However, some still want to faithfully retain all the features. Hence, vowel epenthesis appears, but at a low rate. Another piece of evidence in the experimental data is that [m] adaptation with vowel epenthesis is not like post-consonantal stop adaptation in Korean, which heavily relies on English allophonic rules with various degrees of oral consonant release. Nasal release is generally weak or there is no vocalic-like release after. If vowel epenthesis appears, it is mainly for syllable repair reasons.

Chapter 6 Conclusion

6.1 Summary

This study provides more evidence that nasal consonant adaptation from English to Mandarin is contextualized. Two big datasets are analyzed and compared: corpus data from different sources, e.g. a dictionary, Google Maps, multimedia, etc., and perceptual experimental data collected from Mandarin monolingual speakers and Mandarin-English bilingual speakers. The four main issues have been addressed.

1. English intervocalic nasal and English coda [m] adaptation in Mandarin loanword system, i.e. patterns and generalizations for both processes in the corpus data
2. Possible phonological and phonetic factors that cause the "unnecessary" nasal insertion and the occurrence of vowel epenthesis or nasal place change
3. How speakers with different language backgrounds handle these two types of nasals under audio only perceptual settings
4. Linguistic mechanisms that drive the two adaptation processes

In this chapter, the main findings and discussions of each adaptation process will be summarized. In §6.2, I summarize the corpus datasets that have undergone investigation. I provide a summary of the main findings from the corpus datasets in §6.3. In §6.4, I summarize the findings from the experimental studies and the key discussion points. In §6.5, I revisit the loanword model. In §6.6, I discuss the contributions that the current study makes and give directions to the future loanword research.

6.2 Loanword corpus datasets input sources

In previous loanword adaptation studies, researchers used words from dictionaries and existing conventionalized words from different places. To account for the adaptations, besides the

conventionalized loanwords from a dictionary and social media, place names that contain nasal consonants in Google Maps are also studied. Consonant and vowel combination tables are widely used for generating loanwords nowadays and different languages have their own consonant-vowel combination table based on the foreign languages' true pronunciations.

The transliterations from Google Maps are done by computer programming. I argue that the computer can only capture the main phonetic cues at the segmental level. It cannot fully detect fine acoustic cues because their inputs are based on consonant-vowel combination tables. There is no auditory or acoustic information involved and allophonic rules are not in calculation. Here is some evidence from the two adaptation processes in the current study to support my argument. For intervocalic nasal adaptation, all words with two nasal consonant spelling are always adapted with two nasals in Mandarin and those with one in spelling always have one nasal in their outputs. This means that the program miscalculates the prenasal vowel quality in the adaptation process. In fact, many examples that only have one nasal in spelling are adapted with two nasals in Mandarin (see §2.3.3 for examples) and there also words with two nasals in spelling but are adapted with only one nasal in Mandarin, e.g. *Minnie* → [miː.niː]. For repairing coda [m], except for homorganic environments, coda [m] is always fixed with vowel epenthesis. I also notice that it uses vowel epenthesis to repair all other illicit codas in Mandarin loanwords. It indicates that the input sources are from written form, and hence, it ignores different degree of coda consonant releases in regard to their allophonic rules.

For the adaptation of coda [m] in homorganic environments, the existing corpus data and Google Maps all show that vowel epenthesis never occurs in any Mandarin output. The vowel epenthesis rate for such repair is zero. Nasal place change always applies. I suggest that the

program is designed to avoid vowel epenthesis in homorganic environments to make the outputs sound more similar to their inputs.

6.3 Main findings from the corpus

Two contextualized loanword adaptation processes are studied in detail with corpus data and perceptual experimental data. This section presents the main findings from the corpus data. According to the corpus data, both adaptation processes show that the phonological environments of the targeted segment in English have a direct influence on the Mandarin loanword outputs. That is to say, non-onset nasal segments can be adapted with segment insertion, without segment insertion, and can vary between the two in different contexts.

6.3.1 Intervocalic nasal adaptation

The first adaptation process to undergo investigation is intervocalic nasal adaptation. The targeted segment is the N in CVNV. When the intervocalic nasals enter to Mandarin, presumably, the Mandarin output of a such nasal should only contain one nasal and this one-segment-to-one-segment mapping is the most common and straightforward adaptation method.

However, my corpus data show that intervocalic nasal adaption can be a one-segment-to-one-segment mapping and it can also be one-to-two with an inserted nasal. Adding one nasal seems unnecessary because CV.NV is grammatical in Mandarin. I observe that nasal insertion is significantly correlated to the prenasal vowel quality and the primary word stress location. Nasal insertion occurs when the prenasal vowel is lax and short in duration. It also has to bear the primary word stress, e.g. *Di ˈa<u>n</u>a* → [tai.a<u>n.n</u>aː]. Other than tenseness and the duration of the prenasal vowel, I also proposed that the nasalization on the prenasal vowel is significant because a nasal consonant in such phonological environment is ambisyllabic and the nasal feature heavily spreads to the prenasal vowel. Hence, the number of nasal features is two in the underlying representation in

English. Therefore, in the Mandarin output there are two nasal segments, instead of only one to better match phonetic details and nasal feature number. In addition, when the nasal is ambisyllabic, the syllabification is not clear so the nasal is connected to both coda and onset (cf. analyses of Giegerich (1992), Hayes (1995, 2009), and Kahn (1976) on ambisyllabicity/English syllabification). The syllabification is clear when the stress is on the post nasal vowel, *Deˈnise* → [tiː.niː.sɻ]. Hence, nasal insertion does not appear; instead, it is syllabified to the onset in Mandarin in such cases. In addition, when the prenasal vowel is long, tense, or a diphthong, nasal insertion does not appear as well. This indicates that when the vowel is adapted tense, it occupies two slots in the syllable. Hence, even the prenasal vowel bears nasalization, and there is no space in a grammatical syllable for inserting a nasal.

Another situation is that when the source words are trisyllabic, with ˈCVCəNV word structure, doublet outputs are possible. Words with such structure can be adapted with and without nasal insertion, e.g. *Tiffany* → [tiː.fuː.niː]/[tiː.fan.nei]. I proposed that variable adaptation is due to the short duration and least vowel specification of the prenasal vowel [ə].

Another major finding is that when the prenasal vowel is a low back [ɑ], even though it bears the primary word stress, nasal insertion nearly never occur, e.g. *Cabana* → [kʰaː.baː.naː]. I proposed that (i) both English and Mandarin have the peripheral phonemic [a] so there is no need for sound modification and (ii) the [a] appearing in English loanwords is actually tense, not lax (Green, 2001; Ladefoged & Johnson, 2001). Only prenasal lax vowels trigger nasal insertion in Mandarin loanwords. Therefore, nasal insertion does not appear in Mandarin.

6.3.2 Coda [m] adaptation

This dissertation also investigates English coda [m] adaptation. The targeted structure is word-medial coda [m], word-final coda [m], and coda [m] in homorganic contexts. To fix illicit coda,

there are two possible options, vowel epenthesis and consonant deletion. In the case of an illicit coda [m], nasal place change is a third repair option since Mandarin allows alveolar and velar nasals in coda position. Because [m] is a sonorant, unlike other oral stops, deletion barely occurs.

Other loanword studies indicate that vowel epenthesis is the most widely used strategy to modify illicit syllables. The current corpus data also show that at 80% of the time, coda [m] is repaired by vowel epenthesis. The percentage includes word-medial and word-final positions, e.g. *Jim* → [tɕiː.muː], and *Armstrong* → [aː.muː.sɻ̩.tʂuɑŋ]. When [m] is in homorganic environments with a prenasal lax vowel, though, vowel epenthesis is never chosen for repair, e.g. *Olympic* → [au.lin.pʰiː.kʰɤː]. However, in homorganic environments with a prenasal tense vowel or a diphthong, vowel epenthesis is still chosen, e.g. *Shaumberg* → [ʂau.mu̲ː.pɑu]. In addition, when coda [m] is followed by an obstruent, vowel epenthesis and nasal place change both take place in the Mandarin output for one single English input form, e.g. *Camden* → [kʰaː.mu̲ː.təŋ] ~ [kʰən̲.tun].

As for the epenthetic vowel, it is not surprising that almost all the identified epenthetic vowels after [m] are [u]. There are two cases in which coda [m] is adapted with [o]. The two chosen epenthetic vowels both bear labial features. The labial feature is spread from [m]. This is true to other labial coda consonant adaptations. Consonant feature spreading is also very common in vowel epenthesis in other languages. This is true to loanword phonology and native phonology in many other languages as well.

Due to the findings in the corpus, I proposed that vowel epenthesis is preferred not because the outputs sound the most similar to the inputs, but because it better preserves all the segments and features from the input. I also argue that vowel epenthesis may not be due to consonant release because release of nasal consonants is weaker than oral stops.

If vowel epenthesis is only for preserving segments and features from the source, then why is nasal place change dominantly applied when coda [m] is in homorganic environments? I argue

that it is due to both speakers' perception and their knowledge of English phonology. In homorganic environments, the neighboring segments have a huge degree of gesture overlap so the speaker may misperceive [m] or only perceive the nasal feature but not the place feature. In addition, in a Nasal + obstruent sequence, the place feature of the obstruent is more salient than the nasal place feature. Not adding a vowel leads the outputs to have the same syllable number as their inputs. Meanwhile, phonologically, nasal place change is also one of the options to repair coda [m]. In addition to syllable repair, according to OCP, there is only one labial feature linked to both labial consonants in the English input. Hence, the Mandarin outputs without vowel epenthesis not only sound more similar to the input in the respect of syllable number, the no vowel epenthesis outputs also preserve the nasal feature and labial feature. Another homorganic environment is when the prenasal vowel is long or a diphthong. In this type of homorganic environments, vowel epenthesis occurs. I propose that this is relevant to the prenasal vowel adaptation. A diphthong already makes the syllable heavy and creates a $\mu\mu$-syllable. Therefore, the coda [m] has to be syllabified to the onset position of the next syllable.

When the coda [m] is in word-medial followed by an oral obstruent, variable adaptation appears. Such cases are verified by Google search, i.e. one adaptation form, either with vowel epenthesis or without, is listed in the corpus, and the other one is searched from Google. I suggested that the appearance of vowel epenthesis is due to weaker perception in a less prominent position. It can also be caused when the same words enter Mandarin through different channels, e.g. reading vs. audio. The output without vowel epenthesis emerges more likely from the channel of hearing.

6.4 Main findings from the experimental data

I proposed an analysis with phonetic and phonological factors to account for various adaptation methods. To verify my analysis, I ran perceptual similarity experiments, which are force choice ABX tasks, on 24 Mandarin monolingual and 33 Mandarin-English bilingual speakers.

The experimental results for both adaptation processes are very similar to the corpus data. There are minor discrepancies. However, they are explainable.

6.4.1 Intervocalic nasal adaptation

In Chapter 2, I conclude that nasal insertion is conditioned by prenasal vowel condition and stress location condition. Nasal insertion occurs 92% when the prenasal vowel is non-high and lax or short in duration. Meanwhile, the prenasal vowel needs to bear the primary word stress. Variable adaptation occurs in trisyllabic words. The prenasal vowel is a [ə] and bears no stress. Low back vowel [ɑ] never triggers nasal insertion in Mandarin. The perceptual experiment test items were designed based on the findings in the corpus data.

In Chapter 3, I analyze the experimental results and compare them with the corpus data. The experimental data also indicate that prenasal vowel quality is crucial to deciding whether nasal insertion appears in Mandarin or not. By comparing prenasal lax and tense vowels, I found that prenasal lax vowels trigger nasal insertion significantly more frequently than prenasal tense vowels. However, stress location condition shows discrepancies from the corpus generalization. Both groups preferred nasal insertion in CVˈNita structure and the tendency is stronger in the monolingual group. This is because the tokens show that the prenasal vowel bears heavy nasality spreading from the N. For variable adaptation cases, nasal insertion is more preferable for bilingual speakers than for monolingual speakers. As for the low back [ɑ], I compare it with lax vowels and tense vowels. The results show that it behaves more like a tense vowel than like a lax vowel, which

means that in the experimental data, although it sometimes triggers nasal insertion, the rate is significantly low.

Monolingual and bilingual speakers behave very similarly in all the data analyses. I conclude that intervocalic nasal adaptation is perception-based. I also claim that the proposed analysis based on the findings in the corpus is quite accurate. Although the results from stress location comparison did not follow my prediction, I still confirmed that prenasal vowel quality is the key that triggers nasal insertion in Mandarin loanwords. Compared to the corpus data, I argue that the lower insertion rate is due to speakers' different prenasal vowel adaptation methods but not due to misperception because some studies show that foreigners can actually differentiate lax and tense vowels after practice. In addition, how words enter Mandarin matters as well. Variable adaptation happens more frequently when the inputs are adapted through audio channels rather than through reading. It is quite common that the same word or the same sounds in identical contexts can have more than one adapted form.

6.4.2 Coda [m] adaptation

The main findings in Chapter 4 indicate that vowel epenthesis is widely used to repair the coda [m]. However, whether to adopt vowel epenthesis or not is decided by the phonological environments of the target segment. Vowel epenthesis mostly occurs in Mandarin loanwords when it is a word-medial or a word-final coda. However, in the word-medial position, if coda [m] is followed by an oral obstruent, the same word can be adapted with two forms, which means that vowel epenthesis and nasal place change would both occur. Vowel epenthesis is never the repair strategy when coda [m] is in homorganic environments with a lax and monophthong prenasal vowel.

Chapter 5 presents the perceptual similarity experimental results of English coda [m] adaptation in all the phonological environments identified in Chapter 4. The experimental results show that bilingual speakers prefer vowel epenthesis when they encounter coda [m] in word-medial and word-final positions. However, monolingual speakers do not have a strong preference of strategy. This proves that the existing words are created or generated by bilingual speakers or people who are relatively proficient in English. These people tend to retain the most information from the source.

As for coda [m] in homorganic environments with prenasal vowel lax, same as my prediction, both bilingual and monolingual speakers significantly preferred nasal place change instead of vowel epenthesis for syllable repair. In such environments only 33% bilinguals and 29% monolinguals chose vowel epenthesis. This means that the big gesture overlap leads most people to ignore the weak place feature of [m] or the underlying representation is governed by the OCP with only one labial feature, so [m] is modified to another grammatical nasal coda in Mandarin in most cases. This also probably means that people with different English proficiency actually hear [m] in such environments and that bilinguals have a higher rate to maintain it, although not significantly. As for coda [m] in homorganic contexts with prenasal nasal vowel tense, the experimental results are different from the corpus data. Bilinguals show 19% and monolinguals show 24% vowel epenthesis preference, whereas there is 100% preference in the corpus. I argue that because there are only two prenasal tense vowels or diphthong cases in the corpus, the data size is much too small to represent the environment and get an accurate generalization. In addition, it is quite common that Mandarin speakers only keep the first half of the diphthong to make it a monophthong that occupies two syllable slots during sound modification, e.g. *Downey* →

[tʰɑ̲ŋ.niː]~[tɑ̲u.niː], *Do̲wnton* → [tʰɑ̲ŋ.twən]~[tɑ̲u.twən]. Hence, we can attribute this discrepancy to vowel modification.

Other than the phonological contexts found in the corpus, I also analyzed [m] in monosyllabic and disyllabic pseudo words. The results show that syllable number is not a main factor that has influence on the vowel epenthesis rate but bilingualism is. It does not matter whether [m] is in a monosyllabic word coda position or in a disyllabic word coda position, bilinguals preferred to retain [m] with an epenthetic vowel. Whereas, monolingual speakers use nasal place change and vowel epenthesis equally.

Last, I show that prenasal vowel tenseness does not influence on vowel epenthesis rate in both groups.

Based on the analyses of coda [m] in different contexts, I argue that English coda [m] adaptation is a phonological process. In general bilingual speakers prefer to apply vowel epenthesis, whereas monolingual speakers have no preferred repair method.

6.5 Revisit the loanword models

This dissertation focuses on the sound-based loanword adaptation. Loanwords that are adapted through this method sound very similar to their origins. Since the systematic patterns appear within the same recipient language, what strategies speakers use to fit the foreign words and structures in their native language and make them sound similar to the original forms is always the fundamental question to ask. Each of the three loanword phonology models take a distinct stance on this. The phonology-based approach argues for a production-based approach in which loanword adaptation follows category preservation/proximity principles where segment matching is based on phonological categories. The perception-based approach maintains that loanword adaptations involve speakers' perception or misperception. It focuses on solving two puzzles: unnecessary

repair and patterns that violate the native phonological grammar. The hybrid approach holds the view that loanword adaptation takes both perception and phonology into account.

For the targeted segment adaptation, I have shown evidence that intervocalic nasal adaptation tends to be perception based. Based on my corpus data, nasal insertion is unnecessary repair, which is actually necessary for fine phonetic cue mapping since English and Mandarin both allow CVN structure. I argue that speakers perceive the prenasal vowel duration, nasality for ambisyllabic, and the cue from stress that leads to clear syllabification. One may argue that phonology-based approach also explains the data because the loanwords in the corpus are created by bilingual speakers. Hence, they have access to ambisyllabicity in English phonology. However, my experimental results show that monolingual and bilingual speakers handle intervocalic nasals identically. I argue that the phonology-based model cannot well explain intervocalic nasal adaptation because the monolingual speakers never encounter ambisyllabicity in their native grammar. We can, therefore, further argue that monolingual and bilingual speakers take the fine acoustic cues into consideration when they encounter intervocalic nasals. One other piece of evidence is from the no stress pattern on syllabification among bilingual speakers. Presumably, bilingual speakers should be aware of the stress pattern in English. However, my experimental results show that the two groups behave the same. The responses show that both group preferred nasal insertion for input structure CVˈNita I attribute this to heavy nasalization in the prenasal vowel based on the measurements I took for the test items.

I have shown evidence that coda [m] adaptation is phonologically driven. Other than categorical mapping, this camp also holds a view that loanword adaptation is done by bilinguals, who have access to the donor language sound inventories and syllable structures and then further transfer them into the closest categories and structures in the recipient language. The phonology-

based approach best explains my corpus data and experimental data. Vowel epenthesis is chosen to maximally preserve all the features from [m], although with an epenthetic vowel that may lead the input and output becoming less perceptually similar. I argue against the view that vowel epenthesis is due to perceptual illusory vowel or misperception because English nasals are different from French nasals, which have a vowel-like release. Coda [m] in homorganic environments adapted without vowel epenthesis can also be explained by OCP by underlying representation mapping.

If we only looked at my corpus data, the hybrid approach best explains the two adaptation processes. However, with my experimental data for nasal insertion, we get more information about how speakers are sensitive to the prenasal vowel quality and that bilingualism does not play a role when speakers encounter CVN structure, which is grammatical in both languages. I argue that the adaptation process completes and ceases at the Perception Level. Phonology only plays a minor role therein. For [m] adaptation, the experimental data indicate that bilingualism matters when speakers handle the ungrammatical structure. The two-scansion/hybrid model cannot well explain coda [m] adaptation because at the Perceptual Level, the less salient cue, which is the nasal place here, should be deleted or ignored. However, bilingual speakers have a strong tendency to keep such weak acoustic cues and around 50% of monolingual speakers' responses exhibited vowel epenthesis, i.e. half of the responses kept the nasal place cue. Even under homorganic conditions with a prenasal lax vowel, when the place feature of [m] is almost fully assimilated to the next homorganic consonant, both groups have about 30% vowel epenthesis rates (monolinguals: 29%, bilinguals: 33%). This evidences that coda [m] repair is less perception-led. We only need the Operative Level to account for coda [m] adaptation in Mandarin loanwords.

6.6 Concluding remarks, contributions and directions to the future research

This dissertation examines intervocalic nasal and English coda [m] adaptations in detail with corpus data and perceptual experimental data. The following are the concluding remarks. They answer all my research questions listed in §1.4.

Intervocalic nasal adaptation:

1. When English intervocalic nasals are adapted into Mandarin, the adaptation process is sensitive to the duration, quality, and nasalization of the prenasal vowels in the input.
2. The corpus data, but not the experimental results, also show that the adaptors are sensitive to the primary word stress location in the input.
3. In the case of variable adaptation in identical contexts, ˈCVəNV → CV.CəN.NV ~ CV.CV.NV, nasal insertion variant is cued by the short duration of the reduced vowel in the input.
4. Following 3 above, the experimental results also show variable adaptation in the contexts.
5. Both corpus data and experimental data show that the low back [ɑ] behaves like a tense vowel. It rarely triggers nasal insertion in the output.
6. Nasal insertion is a phonetically driven process although some phonological properties play a very minor role.

English coda [m] adaptation:

1. When coda [m] is adapted into Mandarin, vowel epenthesis is the preferred repair strategy when it is a word-medial and word-final coda in the input. This is true to both corpus data and experimental results.
2. Bilinguals prefer vowel epenthesis; whereas, monolinguals have no preference on repair strategy.
3. Vowel epenthesis never appears in the output when coda [m] is in homorganic environments in the input.
4. Following 2 above, the experimental data show a very similar pattern. Vowel epenthesis is not preferred by both groups. However, the percentage is not as high as in the corpus data.
5. Word syllable numbers are not a main factor, but bilingualism is.
6. Prenasal vowel tenseness is also not a crucial factor.
7. Coda [m] adaptation process is phonologically driven. Although fine phonetic cues play a role, they are not crucial in the adaptation process.

This dissertation makes contributions to the Mandarin phonology, loanword phonology, and speech perception of bilingualism. Mandarin native phonology does not have rules of nasal insertion/consonant gemination and vowel epenthesis. However, they occur actively in language contact situations for mapping fine phonetic cues from the input and for fitting in the native grammar. Such phonological phenomena can also be attributed to orthography and adaptation methods. However, I argue that English orthography is not the main factor that influences nasal insertion in Mandarin loanwords, as shown in §2.3.3, where I present a range of examples that only have one nasal in English spelling. Orthography matters more when the foreign words enter via reading or are created through consonant-vowel combination tables. When words are adapted

through reading or a consonant-vowel adaptation table, they follow the spelling and have nasal insertion. Coincidently, the output shares acoustic similarity with the input. However, when the spelling only has one nasal, the output will also have one nasal. Failure of fine acoustic cue mapping would occur. Similar to coda [m] adaptation, vowel epenthesis emerges because [m] appears in the written input. This may cause vowel epenthesis when [m] is in homorganic environments in the input and lead to unfaithful acoustic and phonological feature mapping because the output will have one more syllable than its input and one more labial feature is added for OCP. The main focus of this dissertation is on sound-based loanword adaptation. Hence, orthography is discussed very little.

After Hsieh et al., (2009), this dissertation examines another two contextualized nasal adaptation processes, which have essential differences in grammaticality. Intervocalic nasal mapping occurs when syllable structure is good in both languages; whereas coda [m] is only licit in English.

This dissertation first provides detailed corpus data analyses on English intervocalic nasal and coda [m] adaptations. They present that nasal segment adaptations are contextualized. The phonological generalizations show evidence that similar patterns occur cross-linguistically.

English intervocalic singleton consonants may be adapted as geminated consonants actively in loanwords in languages such as Japanese, Finnish, Hungarian, and American Italian, in which certain stress location and vowel type conditions also appear to be relevant. Consonant gemination is controlled by the faithfulness of the vowel quality, e.g. length in the donor languages. This suggests a common basis that underlies consonant gemination in loanword phonology.

English coda [m] can be repaired by vowel epenthesis and nasal place change. The choice of the epenthetic vowel falls in the realm of neighboring consonant feature spreading or consonantal

assimilation (Uffmann, 1984, 2007). This is also seen in Nupe, Haya, Yoruba, Sranan, Tswana, Swahili, etc. Consonant assimilation tendency is especially strong on labial consonants. Uffmann points out that in those languages, the pick of the epenthetic vowel can be done by vocalic spreading, e.g. Sranan, Fula, Tswana, Zulu, etc., and it can also be the default epenthetic vowel, e.g. Japanese. However, whenever the preceding consonant is labial, those languages show that the epenthetic vowel is [u] or a round vowel in their vowel inventory.

This dissertation also uses perceptual experiments to test whether the observed patterns also show up in online adaptations. The perceptual experimental results showcase that bilinguals and monolinguals handle the intervocalic nasal similarly but handle coda [m] differently. Nasal insertion for ambisyllabic nasal is an unnecessary repair (Y. Kang, 2010) since Mandarin phonotactics allow CVNV. In general, both groups are sensitive to the fine acoustic cue on the prenasal vowel and handle them similarly. The results show evidence that both groups have contrast on tense and lax vowels. Hence, I claim that the results also indicate that intervocalic nasal adaptation is more perceptually based (Dupoux et al., 1999; Y. Kang, 2003; Peperkamp & Dupoux, 2003b; Peperkamp et al., 2008). Mandarin speakers are sensitive to the prenasal vowel length in the input. In addition, I argue that they hear the nasal feature on the prenasal vowel. CVNV is actually CṼNV in the input. It also means that the inserted nasal does not heavily undergo native grammar examination. The lower nasal insertion rate in the experimental results is due to variable prenasal vowel modifications (Lin, 2008a, 2008b).

However, when Mandarin speakers encounter coda [m], speakers with different language backgrounds handle it differently. Bilingual speakers prefer vowel epenthesis. This results support the phonological based model (LaCharité & Paradis, 2005; Paradis et al., 1997; Paradis & Tremblay, 2009; Rose, 1999) that bilingual speakers are those who introduce the foreign words to

their native language and maximally preserve all the segmental information from the source even at the expense of adding non-existing information in the input. This phenomenon is introduced by the Preservation Principle (Paradis, 1996). The results from monolinguals show evidence that they only focus on syllable repair but they do not have a preferable repair strategy so the outputs have more variability.

This dissertation mainly focuses on corpus data and perceptual experimental data analyses, but it does not address production and social factors, and influence of orthography is purposefully ignored. To have a better comprehensive understanding of the current topic, I have also collected production data from the same people so the data are ready for analyses. In fact, the production data and perceptual similarity data were collected together. The production data were even collected before the current perception data. I decided the order in this way to avoid a priming effect on the production experimental results. If I had run the perception experiment first, they would have heard the given possible outputs of the test items and this would further affect how they would adapt the test item orally. Miao (2005) ran her perceptual experiment first then ran the production experiments on vowel epenthesis. Her production data showed 100% vowel epenthesis rate for syllable repair. From the production data, I can see whether the patterns in the corpus and the perceptual experiments are still maintained. I can also find clues on how tones may affect the adaptation of English nasals, especially for the intervocalic nasal cases. English stress syllable mapping with Mandarin tones still needs more investigation in Mandarin loanword phonology (Hsiao-hung, 2006; Wu, 2006a, 2007). The production data may also provide a picture of how monolingual speakers adapt coda [m] in the word-medial and word-final positions more clearly. I predict that the intrapersonal consistency on selecting repair strategy will also show up in the production data. That said, the production data may also show the two repair strategies are still

adopted at chance among the same group of monolingual speakers. In other words, coda [m] in the word-medial and the word-final positions are repaired with the same method within-person.

Yip (2006) points out that people from two different Mandarin speaking areas share the same grammar; however, they produce different loanword outputs for one input. Her examples show that Mainland Mandarin speakers tend to use vowel epenthesis to fix illicit codas, e.g. *Titanic* → [tʰai.tʰan.niː.kɤː], whereas, Taiwan Mandarin speakers prefer consonant deletion, e.g. *Titanic* → [tʰjeː.taː.niː]. However, many existed loanwords in Mainland China show they tend to revise what they used to use and delete coda consonants nowadays, e.g. Cheetos → [tɕʰiː.twoː]/*[tʂɻ.twoː.sɻ]. This may be attributed to the fact that Mainland people have more and more English contact. It can be also because the form that undergoes consonant deletion is more perceptually similar to the input.

Lastly, I suggest that studies accompanied with orthography in Mandarin loanword phonology are necessary in this regard. Smith (2006) discusses that doublets in Japanese are due to them coming in from text reading and hearing. In most cases, consonants need to have double spelling when the preconsonantal vowel is lax due to English spelling rule. This dissertation uses examples with only one nasal in orthography and spelled with lax vowels to argue nasal insertion is perceptual based. Mandarin speakers can adapt these words by reading. If the outputs show the same tendency, then it means orthography does not play a significant role. It also means that Mandarin speakers somewhat possess representations of such structures from learning English. Similar experiments can be run for coda [m] adaptation. The current perceptual experimental data show that monolingual speakers have no preferred strategy. The results may change if they borrow the pseudo words by text reading.

APPENDIX

Table A.1 Practice Session

A (Mandarin)	B (Mandarin)	X (English)
[ai4.taː2]	[ai4.jiː1.daː2]	Aida [ˈaɪda]
[piː3.tɤː4]	[piː3.tɤː4.əɹ3]	Bitter [ˈbitɚ]
[ɕia4.lin2]	[ɕia4.əɹ3.lin2]	Charlene [ʃarˈlin]
[tɤː2.liː4.kʰaː3]	[tɤː2.rwei4.kʰaː3]	Derick [ˈdɛrək]
[kai4]	[kai4. tɤː2]	Gad [gæd]
[ji1ː.ʂɻ1.tʰaː3]	[ji1ː.ʂɻ1.tʰaː3. əɹ3]	Ishtar [ˈɪʃtɑɾ]
[kʰaː3.liː4.taː2]	[khaː3.rweiː4.taː2]	Karida [kəˈridə]
[kʰən3]	[kʰən3.tʰɤ4ː]	Kent [kɛnt]
[liː4]	[liː4.puː3]	Leep [lip]
[mwoː4.tʰiː2]	[mwoː4. əɹ3.tʰi ː]	Molty [ˈmolti]

1. Some words in the practice session are real words and some are pseudo words.

2. Numerals in possible outputs represent Mandarin tones.

Table A.2 Nasal Insertion Test Items

Structure	V tenseness	ˈV	Token	Possible outputs	
[ˈCVnVC] 10	Tense	i	[ˈbini]	bi1 ni2	bin1 ni2
		e	[ˈbeni]	bei1 ni2	ban1 ni2
		u	[ˈbuni]	bu4 ni2	ben1 ni2
		o	[ˈboni]	bo1 ni2	bang1 ni2
	Lax	ɪ	[ˈbɪni]	bi1 ni2	bin1 ni2
		ɛ	[ˈbɛni]	bei1 ni2	ban1 ni2
		æ	[ˈbæni]	bai4 ni2	ban4 ni2
		ʊ	[ˈbʊni]	bu4 ni2	ben1 ni2
		ɔ	[ˈbɔni]	bo1 ni2	bang1 ni2
		ɑ	[ˈbɑni]	ba1 ni2	bang1 ni2
[CVˈnita] 10	Tense	i	[biˈnita]	bi3 ni2 ta3	bin3 ni2 ta3
		e	[beˈnita]	bei3 ni2 ta3	ben3 ni2 ta3
		u	[buˈnita]	bu3 ni2 ta3	ben3 ni2 ta3
		o	[boˈnita]	bo1 ni2 ta3	bang1 ni2 ta3
	Lax	ɪ	[bɪˈnita]	bi3 ni2 ta3	bin3 ni2 ta3
		ɛ	[bɛˈnita]	bei3 ni2 ta3	ben3 ni2 ta3
		æ	[bæˈnita]	bai4 ni2 ta3	ban1 ni2 ta3
		ʊ	[bʊˈnita]	bu3 ni2 ta3	ben3 ni2 ta3
		ɔ	[bɔˈnita]	bo1 ni2 ta3	bang1 ni2 ta3
		ɑ	[bɑˈnita]	ba1 ni2 ta3	bang1 ni2 ta3
Variable adaptation [ˈCVCənV] 10	Tense	i	[ˈfibəni]	fei1 ben3 ni2	fei1 bo2 ni2
		e	[ˈfebəni]	fei4 ben3 ni2	fei4 bo2 ni2
		u	[ˈfubəni]	fu1 ben3 ni2	fu1 bo2 ni2
		o	[ˈfobəni]	fo2 ben3 ni2	fo2 bo2 ni2
	Lax	ɪ	[ˈfɪbəni]	fei4 ben 3ni2	fei4 bo2 ni2
		ɛ	[ˈfɛbəni]	fei1 ben3 ni2	fei1 bo2 ni2
		æ	[ˈfæbəni]	fa3 ben3 ni2	fa3 bo2 ni2
		ʊ	[ˈfʊbəni]	fu4 ben3 ni2	fu4 bo2 ni2
		ɔ	[ˈfɔbəni]	fo2 ben3 ni2	fo2 bo2 ni2
		ɑ	[ˈfɑbəni]	fa1 ben3 ni2	fa1 bo2 ni2
[ɑ] exception [CVˈbɑnə] 10	Lax	ɪ	[bɪˈbɑnə]	bi3 ba1 na4	bi3 ban1 na4
		ɛ	[bɛˈbɑnə]	bei3 ba1 na4	bei3 ban1 na4
		æ	[bæˈbɑnə]	bai3 ba1 na4	bai3 ban1 na4
		ʊ	[bʊˈbɑnə]	bu3 ba1 na4	bu3 ban1 na4
		ɔ	[bɔˈbɑnə]	bo3 ba1 na4	bo3 ban1 na4
		ɑ	[bɑˈbɑnə]	ba3 ba1 na4	ba3 ban1 na4
	Lax	ɪ	[bɪˈbænə]	bi3 ban1 na4	bi3 ba1 na4
		ɛ	[bɛˈbænə]	bei3 ban1 na4	bei3 ba1 na4
		æ	[bæˈbænə]	bai3 ban1 na4	bai3 ba1 na4
		ʊ	[bʊˈbænə]	bu3 ban1 na4	bu3 ba1 na4
		ɔ	[bɔˈbænə]	bo3 ban1 na4	bo3 ba1 na4
		ɑ	[bɑˈbænə]	ba3 ban1 na4	ba3 ba1 na4

Table A.3 Vowel Epenthesis Test Items

Structure	V tenses	ˈV	Nasal	Token	Possible outputs	
Monosyllabic [CVN] 20	Tense	i	n	[lin]	lin2	li2 ni2
			m	[lim]	lin2	li2 mu3
		e	n	[len]	lei2 en1	lei2 ni2
			m	[lem]	lei2 en1	lei2 mu3
		u	n	[lun]	lun2	lun2 ni2
			m	[lum]	lun2	lu2 mu3
		o	n	[lon]	long2	lou2 ni2
			m	[lom]	long2	lou2 mu3
	Lax	ɪ	n	[lɪn]	lin2	lin2 ni2
			m	[lɪm]	lin2	lin2 mu3
		ɛ	n	[lɛn]	lan2	lan2 ni2
			m	[lɛm]	lan2	lan2 mu3
		æ	n	[læn]	lan2	lan2 ni2
			m	[læm]	lan2	lan2 mu3
		ʊ	n	[lʊn]	lun2	lun2 ni2
			m	[lʊm]	lun2	lun2 mu3
		ɔ	n	[lɔn]	long2	long2 ni2
			m	[lɔm]	long2	long2 mu3
		ɑ	n	[lɑn]	lang2	lang2 ni2
			m	[lɑm]	lang2	lang2 mu3

Table A.3 (cont'd)

Structure	V tenseness	ˈV	Token	Possible outputs	
Word-medial [ˈCVmCV] 10	Tense	i	[ˈlimdi]	li2 mu3 di2	lin2 di2
		e	[ˈlemdi]	lei2 mu3 di2	lan2 di2
		u	[ˈlumdi]	lu3 mu3 di2	lun2 di2
		o	[ˈlomdi]	luo2 mu3 di2	long2 di2
	Lax	ɪ	[ˈlɪmdi]	lin2 mu3 di2	lin2 di2
		ɛ	[ˈlɛmdi]	lan2 mu3 di2	lan2 di2
		æ	[ˈlæmdi]	lan2 mu3 di2	lan2 di2
		ʊ	[ˈlʊmdi]	lun2 mu3 di2	lun2 di2
		ɔ	[ˈlɔmdi]	long2 mu3 di2	long2 di2
		ɑ	[ˈlɑmdi]	lang3 mu3 di2	lang3 di2
Word-final coda [ˈCVCVm] 10	Tense	i	[ˈlidim]	li4 di2 mu3	li4 ding3
		e	[ˈledim]	lei2 di2 mu3	lei2 ding3
		u	[ˈludim]	lu4 di2 mu3	lu4 ding3
		o	[ˈlodim]	luo4 di2 mu3	luo4 ding3
	Lax	ɪ	[ˈlɪdim]	li4 di2 mu3	li4 ding3
		ɛ	[ˈlɛdim]	lei2 di2 mu3	lei2 ding3
		æ	[ˈlædim]	la1 di2 mu3	la1 ding3
		ʊ	[ˈlʊdim]	lu4 di2 mu3	lu4 ding3
		ɔ	[ˈlɔdim]	luo4 di2 mu3	luo4 ding3
		ɑ	[ˈlɑdim]	la1 di2 mu3	la1 ding3
Homorganic environment [ˈCVmbi] 13	Tense	i	[ˈlimbi]	lin2 bi3	lin2 mu3 bi3
		e	[ˈlembi]	lan2 bi3	lan2 mu3 bi3
		u	[ˈlumbi]	lun2 bi3	lun2 mu3 bi3
		o	[ˈlombi]	long2 bi3	long2 mu3 bi3
	Lax	ɪ	[ˈlɪmbi]	lin2 bi3	lin2 mu3 bi3
		ɛ	[ˈlɛmbi]	lan2 bi3	lan2 mu3 bi3
		æ	[ˈlæmbi]	lan2 bi3	lan2 mu3 bi3
		ʊ	[ˈlʊmbi]	lun2 bi3	lun2 mu3 bi3
		ɔ	[ˈlɔmbi]	long2 bi3	long2 mu3 bi3
		ɑ	[ˈlɑmbi]	lang3 bi3	lang3 mu3 bi3
	Diphthong	aʊ	[ˈbaʊmbi]	bao1 mu3 bi3	bang1bi2
		aʊ	[ˈdaʊmbi]	dao4 mu3 bi3	dang1bi3
		aʊ	[ˈgaʊmbi]	gao1 mu 3bi	gang1bi3

Table A.4 Filler Items

Structure	V tenseness	ˈV	Token	possible output	
CV(C) 10	Tense	i	[pi]	pi4	ti4
		e	[pe]	pei4	tai4
		u	[pu]	pu4	tu4
		o	[po]	po4	tou4
	Lax	ɪ	[pɪd]	pi4 de2	ti4 de2
		ɛ	[pɛd]	pei4 de2	tai4 de2
		æ	[pæd]	pai4 de2	tai4 de2
		ʊ	[pʊd]	pu4 de2	tu4 de2
		ɔ	[pɔd]	po4 de2	tou4 de2
		ɑ	[pɑd]	pa4 de2	ta4 de2
CVˈCVC 10	Tense	i	[bɪˈtid]	bi3 ti4 de2	bi3 pi4 de2
		e	[bɪˈted]	bi3 tai4 de2	bi3 pai4 de2
		u	[bɪˈtud]	bi3 tu4 de2	bi3 pu4 de2
		o	[bɪˈtod]	bi3 tou4 de2	bi3 po4 de2
	Lax	ɪ	[bɪˈtɪd]	bi3 ti4 de2	bi3 pi4 de2
		ɛ	[bɪˈtɛd]	bi3 tai4 de2	bi3 pai4 de2
		æ	[bɪˈtæd]	bi3 tai4 de2	bi3 pai4 de2
		ʊ	[bɪˈtʊd]	bi3 tu4 de2	bi3 pu4 de2
		ɔ	[bɪˈtɔd]	bi3 tou4 de2	bi3 po4 de2
		ɑ	[bɪˈtɑd]	bi3 ta4 de2	bi3 pa4 de2
CV(C) 10	Tense	i	[spi]	shi3 bi4	shi3 pi4
		e	[spe]	shi3 bei4	shi3 pei4
		u	[spu]	shi3 bu4	shi3 pu4
		o	[spo]	shi3 bo4	shi3 po4
	Lax	ɪ	[spɪd]	shi3 bi4 de2	shi3 pi4 de2
		ɛ	[spɛd]	shi3 bei4 de2	shi3 pei4 de2
		æ	[spæd]	shi3 bai4 de2	shi3 pai4 de2
		ʊ	[spʊd]	shi3 bu4 de2	shi3 pu4 de2
		ɔ	[spɔd]	shi3 bo4 de2	shi3 po4 de2
		ɑ	[spɑd]	shi3 ba4 de2	shi3 pa4 de2
ˈCVCVC 10	Tense	i	[ˈstidi]	shi3 di1 di3	shi3 di1 di3
		e	[ˈstedi]	shi3 dai4 di2	shi3 tai4 di2
		u	[ˈstudi]	shi3 du4 di2	shi3 tu4 di2
		o	[ˈstodi]	shi3 dou4 di2	shi3 tou4 di2
	Lax	ɪ	[ˈstɪdi]	shi3 di1di2	shi3 ti1 di2
		ɛ	[ˈstɛdi]	shi3 dai4 di2	shi3 tai4 di2
		æ	[ˈstædi]	shi3 dai4 di2	shi3 tai4 di2
		ʊ	[ˈstʊdi]	shi3 du1 di2	shi3 tu1 di2
		ɔ	[ˈstɔdi]	shi3 dou41di2	shi3 tou41di2
		ɑ	[ˈstɑdi]	shi3 da4 di2	shi3 ta4 di2

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