MANDARIN LOANWORD PHONOLOGY:

A CASE STUDY OF THREE ENGLISH MID VOWELS

by

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(Under the Direction of Keith Langston)

ABSTRACT

This thesis explores the topic of loanword adaptation in Standard Mandarin, with special attention to variable vowel adaptations. I present contending theories of loanword phonology, along with complicating sociolinguistic and paralinguistic factors. After a thorough summary of Standard Mandarin phonology following Duanmu (2007) and Lin (2007), I present the results of a psycholinguistic experiment. Speakers from Northern China were asked to listen to a series of nonce place names and write down their own adaptations. The tokens were designed to test three English mid vowels, [ɛ, ʌ, oʊ] in different syllabic environments. For the most part, findings from previous studies were corroborated; however in terms of tone and vowel adaptations, there are certain discrepancies that point toward a theory of loanword adaptation that incorporates both perceptual and phonological factors.

INDEX WORDS: Mandarin Chinese, loanword phonology, speech perception, tone, vowel adaptation

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for my wife, Iris Meng

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INTRODUCTION

This thesis deals with the area of phonology that analyzes the changes and adaptations that take place when a language borrows a foreign form into its native phonological system. Loanword phonology has been a rich area for supplementing or revising broader theories of linguistic systems, as well as how those systems interact with other areas of human cognition. Though the topic has been an area of active research for at least the past six decades (especially after the rise of perceptually-based phonological studies and constraint-based frameworks of Universal Grammar, particularly Prince & Smolensky's Optimality Theory), there are still many unanswered questions and unexplained phenomena in the field, as whole books and volumes of journals devoted to its study will attest.

Chapter 2 attempts an overview of the field so far, from Haugen's (1950) framing of loanword forms in a psychological perspective up until the present day. The main division between researchers has been in delineating the place of auditory perception and phonological processing in adopting loanwords into a speaker's native grammar. Not surprisingly, elements of both have been thoroughly documented and incorporated into models of loanword adaptation. After reviewing previous studies on segmental, as well as suprasegmental, aspects of the word, I turn to factors at play beyond the linguistic system, such as sociological factors and the influence of orthography on adapting words.

The focus of this thesis is Mandarin Chinese, particularly the standard form of the language spoken in Northern Mainland China and described in Duanmu (2007) and Lin (2007). Chapter 3 gives a comprehensive overview of the phonetic and phonological properties of the language, focusing on areas of the grammar that have received extensive attention in the literature. The information presented therein will serve as a background for the rest of the thesis.

Chapter 4 reviews the literature on loanword adaptation in Mandarin in particular, with reference to studies on Cantonese and Taiwanese when relevant. After presenting the major adaptation patterns found in Miao (2005), the most complete source on the matter, a variety of topics in adaptation of stress and tone, tendencies of epenthesis and word length, and patterns of adapting vowels are presented. Special attention is given to the faithfulness, or lack thereof, of vocalic features, showing that the feature [back] seems to be more important in loanword adaptation than [high] or [round].

To test the tendencies exhibited among these various sources, a translation task was devised and the results are presented in Chapter 5. Eight female speakers of Standard Mandarin were recruited to listen to a series of audio recordings and provide a natural translation of what they heard. The tokens were designed as nonce place names and focused on three English mid vowels, [ɛ, ʌ, oʊ], in five different environments: syllables closed by the segments [m, l, p, t] and an open syllable.

The results were consistent with those found in the literature in most cases, but differed in certain aspects of the vocalic adaptation, as well as in the hierarchy of choices for tones on the first syllable. Special attention is also given to the patterns of epenthesis for each type of coda consonant. The findings suggest that not only must one consider the adaptation of a given English vowel or feature in its wider syllabic environment, but also that noncontrastive phonetic factors play a role in Mandarin loanword adaptation. The thesis concludes with a discussion of the results and the identification of questions that require further research.

CHAPTER 1: LOANWORD PHONOLOGY

1. Introduction

As a natural consequence of contact situations, languages often borrow from one another, introducing foreign forms and structures into the borrowing language. Once the provenance of historical linguists exploring etymological phenomena, since the mid-20th century language borrowing has become a mainstay in wider linguistic theory, with no area more prolific than that of phonology. Not only have researchers been interested in the circumstances that give rise to linguistic borrowing and how foreign words and phrases are incorporated through the process, but perhaps more so they have looked at the problem of how an L1 system adapts (or does not adapt) to forms (phones, features, syllables, phonotactic environments, etc.) in the L2 source language that are absent from and/or in direct conflict with the native phonology. Early on, such phenomena were ascribed to the periphery of the grammar and explained by ad hoc re-write rules that served little or no other purpose in the native phonology. However, the advent of constraint-based theoretical models, especially Prince & Smolensky's Optimality Theory (Prince and Smolensky 2004), has made it easier to pull loanword phonology back from the periphery and into the core grammar. That is, the same set of constraints that are used for native phonological phenomena can be used to account for the operations at play in loanword phonology (Yip 1993). At times, we find constraints at play that are universal in nature but dormant in the native phonology, leading to an "emergence of the unmarked" effect, also noted for second language phonology (e.g. Broselow et al. 1998). Following the greater movement in the field to "ground" such constraints in functionalist explanations such as ease of production and/or perception, steps have been taken to align the "perceptual grammar" with the phonology proper.

Chief among the questions in loanword adaptation is what constitutes the dominant source of lexical material for the adaptation of a loanword. Is the process better explained in perceptual (i.e.

phonetic) or in phonological terms? Are the two necessarily separable? This section is an overview of the ideas and data that have been the driving force for attempting to answer this question, as well as the proposals for theoretical models of phonology that have been posited in this endeavor. I will briefly overview sociological and paralinguistic factors that must also be considered in order to capture a complete picture of loanword phonology.

2. Perception is dominant

In the latter half of the 20th century, experimental studies in speech perception gradually began to take on more prominence in the phonological literature, especially in studies of second language acquisition. One famous study has particular relevance for loanword adaptation, Dupoux et al. (1999). In a perceptual experiment, the researchers showed that Japanese speakers could not perceive a difference between nonce words that contained phonotactic violations of Japanese phonology and those that repaired such violations via an epenthetic vowel. Similar results for Koreans were obtained in a subsequent study, Kabak & Idsardi (2007), that pointed toward syllable structure preservation as the driving force for epenthesis. In both cases, however, it is crucial that the epenthetic vowels produced by Japanese and Koreans when speaking English as a second language (or in adapting foreign words) appear to be not a production error, but the result of perceptual effects in the input. It seems to follow then, if these "perceptual illusions" are present in the perceptual component of the grammar, then they must also be present in the phonological component as well.

Perceptual phenomena had been ascribed to loanword adaptation in studies previous to Dupoux et al. (1999). For example, Takagi & Mann (1994) show that in an experimental setting Japanese speakers respond to duration (non-contrastive in the source language[1]) in English source words when adapting consonants and vowels as singletons versus geminates. In particular, the tense/lax contrast in English (absent in Japanese) is perceived as a contrast of duration to the Japanese listener. Furthermore, voiceless stops following a lax vowel are adapted as geminates due to the longer closure duration in that

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[1] However, proponents of phonological explanations could point toward researchers who analyze the tense/lax distinction as an underlying length contrast (Keith Langston, p.c.).

environment, whereas the same stops following a tense vowel are adapted as singletons (Takagi and Mann 1994: 345).

However, a stronger view is taken in Peperkamp & Dupoux (2003). They claim "…loanword adaptations are not due to the phonological grammar, but rather, to perceptual processes involved in the decoding of nonnative sounds. These perceptual processes…are sensitive not so much to the phonological properties of the language as to its phonetic properties (Peperkamp and Dupoux 2003: 367)." Separating the grammar into a phonetic decoding module and a phonological decoding module, they claim the former filters fine details of the acoustic signal before it is sent to the latter for representational mapping. If two nonnative sounds are sufficiently similar to one native category, they are merged, resulting in "phonological deafness" at the segmental level. The same will apply at suprasegmental and syllabic levels as well. They claim that the same process must apply to both monolingual and bilingual speakers.

Using similar data, Peperkamp (2005) elaborates on this claim. She claims that many of the phonological accounts of particular loanword adaptations can be dispensed with if non-conscious perceptual effects are assumed in listeners' on-line adaptations when the word first entered the language. For example, native processes in Lama cause a coda-position palatal nasal to be fronted to an alveolar in paradigmatic alternations. However, when French words ending in palatal nasals are borrowed, they are preserved as palatals by epenthesis rather than being subject to native phonological processes. Similarly, word-final unreleased stops in English loanwords into Korean are adapted as syllable-initial aspirants, even though Korean phonology allows final unreleased stops in coda position. If we assume the forms are perceived in their adapted form in on-line adaptations, the process requires no violations or exceptions to the native grammar.

Furthermore, no phonological analyses need apply to forms when they are taken over by monolinguals, as they would never have had access to the source language phonological representation to begin with. Variation across languages in adaptation strategies are then the result of "fine-grained differences in the surface phonetic structure of individual languages (Peperkamp 2005: 348)." Likewise, variation within a single language, common at early stages of borrowing from a given foreign language, is the result of competing well-formedness structures that share a phonetic proximity in the borrowing language, as paralleled by data in speech perception experiments (Peperkamp 2005: 350).

3. Phonology is dominant

Traditionally, the view with the most adherents has been that loanword adaptations are carried out by bilinguals, relying for the most part, if not entirely, on phonological criteria. In recent times, this stance has been put against the perceptual viewpoint to reveal many seeming contradictions that arise when discounting phonological factors from foreign-speech processing.

The strongest proponents for this view have been Carole Paradis and collaborators (LaCharite and Paradis 2005; Paradis 2006; Paradis and LaCharite 1997). Couched within the framework of Paradis' Theory of Constraints and Repair Strategies (Paradis 1986), she lays a framework for phonological adaptations that abide by two important principles:

1. Threshold Principle: All languages have a tolerance threshold to segment preservation, set at two steps (referred to as repairs) within a constraint domain[2]. Any feature change between the source and borrowing language is considered a "repair" operating to abide by native constraints.
2. Minimality Principle: Repairs apply at the lowest phonological level to which the violated constraint refers and involve as few strategies as possible. The pattern emerging from the data is that beyond two repairs, operations are considered "too costly" and segments are instead deleted, as follows from the Threshold Principle. (Paradis 1996: 511)

These two principles are utilized to account for the patterning of data collected in an extensive database (Project CoPho) of loanword adaptations in four different languages. Within the limits of these two principles, segmental information seems to be maximally preserved, with deletions of some sort accounting for only a little over six percent of all adaptations. (However, compare Golston & Yang (2001) which shows that deletion is overwhelmingly the preferred option in White Hmong.) These cases of deletion are the result of too "costly" repairs, where the Minimality Principle would be violated in preservation of a segment or structure in question, thereby resulting in deletion. In the analyses given, Paradis' model accounts nicely for the 12,635 forms examined. She goes on to criticize classic

[2] The issue of what constitutes a constraint domain is addressed in the same paper, but is not relevant here.

Optimality Theory for being unable to predict the cross-linguistic preference for preservation over deletion given the unconstrained ranking of Max and Dep (but cf. Steriade 2001b).

Paradis & LaCharite (1997) consider adaptations in relation to the Core/Periphery distinction common in generative literature (for studies in loanwords see Itô and Meister (1995a, 1995b)). Phenomena such as onomatopoeia, language games, etc. are generally considered “peripheral” elements of the grammar. Paradis & LaCharite claim that the further one moves from the core grammar, the more relaxed are constraints on forms (a more simplified view than Itô and Mester, who claim certain constraints hold across (historical) strata of the lexicon). Loanwords stipulated as part of the periphery tend more towards non-adaptations, i.e. forms allowing structures not found in the core grammar. Paradis & LaCharite point out that there is a direct correlation between the number of non-adaptations and the proportions of bilinguals in community. For example, in Montreal both non-adaptations and bilinguals have high percentage rates, followed by a more intermediate percentage of both in Quebec as a whole, and relatively few in France. The authors take this as evidence to their claim that borrowers, namely bilingual borrowers, accurately perceive and process the phonological representations of the source language. They further point out that “sociolinguistic studies show that the role of monolinguals in loanword phonology is limited to using and transmitting established loans, and….adapting the peripheral segments, which may sometimes have been left unadapted by bilinguals (Paradis and LaCharite 1997: 394).”

Paradis claims that theories giving precedence to perception fail to account for much of the phenomena observed in loanword data. This can obtain at low levels of segment mapping, e.g. when English /b/ is adapted to French /b/, despite phonetic differences that make it acoustically closer to French /p/, or in the Mexican-Spanish adaptation of the allophonic English flap in words like ‘bitter’ or ‘caddie’, to a dental stop rather than the phonemic category of the Spanish rhotic tap (cf. Oh (1996) for similar phenomena in Korean). Paradis (2006) analyzes a more complex adaptation in Russian of high front rounded vowels following a non-word-initial consonant as the unnatural sequence /C^{j}u/ in the borrowing language, e.g. Russian [al^{j}úr] > French [alyr], or Russian [fl^{j}úg^{j}ɛr] > German [flý:gəl]. In the native grammar, Russian rarely palatalizes before back vowels (Paradis scoured a dictionary for such occurrences, resulting in only 2.1% of cases, 5.2% of which were before [u], and most of which were loanwords), but this tends to be the standard procedure for adapting the foreign vowel [y]. She claims that the perceptual account, for reasons such as salience and source-to-loan similarity, cannot account for such adaptations, unlike a phonological account based on a source language representation that undergoes delinking of the feature [-back], which in turn docks on the preceding consonant.

In the authors' words "[t]he borrower does not directly seek the closest L1 phonetic match, but rather the closest phonological one [in terms of distinctive features] for illicit L2 sounds (LaCharite and Paradis 2005: 227)." They claim if adaptation were driven by phonetic similarity, then we would expect different results than those found in the database. The authors discount the possibility of orthographic influences in such examples above, as expected instances of other adaptations fail to exhibit such influences, as when English orthographic <ea> in words like 'heater' are adapted not as /ea/ but /i/ in French [itəɹ], Spanish [xitər] and Italian [itər] (LaCharite and Paradis 2005: 241). In summary, it is phonemic categories, rather than phonetic approximation, that are behind adaptation patterns.

A strong position within Optimality Theory is put forth by Jacobs & Gussenhoven (2000). Beginning with the assumption that contrasts and saliency differences cross-linguistically cannot stem from the human auditory system (or else it must be claimed that Hawaiian speakers, unlike Cantonese speakers, fail to hear the distinction between [s] and [k] when adapting English words, as the former language lacks the highly salient [s], whereas the latter do not—see Adler (2006) below for more discussion), they claim that in an OT phonological grammar all of the changes to the input can be predicted by constraint ranking. Since human populations don't differ in their auditory anatomy, but rather in their mental grammars, the (non)occurrence of salient segments in a given grammar, or their retention (or not) in loanword adaptations must rely on phonological, rather than perceptual, explanations.

In their account, a language user's universal segment parser will assign a phonological representation to the foreign word in the same way a first-language learner will, with no need for a perceptual stage (Jacobs and Gussenhoven 2000: 209). The difference between L1 acquisition and loanword adaptation is that in L1 acquisition Constraint Demotion (Smolensky 1996; Tesar and Smolensky 2000: among others) will optimize harmony between the lexical representation and the output by changing the hierarchy, while in loanword adaptation Lexicon Optimization (Prince and Smolensky 2004) will optimize harmony by changing the lexical representation to coincide with the constraint ranking. In other words, in L1 acquisition production induces change, whereas in loanword adaptation it is perception that induces change (Jacobs and Gussenhoven 2000: 204). The idea stems from Smolensky (1996) in which one constraint ranking, and thus one grammar, accounts for perception and production (with the word faithfully stored in the lexicon), but competing candidates cause changes to the constraint hierarchy, resulting in different effects between production and perception in L1 acquisition.

It is not clear how Jacobs & Gussenhoven's approach deals with perceptual studies such as Dupoux et al. (1999). Furthermore, their analysis used to account for loanwords in Cantonese involves the positing of seemingly ad hoc constraints and gradient constraint hierarchies. On the other hand, it is clear from the above accounts that the position which claims all changes in loanword phonology are results of perceptual errors is equally weak.

4. The inevitable compromise

The prevailing take on loanword adaptation has come to be that both perceptual and phonological information are relevant when adapting foreign words into a borrowing language. However, there is still debate as to exactly how the two interact.

4.1 The two grammars approach

In the past, it has been common practice to posit a separate perceptual parse that would then be sent to the phonological grammar for further alteration. The most often cited study of loanwords is Silverman (1992), who posits a perceptual level and an operative level to account for patterns in Cantonese loanword phonology. A similar position is taken in Yip (2002a, 2006). In Silverman's account, there is a preliminary scansion where a string of segments are mapped to their closest phonetic match in the native grammar. Salient consonants in phonotactic environments not allowed in the receiving language are retained through epenthesis, while those below the threshold of saliency (e.g.

unreleased stops following nasals in a complex coda) are either not registered at all or simply deleted in the first scansion. The output to the perceptual level is the input to the operative level where native phonological rules then apply to nativize the loan.

However, even in Silverman's perceptual scan a certain degree of phonology is at play, including syllabification and a minimal bi-syllabic word constraint which forces the same segment to delete when the input is already disyllabic but to be retained through epenthesis to avoid a monosyllabic output (e.g. /l/ in initial consonant clusters). In essence, the perceptual scansion is in many ways constrained by the prosodic and segmental composition of the phonological grammar.

Kenstowicz (2003) also posits a separate perception and production grammar to account for patterns in French adaptations into Fon. By his account, a single constraint ranking cannot account for the differing treatment of segments unless a separate perceptual grammar is posited that fails to parse certain segments over others, e.g. final rhotics versus laterals. In another example, Kenstowicz notes that in final clusters a single system would result in double epenthesis, but the attested pattern can be captured with two separate grammars. Ordinarily, medial and final /s/ are adapted as onsets of an epenthetic syllable (whisky > [wisiki], tournevis > [tunɛ̃visi]), just the same as word final stops (pompe > [pɔ̃pu], bic > [biki]). Such implies a ranking of Max >> Dep. However, the words *poste* and *Christ* are adapted into Fon as [posu] and [klisu], respectively. This data implies the opposite ranking Dep >> Max unless a separate perceptual grammar is posited (Kenstowicz 2003: 101-102):

(1) Perception Mapping

/post/	Dep-V	*stop/ obstruent__#	Max-C
post		*!	
☞ pos			*
postu	*!		
posut	*!	*	
posutu	*!*		

(2) Production Mapping

/pos/	Max-C	*stop/ obstruent__#	Dep-V
pos		*!	
☞ posu			*
po	*!		

4.2 The phonetics-in-phonology approach

At least since Stampe's Natural Phonology hypothesis (see Donegan and Stampe 1979), and the rise of experimental phonology, it has been a major goal of the field to ground phonological rules or constraints in functionalist terms (for an overview see Hayes and Steriade 2004; also Kingston and Diehl 1994; Lindblom 1986; Ohala 1983, 1990). One of the more successful additions to the theory has been Steriade's P-map (Steriade 2001a, 2001b), which posits an addition to the architecture of OT that assesses the ranking of faithfulness constraints vis-à-vis a perceptual metric that evaluates relative similarity between input and output, preferencing the least salient departure from the underlying form. She also gives implications for changes to foreign input in loanword adaptation (by applying the P-map to Silverman's (1992) data) and since then many researchers have incorporated the P-map approach into their analyses of loanword data (Adler 2006; Davis and Cho 2006; Kang 2003; Kenstowicz 2005, 2007).

Kenstowicz (2007) uses Steriade's P-map to account for some of the attested patterns of English loanwords into Fijian. In particular, he considers the case of epenthetic vowels, long considered to be chosen in regards to the vowel exhibiting least prominence across various perceptual domains (usually a high and/or short vowel—see Chapter 3 Section 2.2 for more on perceptual salience). Fijian epenthetic vowels appear to be chosen in consideration for minimal saliency for a wider environment than just the segments themselves. Normally, [i] is chosen as an epenthetic for syllable-final consonants due to its short, closed nature. However, after coronal stops, a site for palatalization in Fijian, the lower vowel [e] is chosen, on the grounds that a change in consonant is too great a departure from the source word once it palatalizes. However, in a borrowed sequence [ti], the vowel will remain [i], palatalizing the [t], showing a preference to change the consonant rather than the vowel when the vowel is present in the source, implying a constraint ranking of IdentV >> IdentC. Kenstowicz makes the obvious parallel with Japanese, where the epenthetic of choice is [u], except where it would cause affrication of a preceding coronal stop.

Kenstowicz goes on to show perceptual effects driving the phonological adaptation of voiced stops as voiceless word-finally and medially, but as pre-nasalized stops in initial position (Fijian lacks voiced stops, having only voiceless and pre-nasalized series). As the nasalization on the consonant is attenuated to near imperceptibility when following anything but a vowel in Fijian, the English voiced stops have a shorter perceptual distance from the pre-nasalized series than the voiceless. This effect does not apply when a preceding vowel would render the nasalization salient, thus resulting in a matching of the English percept to a Fijian voiceless consonant, implying the ranking Ident[nasal] >> Ident[voice] (i.e. when the nasality is relevant for evaluation—only following a vowel) (Kenstowicz 2007: 335-338).

Davis and Cho (2006) consider the complexity of how English [s] is borrowed into the Korean phonological system, which famously exhibits a three-way contrast on obstruents as exemplified by lax [t], aspirated [tʰ] and tense [t']. The relevant phonetic cues for this contrast have been shown by others to be primarily the pitch on the following vowel, which is uniformly higher after tense and aspirated consonants, and Voice Onset Time, with lax stops being slightly aspirated and tense stops unaspirated. While Korean exhibits only a two-way contrast on the sibilant obstruent (only [s] and [s'], but no [sʰ]), the sibilant itself is realized as breathy or aspirated when lax (Davis and Cho 2006: 1011). Given these facts, Davis and Cho look at the borrowing of English [s] mainly in final position. Rather than appearing uniformly, English [s] is borrowed word-finally as [s'] followed by an epenthetic vowel, as the frication in the English source is perceived as a released onset, Korean lacking any released consonants in coda position. The choice of tense [s'] occurs despite the phonetic similarity between English [s] and Korean lax [s]. Also, when the intial member of a consonant cluster, it is borrowed consistently as [s], as in [sɨtʰop] > 'stop'.

According to Davis & Cho (2006), to account for borrowings such as [k'es'ɨ] > 'gas' and [mæs'ɨ] > 'mass', many have argued for an analysis based on duration, claiming that this cue (English [s] is longer when not part of a cluster) causes the foreign sound to map to Korean [s'], itself being longer than Korean lax [s]. Furthermore, the environment for cueing [s'], i.e. a following vowel to carry the high F_0 transition, is absent word-finally. The authors cite others who have argued along the same lines, but under the assumption that Korean [s'] is underlyingly a geminate consonant (supported in their claims by independent evidence from Korean), and so the duration distinction is phonological rather than phonetic.

However, Davis and Cho point out certain problematic studies that contradict these traditional analyses. Phonetically, duration varies due to word-position, and so a single word-final /s/ as in 'bus' does not differ significantly from word-initial /s/ in a consonant cluster, as in 'stop' (Davis and Cho 2006: 1013), though the two adapt differently in loanwords. Other perceptual studies have shown the primacy of the pitch cue for obstruent contrasts, with duration playing little role in perception of synthetic speech. Also, the English interdental fricative [θ], which is shorter in duration than English [s], is also borrowed as tense [s'][3]. Davis and Cho support a more phonological analysis in which English [s] is adapted as tense because it occurs in a position that would require a laryngeal feature (see next paragraph), either [+spread glottis] or [+constricted glottis], and since Korean lacks the former feature on sibilants, the latter is chosen as the only other option. This coincides with native Korean phonology where [s] appears as tense where other obstruents would surface as aspirated (e.g in the environment of h-merger following a stop, see Davis and Cho: 1015). They claim the phonetic details are unimportant in this adaptation, not only because there is no following vowel to carry the primary cue of pitch, but also because English [s] is borrowed as [s'] even when it is a second member of a word-final cluster (where it should be shorter than when in final position in a non-complex coda), as in [t'æns'ɨ] > 'danse', and [p^hols'ɨ] > 'false'. Finally, they are left to posit the adaptation of [s] in initial position of clusters, as in [sɨk^hec^hi] > 'sketch' and [p^hisɨt^hon] > piston, as a case of "uniform substitution", since English sC always maps to sɨC^h in Korean.

This does not mean that perceptual matching is entirely ruled out in their analysis, however. To account for borrowing of final voiceless stops as aspirated, even though they usually are not released in English, Davis and Cho posit the aspirated stop as the perceptually "least worst [sic]" option given the environment. Since lax stops voice allophonically in intervocalic position (derived from epenthesis) in Korean, the mismatch between the English voiceless stop and the Korean (subphonemic) voiced stop is too great in perceptual distance. Likewise, the lack of a following vowel to carry F_0 transitions in the English source leads Koreans to resort to aspiration (rather than tensing) to save the stop in

[3] As in my name, as adapted by Korean friends as [neis'ɨn]

adaptation. (Tense consonants in English loanwords usually only occur before a stressed vowel, which would have a higher F_0 correlating to the perceptual pitch cue). Such effects are exemplified in [k^hok^hɨ] > 'coke' and [t^heip^hɨ] > 'tape' (with a variant [t^heip]). In this regard, Davis and Cho argue for a complex interaction between phonological factors, a sometimes uniform mapping in specific instances from the borrowed language into the borrowing language, and perceptual factors aligned with Steriade's P-map that evaluate the minimal perceptual distance between a native match to a foreign percept.

Adler (2006) makes a similar analysis of English loanwords into Hawaiian. In her analysis, she proposes an extension to Steriade's P-map that incorporates not only perceptual distance, but articulatory-based distance as well. She uses this analysis to explain the preference for Hawaiian (which lacks many English segments, including [s] and [t]) to map English [t] to [k], rather than [p] or any placeless segment such as [h] or [ʔ], the change from a lingual articulator to a labial being a harsher violation of articulatory distance than the change from coronal to dorsal articulation or loss of an articulator altogether (cf. similar observations in Kenstowicz and Suchato 2006). However, when an illicit segment occurs in final position, unreleased in the English source, perceptual similarity once again becomes an issue, realizing the obstruents as a glottal stop, implying that changing an unreleased consonant to any consonant with oral closure (which are necessarily released in Hawaiian) is more perceptible than changing it to [ʔ] (Adler 2006: 1038).

Finally, as pointed out by Jacobs and Gussenhoven (2000), [s] is a very problematic segment for perceptual accounts when a language that lacks this very salient consonant in its native inventory encounters it in borrowed words. Adler reports that there is a significant degree of variation in its treatment: sometimes it is deleted, other times it is adapted as [k], other times as [h]. She ascribes this to fact that, fricatives being absent in the native inventory, there is no reasonable match that would carry the salience of the foreign percept, and therefore deletion is just as viable an option as adaptation. In OT terms, she formalizes this as a highly ranked constraint against [s] (*s), and two lower-ranked constraints on the same stratum militating against change or deletion of stridency.[4] This explains the quite different treatment from Cantonese, which has a native [s] it can utilize in loanword adaptation. It turns out that segment-internal saliency alone cannot guarantee a segment's survival, but rather it is constrained by the facts of the native phonological inventory. Adler provides the following tableaux for comparison (Adler 2006: 1042).

(3) Hawaiian: deletion and strident feature change are equally (dis)favored

/s/	*s	Ident[strident]	MaxC[+strident]
s	*!		
☞h		*	
☞k		*	
☞Ø			*

(4) Cantonese: [+strident] candidate available; deletion not optimal

/s/	Ident[strident]	MaxC[+strident]
☞s		
h	*	
k	*	
Ø		*

4.3 Correspondence Theory and loanword adaptation

Optimality Theory offers a convenient way of formalizing loanword adaptation, viz. the notion of Correspondence, whereby Faithfulness constraints assess differences between elements of a phonological input and their correspondents in a surface output. Moira Yip posits a specific family of constraints, MIMIC, which she defines as a type of constraint that "relates the output to a specific sub-type of input, a demonstrably foreign form (Yip 2002a: 5)." Michael Kenstowicz uses a similar method, analyzing loanword data with Output-Output constraints between the output of the borrowing language and that of the source language, e.g. EO-FAITH for English loans (Kenstowicz 2005: 3). Furthermore, he shows that the ranking of these "loan-sensitive constraints" can be different from the faithfulness constraints of the native grammar. That is, the grammar may repair violations of the same phonotactic constraint differently in cases of loanword adaptation than for native input. This also explains the occurrence of

[4] In Hawaiian, [s] actually never deletes pre-vocalically, which Adler formalizes as an undominated faithfulness constraint to segments in such a position.

importations that violate native constraints otherwise repaired in the native grammar, or repairs to foreign forms that are otherwise permitted in the borrowing language's phonology (what Kenstowicz calls a "retreat to the unmarked" (Kenstowicz 2005: 3-4)).

For example, in Korean some have analyzed the laryngeal setting for lax stops as [+voice] (e.g. Kim and Duanmu 2004: cited in Kenstowicz 2005), which devoice in coda position due to a highly ranked Coda-condition constraint. However, English voiced stops in coda position are often repaired by epenthesis in loanword adaptation, showing a differential ranking between IO-Ident [voice] and EO-Ident [voice] (Kenstowicz 2005: 10):

(5) Native Korean vocabulary

/cib/	Coda-Con	Dep-V	IO-Ident [voice]
cib	*!		
cibɨ		*!	
☞cip			*

(6) "pub" from English borrowing

/pʰəb/	Coda-Con	EO-Ident [voice]	Dep-V
pʰəb	*!		
☞pʰəbɨ			*
pʰəp		*!	

Jennifer Smith has a novel take on Correspondence Theory that is expansive enough to account for various seemingly incongruous factors in loanword adaptation (for discussion of "paralinguistic" factors see Section 6). Similar to Kenstowicz (2005; Kenstowicz and Suchato 2006), Smith (to appear) views loanword adaptation as a correspondence between the output of a borrowing language (Lb) and that of the source language (Ls), SBcorr. Central to this relationship is the borrower's posited representation of the source-language form, the pLs representation. The pLs is part of the speaker's phonological system and serves as a "repository for all information the Lb speaker has about the Ls form (Smith: 1)". This information, which is not necessarily the speaker's underlying representation (though it does inform the input to SBcorr), is source-sensitive, and may incorporate a range of information, perceptual, visual, orthographic, conventional methods of adaptation, etc. This incorporation of various forms of source information into a formal model of loanword adaptation can account for widely divergent processes of adaptation discussed throughout the literature. Smith gives the following chart to illustrate correspondence relations in loanword adaptation:

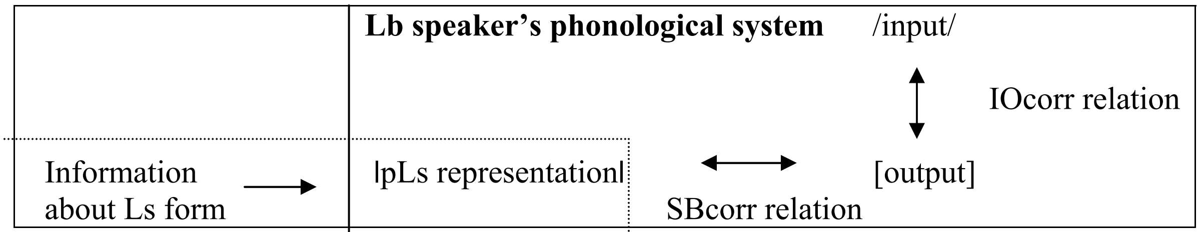

Figure 1: Representation of phonological grammar from Jennifer Smith (to appear)

5. Suprasegmental phenomena

Though there are still unresolved issues concerning interlinguistic segmental mapping, loanword adaptation of suprasegmental properties is a greater mystery still. For some tonal languages adaptation is a relatively straightforward process. Often the stressed syllable in a source word will be adapted with a high tone, while unstressed syllables carry either mid tones or an inserted default tone (usually low or mid), but interacting with the borrowing phonology just as with segmental mapping (Kenstowicz 2003: for Fon; Kiu 1977; Silverman 1992: for Cantonese). Yoruba adapts English stressed syllables as a high tone, with all preceding syllables mid and the final syllable low, corresponding to the English citation contour H*L% (Kenstowicz 2004). Tones on epenthetic vowels in Yoruba copy from an adjacent tone, however when in word-medial position, the choice is made depending on environment: vowels splitting an obstruent-sonorant cluster copy from the vowel following the sonorant, otherwise the high tone of the stressed correspondent is spread from the left. This is the result of an interaction of native constraints *VOV (no spreading tones across an obstruent) and *L+ (don't spread low tones) (Kenstowicz 2004: 7-10).

Yoruba epenthetic vowels follow a very common pattern in tone loans, i.e. consonantal features determining the outcome of the tone. In Thai, for the most part syllables terminating in a sonorant take M while syllables ending in an obstruent take H (Kenstowicz and Suchato 2006). In Lhasa Tibetan (which contrasts high and low tones only), tones from Mandarin loanwords are completely ignored and a default process is adopted whereby all non-initial syllables are assigned a high tone and initial syllables are adapted as high when the onset is an obstruent and low when the onset is a sonorant[5] (Hsieh and Kenstowicz 2006). The same process applies to English loanwords regarding stress contours, except that if the initial syllable begins with a voiced obstruent it is adapted as voiceless unaspirated (Tibetan has no voiced obstruents), and the tone is adapted as low. Vowel-initial syllables are adapted as high, perhaps due to default tone insertion (Hsieh and Kenstowicz 2006: 291). The authors see this adaptation pattern as an enhancement effect whereby the feature [voice] on obstruents and sonorants in initial position is enhanced by the register of the tone, [+voice] for Low and [-voice] for High. (For more explanation on enhancement effects see Chapter 3, section 2.2).

Other languages show a similar "deafness" in prosodic adaptation (see Chapter 3, section 4.2 for examples from Taiwanese). Shinohara (2004) finds that in English loanwords, stress is carried over into the Japanese pitch-accent system as a pitch peak, but in French loans no accent is recognized and a peak is assigned by a default process emergent from the native ranking of metrical constraints. He furthermore finds that an accent is systematically avoided in epenthetic vowels, implying knowledge of their presence in the adapted form (and thereby their absence in the perceived form, contra (Dupoux et al. 1999)). White Hmong is another language that shows this differentiation between English and French prosodic patterns: French loans are adapted with low tones all the way across the word, while English loans are adapted based on syllable type, but only using a subset of White Hmong's set of seven tonal types (Golston and Yang 2001). For the most part, Hmong tones are a function of syllable structure and prosody, whereby final stressless syllables carry creaky voice (considered a type of tone in Hmong phonology) and heavy syllables carry a falling tone. However, the coda syllable of the source word also affects the tonal selection, e.g. final voiceless consonants carry rising tone, even when these consonants delete.

Finally, work by Kenstowicz on Korean dialects shows an intricate process of tonal adaptation in loanwords based on perception of non-contrastive features in the source word (Ito and Kenstowicz 2009a, 2009b; Kenstowicz and Park 2006). In contrast to Mandarin loanwords into Tibetan, Yanbian Korean (a

[5] The authors checked this tendency against a corpus and ruled out any frequency-based effects whereby a more common tone-to-syllable type preference in the native inventory would bias the adaptation.

pitch-accent dialect of Korean spoken in Northeast China) adapts Mandarin loans according to the source language's tonal specifications. Focusing on an elicited corpus study of disyllabic loans (from one native speaker), Ito & Kenstowicz (2009b) examine how Mandarin's system of fifteen possible tonal combinations for a disyllabic word is adapted into Yanbian's H(igh).L(ow) vs. L.H lexical specifications. Their findings are that tonal values are adapted depending on the final Mandarin syllable: if it is a simple tone, it is adapted as such into the final syllable of the Yanbian loan, if it is complex, the tonal value of the first mora of the final syllable is chosen for the loanword's final syllable, with some variation. The authors explain this faithfulness effect, as well as variation patterns, citing studies that show a tonal peak delay in Mandarin syllable transitions. In Mandarin, F_0 transitions from a preceding syllable are often coarticulated on the onset and beginning of the vowel in the next syllable. This "surface noise" is filtered out by Chinese speakers since each syllable has a lexical specification, however given the H vs. L lexical system of Yanbian, borrowers are aware of this site as a contrast between high and low tones, which thus serves to provide phonetic motivation for the placement of pitch accent in the loanword.

This can be compared with the adaptation of the Mandarin aspirated vs. non-aspirated contrast into Yanbian's three-way contrast on obstruents (see Section 4.2 above). Mandarin aspirated stops are regularly adapted into Yanbian as aspirants and sibilants are adapted as tense (similar to Davis & Cho (2006)'s findings), but unaspirated stops differ between tense and lax Yanbian stops. In Yanbian, pitch correlates are largely subsumed by the tonal system of the borrowing language and VOT values vary little between tense and lax stops, so vowel quality (breathy vs. creaky) plays the major role in loanword adaptation (Ito & Kenstowicz 2009a, cf. Kenstowicz and Park (2006) for phonetic analysis showing the same effect in Kyungsang Korean). In the absence of distinctive F_0 cues, the breathy vs. creaky quality of the following vowel enhances the contrast for the stop consonant in Yanbian, creaky vowels following tense consonants and breathy following unaspirated (Ito & Kenstowicz 2009a). Furthermore, sibilants in Mandarin are usually associated with creaky voice, explaining the consistency in adaptation on solely phonetic grounds.

Finally, in Mandarin vowels following an unaspirated consonant are relatively creaky in word-initial syllables and so match to Yanbian tense, however word-medially they receive an apparently default lax specification, except when the Mandarin syllable carries a falling tone, which is cross-linguistically enhanced by creaky-voice (Ito & Kenstowicz 2009a: 7). The authors tentatively explain the variation in word-medial position by the lack of voicing on Mandarin intervocalic stops, which have been shown to be the prime perceptual cue for that position in the native system in perceptual experiments on Yanbian speakers.

6. Sociological and paralinguistic factors

Of course, loanword adaptation does not take place in a vacuum. The circumstances that first give rise to language contact, including the nature of how a source-language is used in a community, as well as other cognitive functions, also have some effect on the process. As it is largely outside the scope of this thesis to consider language contact in a broader setting, I will briefly overview some of the major studies in these areas.

6.1 The role of bilinguals

One of the earliest proposals to view linguistic borrowing from a sociological and psychological perspective (previously loanwords were considered mostly out of etymological interest) is Haugen (1950). As would be the norm for studies to come, Haugen claims that "for any large-scale borrowing a considerable group of bilinguals has to be assumed" (Haugen 1950: 210). This proposal is often cited as evidence for phonological representations in loanword phonology (e.g. LaCharite and Paradis 2005; Paradis and LaCharite 1997).

Focusing mainly on borrowings in German and Scandinavian communities in the United States, Haugen defines borrowing as the "attempted reproduction in one language of patterns previously found in another", and goes on to delineate different types of borrowing, beginning with importations (where the source is more faithfully adapted into the borrowing language, to the point that "a native speaker [of the source language] would accept it as his own" (Haugen 1950: 212)), versus substitutions (where the source form has been considerably altered in adaptation). As Haugen points out, if the loan lacks any elements that would require innovations in the borrowing language, it is hard to distinguish between the two. Finally, he considers loan translations (a.k.a calques) and semantic loans, which he sees as types of complete morphemic substitution, as opposed to the other two types, which involve either partial substitutions or no substitution at all. The difference between the greatest and least distortion between the source and borrowed form depends on the degree of bilingualism in the community (Haugen 1950: 216).

Haugen attempts to sketch a basic lifespan for a loanword, from initial contact to full status as a native lexical item. In his words,

> a bilingual speaker introduces a new loanword in a phonetic form as near that of the model language as he can…if he has occasion to repeat it, or if other speakers also take to using it, a further substitution of native elements will take place…if monolinguals learn it, a total or practically total substitution will be made. (Haugen 1950: 216)

He provides the following periods, not necessarily existing in chronological order:

1. pre-bilingual period: Loans generate from a small group of bilinguals and spread widely to the monolingual majority. They show almost complete nativization.
2. adult bilingualism: a growing knowledge of the source language in the community leads to more systematic substitution with standardized forms for new loans. This may result in certain changes in phonotactic distributions of the borrowing language's native phonemes.
3. childhood bilingualism: marked primarily by importation rather than substitution, so that foreign sounds are introduced into the borrowing language.

Within any one community the same word may exhibit degrees of variation due to varying degrees of bilingualism, with considerable interference from the source word as used in the original language, a process Haugen calls "reborrowing" (Haugen 1950: 222). He gives the example of immigrant groups in America in which the younger and older speakers use different forms of the same loanwords, the differences being degrees of phonological and morphological importation.

Haugen also points out several other factors that influence the nature of loanword adaptation. He claims that spelling pronunciations may influence the composition of a loan, "where the reproduction varies from normal in the direction of a pronunciation traditionally given to a letter in the borrowing language" (Haugen 1950: 223). Finally, he points toward scales of adoptability, whereby certain linguistic features may show a greater likelihood than others to be borrowed, e.g. nouns are more easily borrowed than other parts of speech, then suffixes, then inflections, then sounds (Haugen 1950: 224).

Poplack & Sankoff (1985; 1988) examine Haugen's criteria in the setting of bilingual communities in the United States and Canada, looking at both the levels of integration at time of contact and the evolution of forms over successive generations. They point out that children may show different patterns of loanword use than their elders due to an underdeveloped vocabulary, while variation among older generations may be explained by different degrees of familiarity with the source language (Poplack and Sankoff 1985: 125). A major concern of theirs is distinguishing borrowings from code-switching and incomplete second-language acquisition by speakers of the borrowing language. They rely on rates of use in the speech community and degree of native-language synonym displacement to make this distinction, positing the following four criteria:

1. frequency of use: the more frequently used, the more likely an item is a true loanword
2. native synonym displacement: measured by a translatability test, if an item is shown to displace a native synonym, it can be considered to have taken over the native term's role in the lexicon
3. morphophonemic and/or syntactic integration: the more integrated, the more likely it is an established loanword
4. acceptability: if judged by native speakers to be an appropriate designation, despite their lack of knowledge of its etymological origins, it can be considered to be a part of the native lexicon.

Poplack and Sankoff (1985) gathered data from 14 children and eight adults from a stable bilingual Puerto Rican community in East Harlem, New York. Following meticulous statistical analyses, they found the earlier claims to be borne out by the data. One of the principal findings was that a term is transmitted across generations in the form under which it was accepted into the speech community, rather than showing less degrees of adaptation for younger speakers as claimed by previous studies (including

Haugen (1950)). They consider the use of a word that differs from that of the community-accepted form in a native language context to be evidence of a codeswitch rather than an importation (Poplack and Sankoff 1985: 126). They draw the conclusion that patterns are systemic and community-wide in application, rather than "transitory tendencies on the part of first-generation immigrants…[or] artifacts of the acquisition process (Poplack and Sankoff 1985: 128)."

Poplack et al. (1988) examine various sociolinguistic factors by examining English loanwords into French in communities in France, and two different neighborhoods in Montreal, Canada. They draw a distinction between nonce borrowings (those that occur only once in a corpus) and widespread loans (those with greater frequencies of use), and attempt to see to what extent the former is a weaker or incipient version of the latter, and what their relationship to code-switching may be. Overall, their data showed a very small percentage of loanwords (just over four percent), with a strong bias for content words rather than function words in borrowings, and within content words, a preference for nouns, followed by verbs, then interjections, then adjectives, then conjunctions (Poplack et al. 1988: 63). The authors take borrowing into one of these lower categories as evidence of more innovation, since borrowing content words (and nouns especially) is facilitated by the ease of structural integration and the presence of greater semantic content than function words. They found that sociological factors, such as class membership, showed little effect on the adaptation of borrowings compared to source-language proficiency, e.g. proficient English speakers use less French phonology than monolinguals. All speakers integrate widespread loans more than they do nonce borrowings, while source words are integrated into French morpho-syntactic patterns immediately on contact, with phonological integration being a gradually increasing function of how old the word is and the frequency of its usage (Poplack et al. 1988: 75).

As for individual factors, Poplack et al. (1988) found the following:

1. Social class membership strongly affects the overall rate of borrowing, with working class groups borrowing more words than middle class speakers. Working class members are also more likely

to use innovative loans, while middle class members stick to mostly nouns, pointing towards a stigma attached to borrowing words from English, i.e. speaking what is considered “incorrect French”.

2. Women use fewer loanwords overall, as well as fewer nonce loans than widespread loans. The types of loans exhibited by women are also for the most part confined to categories of furniture, food, etc., while men favor loans related to sports and the workplace. As the authors point out, this might only mirror preferences in conversation topics rather than any property of linguistic borrowing. Men prefer more established loanwords (i.e. loans that historically have been part of the language longer, not to be confused with widespread loans---those that appeared more frequently in the authors’ data) , as well as nouns over other parts of speech, than do women.

3. Age and proficiency show systematic effects on the data (e.g. the greater the proficiency in the source language the greater the preference for nonce and more recent loans, and the greater rate of innovative borrowings among younger speakers), but are marginal overall. Younger speakers proficient in English have higher borrowing rates and use more nonce words and fewer widespread loans overall.

4. Speakers who use widespread loanwords tend to produce them with the borrowing language’s phonology. While highly proficient source-language speakers use more borrowed tokens and more of each type, they are particularly the ones that cleave to the borrowing language’s phonology, again pointing to the strong social pressure to speak “correct French”.

5. The greatest factor that played a role was neighborhood, where the community an individual belonged to set the standard for rate and types of borrowing. The more exposure to the foreign language, and proportionally the greater number of bilinguals within the community, the greater the chance of borrowings extant in the community’s usage, and the greater the chance of nonce and innovative borrowings. This means that the norms of the speech community contribute more to the nature of linguistic borrowing than any individual factors, including bilingual proficiency, a point that leads the authors to conclude that borrowing is an “acquired process” rather than primarily a means to serve lexical need.

These findings coincide well with observations in Heffernan (2003, 2005). Heffernan finds that at different periods of contact between Japan and China, Sino-Japanese loanwords have exhibited variant tendencies. At times of greater contact, presumably resulting in more bilinguals, more phonological contrasts in the Chinese source loans were maintained, as opposed to periods when the two countries were more distant from each other in cultural and political relations. For some words, however, tendencies from earlier periods remained, even as relations weakened, implying an awareness of "community standards" for the adaptations of loanwords (Heffernan 2005: 122). Furthermore, by contrasting the Sino-Japanese examples with data from Austronesian languages, Heffernan weighs in on the phonology-vs.-phonetics debate, positing that smaller degrees of contact (and thus fewer proficient bilinguals) result in more phonetic similarity judgments in adaptation and vice versa. For example, in many Polynesian languages, English-source stops that are allophonically flapped in onset position of unstressed syllables are adapted as taps or laterals by borrowers, a phenomenon absent in contact situations with a greater number of bilinguals (cf. Paradis and LaCharite 1997 discussed above).

6.2 Orthographic influences

Orthography has also been shown to play a role in loanword adaptation, despite linguists' bias towards the "primacy of speech" (Detey and Nespoulous 2008). Vendelin and Peperkamp (2006) distinguish between two types of orthographic adaptation: reading adaptation, in which source language words are read as if they were words of the borrowing language (e.g. English reading of /cul-de-sac/ as [kʌl.də.sæk] rather than the French [kyt.sak]), and phonographemic pronunciation, in which the graphemes of the source word are pronounced according to a standardized pronunciation for native learners of the source language (e.g. how French schoolchildren learn to pronounce the English graphemes <u> and <oo> as their native phoneme [œ] and [u], respectively). The authors show that this is a general tendency in loanword phonology as evidenced by elicited forms of English words from French participants. Since this pronunciation is presumably based on perceptual tendencies of L2 learners, there should be much overlap in adaptations of oral versus orthographic input from L2 to L1, therefore making it difficult to accurately distinguish between the two in many cases (Vendelin and

Peperkamp 2006: 1003). Furthermore, effects of orthography may indirectly influence borrowing via analogy, where a percept is given a mental orthographic representation that is acted on by subsequent stages of adaptation (Vendelin and Peperkamp 2006: 1004).

Detey and Nespoulous (2007) test this observation in an experiment involving college-age Japanese learners of French that show that epenthesis actually increases with visual modality, presumably because their subjects mentally transfer an alphabetic system to their own moraic katakana representation according to standard conventions of adaptation, and also due to French orthographic consonant clusters (which may not be pronounced in French) which are interpreted visually as complex codas and thus candidates for repair. This implies that Japanese speakers are aware of the epenthetic convention and will apply it in the case of a new loan, irrespective of their auditory or phonological perception.

Jennifer Smith has offered further evidence for this principle by comparing loan doublets (loans that exhibit more than one form) in Japanese that employ both epenthesis and deletion for the same entry (Smith 2006). She argues that forms showing greater rates of deletion are based on auditory borrowings, whereas those with higher rates of epenthesis are based on orthographic loans. For example, in loans that exhibit deletion, unstressed source vowels are adapted as [ɯ], the most commonly occurring Japanese epenthetic. However, in those loans relying on epenthesis, the same vowels rely on spelling-pronunciation values (e.g. [ɾi.sɯ.ɾiN] and [gɯ.ɾi.se.ɾiN] > ‘glycerin’). Orthography not only has the effect of causing epenthesis of clusters not pronounced in the source language, but also, Smith argues, of giving cues for segments perhaps not perceived in the auditory input.

CHAPTER 2: CHINESE PHONOLOGY

1. Introduction

The following is a comprehensive overview of the phonetics and phonology of Standard Mandarin Chinese. I will use this term interchangeably with the less specific “Mandarin” and “Chinese”, but will be referring to the dialect of Mandarin speakers of North and Northeastern China, which is based on the speech of speakers in Beijing. Standard Mandarin is the basis for the analyses of Chen (1999), Duanmu (2007) and Lin (2007), the latter two of which comprise the bulk of source material for the current overview. All examples given in the text come from Lin (2007), unless otherwise stated.

Mandarin Chinese is a member of the Sinitic branch of the Sino-Tibetan language family. For an overview of its history see Norman (1988) , for sociolinguistics and the development of the modern language see Chen (1999). Typologically, Mandarin has a highly analytic morphology, where every syllable represents a morpheme, and most words contain no more than two syllables (see section 2.4). It also uses a morphographic writing system, where each character stands for an individual morpheme and therefore a single syllable. Most of the data that follows will give the Chinese characters, the IPA transcription and a gloss, unless the source material lacks a gloss.

Section two gives the segmental, tonal and syllabic inventory, with additional information on prosody. Section three covers higher level phonology in depth, with direct attention to individual works that have shaped Mandarin phonological analysis, or are directly relevant to the analysis of mid-vowel assimilation.

2. Basics

2.1 Phonetic inventory

Chinese has the following phonetic segment inventory. In the chart, sounds in pairs represent an aspirated/unaspirated distinction (except j/ɥ, which are both palatal glides). The characters for standard Pinyin Romanization are given below in italics.

Consonants	Bilabial	Labio-dental	Dental	Retroflex	Alveolopalatal	Palatal	Velar
Stop	p p^h *b p*		t t^h *d t*				k k^h *g k*
Fricative		f *f*	s *s*	ʂ *sh*	ɕ *x*		x *h*
Affricate			ts ts^h *z c*	tʂ $tʂ^h$ *zh ch*	tɕ $tɕ^h$ *j q*		
Nasal	m *m*		n *n*				ŋ *ng*
Central Approximant	w *w/u*			ɹ *r*		j / ɥ *y*	
Lateral Approximant			l *l*				

Vowels (diphthongs)	Front		Central	Back	
	unrounded	rounded		unrounded	rounded
High	i	y			u
High-Mid	e ei		ə	ɤ	o ou
Mid	ɛ				ɔ
Low	æ/a ai			ɑ ɑu	

Table 1: Standard Mandarin segment inventory.

Obstruents in Mandarin contrast for aspiration, as opposed to the voicing distinction in English. The aspirated series appear as [p^x, t^x, k^x, ts^x, $tʂ^x$] before a back vowel (Duanmu 2007; Norman 1988). The so-called retroflex consonants are more often articulated with the upper surface of the tongue rather than the under surface (Lee and Zee 2003; Lin 2007). The place of constriction for dentals is more forward than the corresponding American English sounds (Duanmu 2007: 25). In Mandarin [ɹ] is invariably articulated as an apical post-alveolar with no lip rounding (Lin 2007: 28). Duanmu, on the other hand, treats it as [ʐ], citing its similar patterning with [ʂ][6]. Rather than positing a solitary voiced obstruent, he suggests the distinction can also be one of aspiration ([ʂ] & [ʂʰ] for [ʐ] and [ʂ], respectively), pointing out that unaspirated fricatives always produce less friction than their aspirated counterparts (Duanmu 2007: 24). Finally, in coda position nasals do not receive full closure, resulting in a long nasal vowel.

The glides [j], [w], [ɥ] are non-syllabic counterparts of the vowels [i], [u], [y], respectively (Lin 2007: 67). The first two may appear as offglides in addition to onglides, but the high rounded front glide may only appear prevocalicaly. Furthermore, for some speakers [w] following a labial consonant is relatively short and weak, closer to an [o] in production (Lin 2007: 174-175).

There is no tense/lax distinction in Chinese vowels, though the vowels [e] and [o] are usually pronounced as [ɛ] and [ɔ] in syllable final position. As in English, nasalization of a vowel preceding a nasal consonant is allophonic. In diphthongs, Mandarin vowels do not quite reach the height of [i] and [u] but have been traditionally transcribed to accord with the phonemic system. The diphthong [au] differs from English in having a higher ending [u], as opposed to English [ʊ], though high vowels in diphthongs tend to be lower phonetically than their monopthongal counterparts (Lin 2007, p. 78). Furthermore, the low vowel in the onset of [au] is further back than that of the diphthong [ai], unlike the more stable [a] of English (Lin 2007, p. 68). Phonetically speaking, diphthongs and long monophthongs are of the same duration.

Mandarin has what have been analyzed as two apical vowels, [ɿ] and [ʅ]. These two symbols have long been in use by Sinologist phoneticians, but have no universally accepted IPA equivalent. As Peter Wells states “The complexity of these phonetic representations can be interpreted as a shortcoming in the IPA alphabet (Wells 2007).” According to Wells, some have suggested the representation [zᵚ] for the apical consonants and [ʐʲ] for the retroflex series (with abounding similar variations). However, while he advocates adding the established characters used above to the IPA, he claims that a syllabic [z] and [ʐ]

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[6] This analysis is also dependent on his positing [z] as the nucleus in 死 [sz] ‘death’, therefore making [ʐ] the retroflex counterpart in 史 [ʂʐ] ‘history’. See the discussion of apical vowels below.

accurately capture the sounds in question. Such an analysis, shared by Duanmu (2007), would add an extra consonant to the phonetic inventory above (see fn. 1 above).

Ladefoged & Maddieson (1996) prefer the term "fricative vowels", analyzing them as syllabic fricatives that occur as allophones of the high vowel [i]. In syllables containing such segments, the tongue is in essentially the same place for the nucleus as for the onset. Ladefoged & Maddieson claim the term "apical" comes from the position in the alveolar case, but is "not appropriate" for retroflexes (Ladefoged and Maddieson 1996: 314). They are limited in distribution; the first appearing only after dental affricates and fricatives and the latter only after retroflex consonants (which, as Ladefoged & Maddieson point out, puts them in complementary distribution with [i]). Duanmu (2007: 44) considers them to have no underlying representation, but to be the result of spreading of the onset consonant to fill an empty nucleus, thus a syllabic consonant[7]. Lin 2007, following Lee & Zee (2003), also considers them to be syllabic approximants, and uses [ɹ̩] in transcription, where the onset is voiceless and the nuclear counterpart is voiced, e.g.

子	'son'	[tsɹ̩]214	[tsɿ]214	纸	'paper'	[tʂɹ̩]214	[tʂʅ]214
词	'word'	[tsʰɹ̩]35	[tsʰɿ]35	吃	'to eat'	[tʂʰɹ̩]55	[tʂʰʅ]55
四	'four'	[sɹ̩]51	[sɿ]51	十	'ten'	[ʂɹ̩]35	[ʂʅ]35
				日	'sun'	[ɹ̩ɹ̩]51	[ɹʅ]51

Finally, Mandarin has been analyzed as having the rhotacized vowel [ɚ], as in words like 二 [ɚ]51 'two' and 耳 [ɚ]214 'ear'. Duanmu (2007) points out that it is sometimes articulated as [aɚ]. Standard speakers tend to use only tongue body retraction in implementation, while moving the tongue tip toward the post-alveolar region. Since this type of articulation is commonly transcribed as a retroflex sound, it is often considered a retroflexed vowel (Lin 2007: 80-81 and references therein). However, researchers have transcribed it in at least three ways: as the rhotacized vowel [ɚ], as a retroflexed vowel [əʴ], a syllabic consonant [ɹ̩], or as an approximate consonant following the vowel [əɹ]. Acoustically, it seems most accurate to transcribe it as [əɚ], as the formant trajectories resemble those of a diphthong

[7] Otherwise, Mandarin only has a limited set of syllabic nasals, which form 5 distinct syllables used for interjections.

(Zee and Lee 2001). When the suffix 儿 [ɚ]35 'son' is attached to another morpheme to form a diminutive (a process called erhua[8] 儿化) the syllable rime is altered, often resulting in rhotacization of the vowel, e.g. 把 [pa]214 'handle' → [paɚ]214. Following Lin (2007), I will transcribe such syllables with a consonantal rime, e.g. 二 'two' [əɹ]51.

2.2 Tone

Mandarin has four lexical tones, as well as a neutral tone on some syllables. Lin (2007: 89) gives the following table:

Tone number	Pitch pattern	Pitch value	Example
1	high level	55	$[ma]_{55}$ *mā* 'mother' 妈
2	high rising	35	$[ma]_{35}$ *má* 'hemp' 麻
3	low falling-rising	214	$[ma]_{214}$ *mǎ* 'horse' 马
4	high falling	51	$[ma]_{51}$ *mà* 'to scold' 骂

Table 2: Standard Mandarin tonal inventory.

For ease of transcription, tone will be indicated using the numerical pitch values, which range from the highest relative value 5, to the lowest 1. The first number in the series shows the approximate onset pitch value and the following numbers indicate subsequent values matching the patterns in the second column.

Duanmu (2007: 248-249) states the distribution of tone among syllables as the Tone-Stress Principle, whereby only stressed syllables can carry a lexical tone, whereas unstressed syllables can only carry boundary tones[9], or attain tonal values from adjacent syllables. He couches this generalization in typological terms, citing the tendency for languages to only assign pitch (for intonation) to stressed syllables.

Tone 3 is less common and generally occurs only in pre-pausal positions, where the syllable is lengthened, giving room for a third mora (Duanmu 2007: 235). For many speakers T3 breaks into two syllables, with a glottal stop in between (Duanmu 2007: 244). In careful speech and at the end of a word

[8] This affixation process goes beyond diminutives—see (Lin 2004) for an overview.
[9] Boundary tones are tones that mark the end of a phonological or intonational phrase, often represented with an adjacent % and //, respectively (see (Yip 2002b))

the third tone falls and then rises higher than the onset pitch. However, in non-final position and in casual speech it is often realized as a low tone 21 or 22, though Duanmu (2007) claims this may occur even in final position. Furthermore, tone four often has a less dramatic pitch pattern, closer to 53 (Lin 2007: 96). Many contextual factors, particularly adjacent tones, affect the phonetic realization of tone, with pitch contours somewhat obscured. Tone only spreads to unstressed syllables (i.e. those with the neutral tone), implying that such syllables are underlyingly unspecified for tone.

The following examples illustrate the neutral tone:

māma	[ma]$_{55}$[ma]$_{2}$	妈妈	'mother'
lái le	[lai]$_{35}$[lə]$_{3}$	来了	'have come, came'
jiějie	[tɕje]$_{214}$[tɕje]$_{4}$	姐姐	'older sister'
kàn le	[khan]$_{53}$[lə]$_{1}$	看了	'have seen, saw'

The single numbers are to indicate the relatively shorter duration of the neutral tone, though phonetically after a high register tone (1, 2 or 4) the neutral tone falls slightly, and after a low register tone (3) there is a slight rise (Lin 2007: 99). A syllable carrying a neutral tone is shorter in duration (by 100 ms) and weaker in prominence than other syllables, with a somewhat reduced rime. Additionally, the neutral tone can only appear on a word-final syllable. Words that contrast in Standard Mandarin by neutral vs. full tone include 生活[10][ʂəŋ]$_{55}$[xwo]$_{35}$ 'life' vs. [ʂəŋ]$_{55}$[xwo]$_{2}$ 'livelihood', 多少 [two]$_{55}$[ʂɑu]$_{35}$ 'many and few; more or less' vs. [two]$_{55}$[ʂɑu]$_{2}$ 'how many', 东西 [tuŋ]$_{55}$[ɕi]$_{55}$ 'east and west' vs. [tuŋ]$_{55}$[ɕi]$_{2}$ 'thing, stuff'.

Duanmu (2007: 229) gives the following factors that influence the F_0 contour of a tone:

-a sonorant onset destabilizes F_0 contour

-onset consonant voicing causes a murmured vowel, which lowers F_0

-aspirated obstruents raise the initial F_0 and also pair with non-murmured vowels

-high vowels give a higher F_0 contour than low vowels

-a syllable at the beginning of an intonation group has a higher F_0 contour

[10] The Chinese characters are the same for both words only the second has variable pronunciation.

-higher tones are produced with higher amplitude than low tones

-speech rate, which causes some lag time between syllables and tones, as well as shortened tonal targets

Tone can even affect segment structure to a limited extent. Duanmu (2007) points out that a high tone can raise the vowel and a low tone lower the vowel, as in the following examples:

T1 (H)	[wii]	[juu]	
	'tiny'	'excellent'	
T3 (L)	[wəi]	[jəu]	([wei] & [jou] in Lin's transcription)
	'tail'	'have'	

The nuclear vowels in the first pair of words do not contrast with those in the second two words for the given environment, but rather are in complementary distribution according to the tonal value, the latter being the source of semantic contrast (examples from Duanmu (2007: 243).

The following data gives the distribution of tones across Mandarin syllables, which are approximately 1,300 in total when tones are included (Duanmu 2007: 253):

Frequency of tones (how many syllables carry Tone X)

Tone:	T1	T2	T3	T4	All
Number of syllables:	337	225	316	347	1,255

Total density on syllables (how many syllables allow x number of tones)

Tones per syllable:	4	3	2	1	All
Number of such syllables:	178	130	59	35	4022

Table 3: Tonal distribution (Duanmu 2007)

2.3 The Syllable and phonotactics

The maximal projection of the Chinese syllable is (C)(G)V(G)/(C). When each of these syllabic slots is filled, each segment is somewhat shortened, with mid-vowels becoming weaker and shorter and closer to schwa (Lin 2007: 133). Weak syllables (those lacking an underlying tone or stress) are half as short as a full CV syllable (Duanmu 2007: 41 and references therein), while vowels in full open syllables are lengthened.

To account for lack of onset maximization in polysyllabic words, syllables represented as beginning with a vowel, often referred to as "zero-initial" syllables, are analyzed as having an underlying place holder in onset position (the “zero onset” (Duanmu 2007)), the reasoning being that coda segments do not re-syllabify because syllables ostensibly beginning with a vowel already have an onset consonant (Lin 2007: 113-115). A syllable with a high vowel takes the corresponding glide as its onset consonant, while mid or low vowel nuclei take [ŋ] or [ʔ], the latter varying depending on speaker (Lin 1999; Duanmu 2007). Bao (1990) claims the zero onset may also be a “frictionless velar or uvular consonant”, and that it may still appear phonetically in a syllable beginning with a high front vowel, but not a high back vowel. The consonants are non-contrastive in such occurrences, and speakers are often unaware of their existence. In weak, toneless syllables, the onset is articulated with the preceding coda consonant or [j] or a voiced glottal [ɦ] if the preceding syllable ends in a mid or low vowel. However, this is interpreted as gemination, rather than resyllabification, as the segment also remains in the preceding coda.

nán a! [nan]$_{35}$[a] → [nan]$_{35}$[na]$_{2}$ ‘Hard!’ 难啊
kuài a! [kwai]$_{53}$[a] → [kwai]$_{53}$[ja]$_{1}$ ‘Hurry!’ 快啊
wŏ a! [wo]$_{21}$[a] → [wo]$_{21}$[ja]$_{4}$ ‘Me!’ 我啊

It should be pointed out that, contra Lin (2007), Duanmu (2007) argues against this analysis in non-initial syllables, claiming it is unneeded formally and inaccurate phonetically. In his analysis, the obligatory onset in word-initial onsetless syllables is the effect of an unintended articulatory lag in assuming a vocalic position word initially, which is arguably unimportant to phonology and therefore receives no representation. If this effect is mere phonetic detail, then when there is a preceding syllable, the zero onset should be absent, as in the following forms from (Duanmu 2007: 75).

[taa.ɤɤ]/*[taa.ʔɤɤ] ‘big goose’ 大鹅
[maa.æ̃n]/*[maa.ʔæ̃n] ‘horse saddle’ 马鞍
[taa.ii]/*[taa.jii]/*[taa.ʔii] ‘big clothes (coat)’ 大衣

Duanmu cites previous phonetic studies that show these to be the more natural pronunciations. Furthermore, the contrast between the following words, cited from the same studies, casts further doubt on the existence of an obligatory onset (Duanmu 2009: 75):

V.NV [fa:] + [næ̃n] → [fa:næ̃n] ‘raise trouble’ 发难
VN.V [fæ̃n] + [æ̃n] → [fæ̃:æ̃n] ‘overturn case’ 翻案
VN.NV [[fæ̃n] + [næ̃n] → [fæ̃n:næ̃n] ‘overturn trouble’ 翻难

The contrast in the latter two shows that the nasal coda does not spread to the onset of the following syllable, as it might to provide an obligatory onset. (Though the third example is unnatural semantically; it is cited only to support Duanmu's position). Ultimately, he argues, there is no advantage to positing a zero initial over an onsetless syllable. It would appear as if the verdict is out on whether or not a zero onset is indeed needed. In keeping with tradition, however, I will assume the zero onset unless there is compelling reason to do otherwise. Ultimately, further acoustics studies are needed to settle the issue.

All consonants occur in onset position except for [ŋ][11], while only four consonants can appear in coda position, viz. [n] and [ŋ], or the glides [j] and [w] (though not [ɥ]). More limited in number are the rhotacized rimes. The exact analysis of such syllables varies (see section 2.1 above). A syllable with the rime [əɹ] cannot take an onset consonant. A rime with a syllabic consonant (or, depending on interpretation, an apical vowel) does not take a coda consonant and can only take a single consonant in the onset position with the same place of articulation. Finally, [ə] cannot be the only rime segment, but must take a glide or nasal coda.

2.4. Distribution patterns and word types

Duanmu (2007) puts the number of possible syllables at 9,200, reduced to 1,900 if all phonotactic constraints are taken into consideration (Duanmu 2007: 48-49). However, in actuality only about 400 are attested. When tone is included in the count, the number of attested syllables is 1,300 (though the number of possible syllables rises as well). The reason for many of these gaps is discussed in the phonology section.

In regards to frequency, Duanmu cites corpus studies that show a significant imbalance in homophones. Out of a corpus of 6000 syllables, 15 syllables account for a sixth of the vocabulary (1,028 words). These consist of, in order of most words to least, [i], [tɕi], [y], [fu], [tʂɿ], [li], [tɕi], [ɥan], [ɕi], [tɕan], [ʂɿ], [u], [wəi], [tɕy], and [pi] (Duanmu 2007: 94). Furthermore, to add to the ambiguity, about a third of all syllables are unstressed and reduced according to a corpus study reviewed in Duanmu (2007),

[11] That is, if one doesn't consider the zero-onset.

this presumably due to frequency effects (Bybee 2001: cited in Duanmu 2007). Finally, Duanmu claims that of the 1,300 syllables in Standard Chinese, about 200 are rarely used.

Mandarin has what is sometimes referred to as a dual vocabulary, whereby almost every "word" has both a monosyllabic and disyllabic form, with various restrictions on collocations and usage. This has led San Duanmu to claim the following:

> The presence of the dual vocabulary makes it hard or meaningless to answer a seemingly simple question, namely, are most Chinese words monosyllabic or disyllabic?...What we can say is that nearly all syllables in Chinese are words, although most of them can also appear as disyllables. Also, in a modern text or in speech, most words used are disyllabic, although most of them also have a monosyllabic form. (Duanmu 2007: 165)

Duanmu (pp. 160-161) cites statistics from previous studies that show the prevalence of disyllabic words throughout Mandarin vocabulary:

Percentage of tokens per syllable type

Length	1 syllable	2 syllables	3 syllables	4 syllables	All
Count	809	2,094	89	8	3,000
%	27.0	69.8	3.0	0.3	100.0

Percentage of monosyllables per category (excluding proper names)

Category	Total	Monosyllabic	% Monosyllabic
Noun	1,690	262	16
Verb	925	380	41
Adjective	451	140	31
Adverb	194	41	21
Others	364	223	60
All	3,624	1,046	29

Percentage of monosyllables in newly introduced terms

Year introduced	Total Terms	% monosyllabic
mostly since 1949	982	0
since 1992	448	0

Table 4: Distribution of vocabulary by word size (Duanmu 2007)

Duanmu attempts to account for this distribution with what he calls the Stress-to-Information Principle (Duanmu 2007: 143-145), which states that words that carry more semantic information receive stress (see section 3.5 below for theories on stress). Syntactic non-heads, which are less predictable and therefore carry more information, have stress, whereas syntactic heads are more predictable and are therefore unstressed. Note that Duanmu draws on current syntactic theory that posits many function words (e.g. 的 [tɤ] in 'X 的 Y' phrases, classifiers in classifier phrases, prepositions of prepositional phrases, aspect markers for inflectional phrases, etc.) as syntactic heads. Function words are much more limited in number in a given language's vocabulary and are thus more predictable than content words, which constitute the bulk of vocabulary. In the above categories, it is a word functioning as a syntactic head that tends to be monosyllabic (most of these being function words falling under the 'Others' category). He further proffers a principle, Anti-Allomorphy, which requires word carrying phrasal stress to use the disyllabic, rather than the monosyllabic form, thereby predicting distribution patterns of the dual vocabulary (Duanmu 2007: 174, 183).

2.5 Stress and intonation

Given the behavior of the neutral tone, it is fairly uncontroversial that Mandarin utilizes stress in the conventional sense. In Standard Mandarin, stress manifests itself by the expansion of pitch range and time duration, and sometimes loudness (Lin 2007: 224 and references therein). The neutral tone distinction is sometimes considered a contrast between full and light syllables, the former having a duration of approx. 200 ms, the latter 100 ms (Duanmu 2007: 130). Duanmu (2007) gives the following example of contrastive stress at the phrasal level as illustration (transcription in pinyin):

我 姓 黄，不 姓 王。
Wǒ xìng HÚANG, bú xìng WÁNG.
I name HUANG, not name WANG.
'I (am) named HUANG, not WANG.'

Foot structure, as evidenced by words with neutral tone, as well as patterns of tone sandhi (see 3.4 below), is left-prominent with a stressed-unstressed pattern. What is less clear is how, if at all, stress manifests itself at the word level when all syllables are full (i.e. with no neutral tones). When each syllable in a word has a full tone, however, analyses differ as to stress placement and foot assignment. Native speakers have even been shown to have difficulty in stress judgements (Duanmu 2007: 155).

Another phenomenon that points toward metrical structure is the strong tendency for disyllabic words, which is maintained through such processes as reduplication or affixation/compounding of another morpheme that carries no pertinent semantic information (the "dual vocabulary") (哥 $[kɤ]_{55}$ 'brother' → 哥哥 $[kɤ]_{55}[kɤ]_{2}$, 鼠 $[ʂu]_{214}$ 'mouse' → 老鼠 $[lɑu]_{35}[ʂu]_{214}$ 'mouse'). This tendency has been shown to manifest itself in patterns of loanword adaptation and second language acquisition data (Broselow et al. 1998).

Since tone is used in Mandarin to distinguish lexical items, it is not as freely used in intonation as in a non-tonal language. Often, grammatical particles are used for this effect. However, intonation is present in the spoken language. Tones are affected by a gradual declination over the intonational phrase, so that a high tone at the beginning of an utterance is relatively lower in pitch than a high tone at the end of an utterance, though phonological identity is left unaffected (Lin 2007: 228). Where intonation is most obvious is in contrasting statements and interrogatives, the latter having a starting pitch that is relatively higher than the former, with an overall higher pitch range. Though the first tone falls slightly on a phonetic level in a statement, and rises slightly in a question, tonal contours are essentially kept intact, so that the pitch movement is superimposed over the individual pitch movements of the lexical tones (Lin 2007: 229-230). However, in phrase final position in emotive speech or for purposes of emphasis there are cases of a phonological tone being added to the overall intonational phrase, e.g.

忙 $[mɑŋ]_{35}$ + affirmative intonation L → MHL tone 351 '(really) busy!'
忙 $[mɑŋ]_{35}$ + question intonation H → MH^{+} tone 36 '(did you say) busy?'
慢 $[man]_{51}$ + question intonation H → HLM tone 513 '(did you say) slow?'

3. Phonology and theoretical analyses

3.1 Consonants[12]

Duanmu (2007) discusses what he terms overanalysis and underanalysis of sounds in pursuit of phonemic economy (Duanmu 2007: 12-14). In particular, he examines the reasoning behind labialization vs. glide representation for [w], and also vowel length. In Mandarin a sequence sw- is not realized as two distinct sounds (as in English) but rather as one segment with secondary labialization. However, most Chinese phonologists do not analyze obstruents into two groups, labialized and non-labialized, rather they treat [w] as a separate segment for purposes of economy. The same is true of long vowels. In open full syllables (syllables with stress and/or tone) the vowel is longer than that same vowel in a closed syllable, yet [a] and [a:] are analyzed as one sound due to their predictable distribution. Duanmu favors the latter analysis but argues against the over-analysis in the former. He claims that, in addition to phonetic accuracy, little economy is lost by representing the labialized obstruents as a series separate from non-labialized obstruents since it posits fewer articulatory gestures for the speaker, and in terms of distinctive features, it simply adds one feature, viz. [+round] for [ʷ] (Duanmu 2007: 14-16). Furthermore, he uses this analysis to justify the alveolopalatal series (see below).

Among the coronal consonants, Lin (2007) distinguishes among [+anterior] t, n, s, ts, ts^h, l; the [-anterior] ʂ, tʂ, $tʂ^h$, ɹ; and [+anterior, -back, +high] ɕ, tɕ, tɕh, the last of which involves simultaneous dental contact and palatal closure (Duanmu 2007: 19). [l] is analyzed as [+continuant, +lateral]. Duanmu (2007) considers nasals to be unspecified for [continuant] (which he calls [stop]) since they lack closure in coda position. Crucially, the nasals [n] and [ŋ] are considered [-back] and [+back] in all scholarly sources.

There is a general constraint against dental and alveolar fricatives/affricates, as well as velar obstruents when they precede high front vowels and glides. The result is palatalization of these before the

[12] The phonemic inventory for consonants is identical to the phonetic inventory given above with the possible exception of the allophonic variation concerning alveolopalatal series with the dental, retroflex and velar stops (see below for discussion). As there is no universal agreement as to the series to be chosen as the “phonemic” series, I do not include a separate chart for consonantal phonemes.

high front vowels and glides. Likewise, the alveolopalatals can only occur with the front glides and high vowels, unlike the other three series. In other words, the palatal series is in complementary distribution with the velars [k, k^{h}, x], dentals [ts, ts^{h}, s] and retroflexes [tʂ, tʂ^{h}, ʂ] (Duanmu 2007: 31). Lin (2007: 118) states the constraint informally as “a consonant with [+high, -back] features must be followed by a [+high, -back] vowel/glide.” However, analyses differ as to what is the underlying series among these consonant groups and what are the surface allophones. Duanmu (2007) treats them as a special consonant-glide series, noting the following speaker variation[13] (Duanmu 2007: 31):

C+G	Variety A	Variety B	
[ts] + [j]	[ts^{j}an]	[tɕan]	‘sharp’
[ts^{h}] + [j]	[ts^{hj}an]	[tɕ^{h}an]	‘owe’
[s] + [j]	[s^{j}an]	[ɕan]	‘thread’
[ts] + [ɥ]	[ts$^{\text{ɥ}}$an]	[tɕ^{w}an]	‘donate’
[ts^{h}] + [ɥ]	[ts$^{h\text{ɥ}}$an]	[tɕ^{hw}an]	‘persuade’
[s] + [ɥ]	[s$^{\text{ɥ}}$an]	[ɕ^{w}an]	‘select’

By Duanmu’s account, in variety A the major articulator is Cor only, while in B both Cor and Dor are major articulators (cf. Lin’s [+ high] specification), the two differing only in the primacy of Dor. (N.B. that [j] is taken to be dorsal rather than coronal, while [ɥ] is both dorsal and labial.) This argument is furthermore extended to nasals (see section 3.2.1 on possible CG combinations below). This leads him to the conclusion that underlyingly the series are dentals which become palatalized and labialized through feature spreading from a high vowel [i] or [y]. For variety B speakers, Dor changes into a fricative through rightward feature spreading[14], turning the C^{G} into a palatal (Duanmu 2007: 31-34). Note that, as a result, with the loss of the palatal secondary articulation, the [ɥ] becomes [w], a result of only the [+labial] feature remaining in secondary position. This coincides with historical data, whereby modern alveolopalatals derived from both palatalized dentals and palatalized dorsals (e.g. the older pronunciation of Beijing as ‘Peking’).

[13] N.B. Duanmu’s transcriptions do not indicate low front vowel raising.

[14] For these purposes Duanmu is using a feature [+fricative] which in the present case spreads from the initial consonant to the secondary articulation [j] or [ɥ].

In certain environments obstruents may voice and even weaken in fast speech. This is an optional process and applies mostly to frequently used words and expressions. This may occur in syllables taking the neutral tone, as well as in the second syllable of a trisyllabic expression (Lin 2007: 159-160).

3.2 Vowels and glides

The following chart illustrates the phonemic inventory for Standard Mandarin vowels. There has been some disagreement on exactly how many vowel phonemes need be posited for Mandarin, but the following chart from (Lin 2008a: 178) is a fairly conservative estimate used by Lin (2007) and Duanmu (2007).

	front unrounded	front rounded	central	back rounded
high	i	y		u
mid			ə	
low			a	

Table 5: Standard Mandarin phonemic vowel inventory (Lin 2008a).

3.2.1 Glides

In Mandarin glides do not contrast with their corresponding high vowels and so by most accounts they are taken to be variants of each other. Lin (2007) gives glides the same vocalic features of their syllabic counterparts. When [w] occurs initially without a consonant, for some speakers (mostly Beijing speakers) it varies phonetically, usually as the labio-dental [ʋ] (Bao 1990; Chen 1999; Duanmu 2007). There is one environment in which this variant does not occur, viz. before [o], violating a co-occurrence constraint in Mandarin for the feature value [+round] (more on this constraint later). Finally, many have analyzed [ɥ] as [jw] articulated simultaneously, given that the glide does share the component feature values for the other two glides (Duanmu 2007: 23).

Treating CG as a single, coarticulated sound C^G, Duanmu (2007) provides the following consonant-glide attestations, 29 out of the possible 54 combinations:

	C	C^{j}	C^{w}	C^{ɥ}
labial	p	p^{j}	---	---
	p^{h}	p^{hj}	---	---
	m	m^{j}	---	---
	f	---	---	---
dental	t	t^{j}	t^{w}	---
	t^{h}	t^{hj}	t^{hw}	---
	n	n^{j} ?ɲ	n^{w}	n^{ɥ} ?ɲ^{ɥ}
	l	lj	l^{w}	l^{ɥ}
	ts	(tɕ) ?ts^{j}	ts^{w}	tɕ^{w} ?ts^{ɥw}
	ts^{h}	(tɕh) ?ts^{hj}	ts^{hw}	tɕ^{hw} ?ts^{hɥw}
	s	ɕ ?s^{j}	s^{w}	ɕ^{w} ?s^{ɥw}
velar	k	---	k^{w}	---
	k^{h}	---	k^{hw}	---
	x	---	x^{w}	---
retroflex	tʂ	---	tʂ^{w}	---
	tʂ^{h}	---	tʂ^{hw}	---
	ʂ	---	ʂ^{w}	---
	ʐ [=ɹ]	---	ʐ^{w}	---

Recall from above that in Duanmu's analysis the alveolopalatals (as well as the palatalized nasals) are underlying dentals that have undergone feature spreading, which I have added to the chart following '?'. Duanmu notes that the lack of retroflex combinations with the front glides is due to difficulty of producing a front sound with the tongue pulled back for retroflexion. He explains many of the other gaps with a general constraint that states: when G has an articulator that has its own feature, it does not combine with a C that has that articulator[15]. If the glides have the feature structure:

```
      [j]               [w]                  [ɥ]
   Dor-Cor            Dor-Lab            Dor-Cor-Lab
     |                   |                 |        |
  [-back]             [+round]          [-back]  [+round]
```

Then the following chart captures the pattern emerging from this constraint:

	[j]	[w]	[ɥ]
Lab	+	--	--
Cor	+	+	+
Dor	--	+	--

This only leaves a few gaps, such as *[fj], which is probably accidental (Duanmu 2007: 25-30).

---

[15] Duanmu notes the unexplained exception for labials preceding the vowel [o]: [mwo:], [pwo:], [phwo:], and [fwo:]. See Lin (2007)'s alternative constraint in Section 3.3.3, p. 21.

3.2.2. High vowels

High vowels in Standard Mandarin ([i], [u], [y]) are contrastive as illustrated by 力 [li]$_{51}$ 'power', 路 [lu]$_{51}$ 'road', and 绿 [ly]$_{51}$ 'green'. As mentioned before, high vowels in an onsetless syllable spread to the onset position. They cannot be followed by a glide in coda position, only a nasal consonant. When a high vowel precedes a mid or low vowel, the more sonorous vowel is assigned to nuclear position, and the high vowel is reassigned to onset position as a glide (Lin 2007). Bao (1990) takes a different approach in positing a two-vowel inventory for Mandarin, [+low] and [-low], in which the high vowels are derived syllabically through vocalization of the three glides. This further implies that surface high vowels are always preceded by their corresponding glides, unless ruled out by phonotactic considerations (Bao 1990, 1996).

3.2.3. Mid vowels

The mid vowels of Mandarin are [e], [ə], [ɤ], and [o]. When [e] and [o] appear in diphthongs, many speakers produce a mid vowel closer to [ə], e.g. 给 [kei]$_{214}$ sounds like [kəi]$_{214}$ and 狗 [kou]$_{214}$ like [kəu]$_{214}$. This has led to some transcriptions where [e] and [o] are written for these vowels in final position, with a schwa when they are in diphthongs (Lin 2007, p. 74). (N.B. Duanmu (2007) is one of the sources that use this notation.) Additionally, when part of a diphthong, [o] is less rounded than in final position. Finally, it is common for speakers from Northeast China to use [ɤ], rather than [o], after labials.

Mid vowels are produced with the same backness and rounding as an adjacent high vowel or glide, therefore [e] will never be adjacent to [u] or [w], and [o] will never be adjacent to [i], [j] or [ɥ]. It is noteworthy that front mid vowels assimilate in backness, but not in rounding, which means that [ɥ] + [e] does not result in [ø]. This is in keeping with a crosslinguistic tendency to avoid front rounded vowels, as rounding on vowels may be viewed as a perceptually enhancing effect for back vowels.

When a mid vowel comes between a high front and high back vowel/glide, the result is regressive assimilation, where the mid vowel takes on the features of the following vowel/glide, as in 油 [jou]$_{35}$ 'oil' not *[jeu]$_{35}$, 刘 [ljou]$_{35}$ 'a surname' not *[ljeu]$_{35}$, 贵 [kwei]$_{51}$ 'expensive' not *[kwoi]$_{51}$. This makes sense syllabically, in that the mid vowel assimilates with the segment within the rime, rather than that of the onset. If there are no other segments present in the rhyme, then assimilation to the next adjacent segment will occur (Lin 2007: 156-157). Lin (2002) posits the following harmony constraints to account for this distribution, with the ranking:

> ALIGN-RIME: Align the V-PL features of a high glide within the rime
> ALIGN-CV: Align the V-PL features of a high glide within a CV syllable[16].
> *ø >> ALIGN-RIME, ALIGN-CV >> *o >> *e >> *ə

Progressive assimilation, that is assimilation from the glide to the vowel, is stipulated to be the default process in a CV syllable, since regressive assimilation is only applicable in a double-glide syllable (Lin 2002). Given this ranking, any vowel in the output that lacks place features is realized as schwa. Standard Mandarin, therefore, resolves constraint conflict in this case by enforcing "feature harmony as much as possible to the extent that the unwanted segment [[ø]] would not surface" (Lin 2002: 310). Lin looks at data from 160 dialects of Mandarin to show that a factorial typology of these six constraints can account for all of the variation observed. The following tableaux illustrate this ranking. Note that highly-ranked Ident constraints confine candidate options, e.g. ruling out /yə/ > [jə] to preserve rounding on the glide.

(7) Underlying high back rounded vowel.

/uə/	*ø	ALIGN-RIME	ALIGN-CV	*o	*e	*ə
wə			*!*			*
☞wo				*		

(8)Underlying high front unrounded vowel.

/iəu/	*ø	ALIGN-RIME	ALIGN-CV	*o	*e	*ə
jəw		*!*				*
jew		*!*			*	
jøw	*!	*				
☞jow				*		

[16] Lin's analysis follows Duanmu (2007) in positing the pre-nuclear glide as a secondary articulation on the initial consonant.

(9) Underlying high front rounded vowel.

/yə/	*ø	ALIGN-RIME	ALIGN-CV	*o	*e	*ə
ɥə			*!*			*
ɥø	*!					
ɥo			*	*!		
☞ɥe			*		*	

The schwa occurs only before a nasal coda; it is otherwise [ɤ] when the syllable is open. When a nasal coda is adjacent to a high vowel, [ə] is inserted between the two (presumably chosen as the least salient vowel), and the vowel resyllabifies as a glide in onset, e.g. 冰 /piŋ/ [pjəŋ]$_{55}$ 'ice' and 春 /tʂ^{h}un/ [tʂ^{h}wən]$_{55}$ 'spring'. However, this rule only applies when the high vowel is opposite in backness from the following nasal consonant (cf. 宾[pin]^{55} 'guest', 红[xuŋ]^{35} 'red').

This distribution leads to the phonemic analysis of one underlying mid vowel /ə/, with the following distribution:

Mid Vowel Allophony (Lin 2007: 76):

[ə] before consonants
[e] in a dipthong followed by [i]
  in syllable final position preceded by [j] or [ɥ]
[o] in a diphthong followed by [u]
  in syllable final position preceded by [w]
[ɤ] in syllable final position in a CV syllable

This analysis of the mid vowel phoneme in Mandarin specifies only the UR features [-high, -low] since it does not contrast with other vowels for [back] or [round], but rather gets these feature values from adjacent sounds. It also depends on the [+back] feature for [ɤ] to be assigned as a default value [(Duanmu 2007: 22).

3.2.4. Low vowels

Similarly, Mandarin has one underlying low vowel phoneme /a/, with three allophones [a], [ɑ], and [ɛ][17], the last of which is the result of fronting and raising between a front glide and [n].

[17] For some speakers the value is [æ].

Low Vowel Allophony (Lin (2007: 78))

[ɑ] before [u] and [ŋ]
[ɛ] between [j]/[ɥ] and [n]
[a] in other contexts

To account for this distribution, Lin (2007) posits a constraint against segments in the rime disagreeing as to the features [back] and [round]. So, [kɑu], [kai], [kan] and [kɑŋ] are permissible surface forms, but not *[kau], *[kɑi], *[kɑn] or *[kaŋ]. Furthermore, to rule out the segments *[œ] and *[ɒ], there is a constraint against low rounded vowels. Between the front glides and the alveolar nasal [n], there is an optional raising rule, changing /a/ to [ɛ]. Duanmu 2007 points out that /a/ in open syllables can become [ɑ], possibly because the default value on a long vowel is [+back, -round] (Duanmu 2007: 67). This, however, would mean that either front vowels in open syllables are not long, or that the default does not apply for these vowels. Duanmu does not mention this apparent contradiction.

3.2.5. Diphthongs and other issues

Differing from traditional accounts in which all vocoids are treated as vowels, Lin 2007 considers all diphthongs in Standard Mandarin to be falling diphthongs (i.e. the sonority moves from high to low), by virtue of the fact that syllables such as /ɕiaŋ/, /ɕie/, /kuan/, and "triphthongs" like /diau/, and /duəi/, take the first vowel as an onset glide and thus have the phonetic forms [ɕjɑŋ], [ɕjɛ], [kwan], [djɑu], and [dwei].

In syllables taking the prosodically weak neutral tone, the rime is variably reduced depending on speaker, speech rate and style. Note that some of the rimes produced in reduction violate well-formedness constraints on syllable structure (Lin 2007: 163).

[t^{h}ou]$_{35}$ [fa]$_{3}$ → [t^{h}ou]$_{35}$[fə]$_{3}$ 头发 'hair'
[kɤ]$_{55}$[kɤ]$_{2}$ → [kɤ]$_{55}$[kə]$_{2}$ 哥哥 'older brother'
[nai]$_{21}$[nai]$_{4}$ → [nai]$_{21}$[nəi]$_{4}$ 奶奶 'grandma'
or [nai]$_{21}$[nei]$_{4}$
or [nai]$_{21}$[nɛ]$_{4}$
[ɕi]$_{55}$[wɑŋ]$_{2}$ → [ɕi]$_{55}$[wəŋ]$_{2}$ 希望 'to hope'
or [ɕi]$_{55}$[wə̃]$_{2}$
[ɕin]$_{55}$[ɕjɛn]$_{2}$ → [ɕin]$_{55}$[ɕjən]$_{2}$ 新鲜 'fresh'
or [ɕin]$_{55}$[ɕin]$_{2}$

As mentioned earlier, the mid vowels [e] and [o] may also be reduced to schwa or deleted when part of a diphthong in a syllable with an initial consonant[18] and a pre-nuclear glide:

/liəu/$_{35}$ → [ljou]$_{35}$ 流 'to flow'
or [ljəu]$_{35}$
or [lju]$_{35}$
/tsuəi/$_{51}$ → [tswei]$_{51}$ 罪 'sin'
or [tswəi]$_{51}$
or [tswi]$_{51}$

Finally, there is optional vowel devoicing in neutral-toned syllables in fast speech. However, there is a hierarchy of likelihood when it comes to devoicing. High and apical vowels following voiceless obstruents are most likely to devoice, with [i] more likely than [u] to be affected, and [y] even less likely (Lin 2007: 164). Furthermore, devoicing may also apply in non-final position after an aspirated consonant in a low-toned syllable, e.g. third tone.

3.3. Syllabification

The internal structure of the syllable has been the object of much debate in the literature. Bao (1990, 1996) discusses this extensively, using data from various Mandarin dialects, focusing on peripheral occurrences such as language games, speech errors, and diminutive suffixation. He focuses particularly on the patterning of medial glides.

In Chinese, glides are usually analyzed as underlying high vowels that appear in onset position in surface forms (Duanmu 2007; Lin 2007). Whenever a high vowel is followed by a mid or low vowel, the more sonorous vowel will syllabify as a nucleus, and the less sonorous as a glide in onset position. An underlying morpheme that consists of just a vowel will spread to the onset in the form of a non-syllabic glide, e.g. UR /y/$_{35}$ 'fish' 鱼becomes [ɥy]$_{35}$. This satisfies a general constraint that a syllable must have an onset consonant, which also explains the zero-initial syllables mentioned above (Lin 2007: 171-174). Refer back to the introductory section on syllables for what segments fill the empty onset in what environment.

[18] Though not, however, when there is a zero-initial: /uəi/$_{214}$ → [wei]$_{214}$ 尾 'tail'.

3.3.1. Excursus on Bao (1990, 1996)

Giving the syllable the tentative structure $[[C_i\ G_m\ ]\ [VC_f]]$[19], Bao 1996 comes to the following conclusions:

1. V and C_f unambiguously form a constituent
2. G_m is indeterminate, sometimes joining with C_i, sometimes with VC_{f}. However, to adapt themselves as they do in the data implies that they are not coarticulated with C_i.
3. To the extent that G_m is syllabically determinate, the medial glides [w] and [j] & [ɥ] exhibit asymmetrical behavior. In the data, the first two glides are transcribed as their vocalic counterparts [i] and [u] when in on-glide position.

The first two points can be exemplified by his analysis of previous findings on speech error data. Out of 120 logical error types, only 10 are attested in the data. Bao uses the format ERROR(X,Y), where X and Y are strings of phonological material of any length. X of the intended syllable (syllable attempted in pronunciation) is replaced by Y of the cause syllable (syllable nearby in speech that affects the error in the intended syllable). Cause syllables are given in parenthesis after the "derivation" of the intended syllable: (N.B. Error transcriptions are given in pinyin to abstract away from phonetic details. No glosses are given.)

ERROR(V,VC_f): fù > fēn (zhēn)
ERROR(G_mV,VC_f): guó > gōng (zhōng)

Evidence shows that ERROR, which applies only once, targets a constituent in a hierarchical syllable. e.g.:

ERROR(C_iG_m,C_i) where xi is replaced by s, gu by b, qi by d

xià > sà (sī)
guàn > bàn (bèi)
qiáo > dào (dà)
fā > huā (huēi)
dā > jiā (jiē)

[19] where G_m= medial glide, C_f= final segment, C_i=initial segment, O=onset, R=rime.

Errors of type ERROR(Ci,CiGm) and ERROR(CiGm,Ci) suggest that Gm is part of the onset, whereas those of the types ERROR(VCf,GmVCf) and ERROR(GmVCf,VCf) suggest that Gm is part of the rime. This gives us the syllable structure with the indeterminate glide:

$[[C_i]G_m[[VC_f]_R T]_{R'}]$

where T = tone, and R' is a higher branching node of the rime than that which constitutes only VC_f.

The third point of Bao's findings is exemplified by two Mandarin dialects, Likezhao and Taiyuan. Many dialects have a set of dissyllabic words in which the second syllable invariably begins with the lateral l, termed "L-words". The origins of such words are indeterminate. The following is data from Yikezhao, a dialect of Yikezhao Inner Mongolia, related to Taiyuan.

a. with medial glide [i]

tiəʔ > tiɛʔ liəu 'round and smooth'
tiau > tiɛʔ liau 'to exchange'
tɕin > tɕiɛʔ lin 'lively'

c. with medial glide [u]

t^huo > t^huəʔ luo 'round objects'
t^huan > t^huəʔ luan 'to circle'
k^huŋ > kuəʔ luŋ 'to roll'
ku > kuəʔ lu 'to solder'
xu > xuəʔ lu 'confused'
(the schwa is raised and fronted to [ɛ] when preceded by glide [i])

The process is captured by:

REPLACE(C_i): Replace the initial of the second syllable with [l].
REPLACE(R): Replace the rime (VC_f) with [əʔ]

The data from Taiyuan show an asymmetrical patterning of medial glides[20]. (Recall that the glides [j] and [w] are represented as [i] and [u].) L-word formation follows the same rules of partial reduplication:

Base:	t.əŋ	ts^hu.æ
Copy:	t.əŋ t.əŋ	ts^hu.æ ts^hu.æ
REPLACE(Ci):	t.əŋ l.əŋ	ts^hu.æ lu.æ
REPLACE(R):	t.əʔ l.əŋ	ts^hu.əʔ lu.æ

[20] The original data shows some exceptions which Bao explains with further phonotactic rules.

Base:	k.iau
Copy:	k.iau k.iau
REPLACE(Ci):	k.iau l.iau
REPLACE(R):	k.əʔ l.iau

In comparing ts^hu.æ, which retains the back glide in the first word, with k.iau, which loses the front glide in the first word, it is clear that the glide patterns differently with respect to syllable structure depending on its backness. This would imply that the syllable k.iau has the following constituency:

$[C_i\ [G_m\ [V\ C_f]_R]_{R'}]$

The glide [u] doesn't form a constituent with $[VC_f]$ since it survives REPLACE(R), and it is independent of C_i, since it survives REPLACE(C_i). ts^hu.æ would either have the following possible constituencies:

$[C_i\ G_m\ [V\ C_f]_R]$ or

$[[C_iG_m]_O\ [V\ C_f]_R]$

or the same syllable structure as k.iau would apply, but the second rule applies differently depending on the glide: REPLACE(R) if the glide is back, or REPLACE(R') if the glide is front.

With respect to the rounded palatal glide, the rules seem to treat it as a combination of [i] + [u], so that the word kyɛ has the structure $[[\text{ku}]_O\ [\text{i}\varepsilon]_R]$, with the back vowel as part of the onset, the front vowel as part of the rime. The derivation applies as such:

Base:	ku.iɛ
Copy:	ku.iɛ ku.iɛ
REPLACE(Ci):	ku.iɛ lu.iɛ
REPLACE(R):	ku.əʔ lu.iɛ

The same indeterminancy is shown in Yanggu diminutive affixation and the fanqie language May-ka (Bao 1990, 1996).

A fanqie language is the language of a game that involves dividing a syllable from a given source into an initial and a final. May-ka is one such language game in standard Mandarin. The rules of May-ka are:

Reduplicate the syllable in full.

In the first syllable, replace the rime with [ai].

In the second syllable, replace the onset-initial (i.e., the first C of the initial) with k.

After this, various phonological rules apply, such as raising of a low vowel after a front glide and palatalization of velars (the same rules as the general phonology).

May-ka ma 55 > mai 15 ka 55 ‘mother’
pən 15 > pai 15 kən 15 ‘book’
tɑo 51 > tai 15 kɑo 51 ‘path’

Therefore, the derivation of *pei* would follow as:

p.ei
p.ei p.ei
p.ai-k.ei

Bao treats the front and back glides differently, classifying the latter as an initial, but not the former. He draws this conclusion partly due to the nature of variation of [w], which ranges across values from [w] to [v] (Bao 1990: 334), similar in nature to the zero onset (see above). However, the front glides show no such variation. This leads him to posit that in syllable-initial position, the front glides are a case of a zero-initial sharing the onset with a glide (which has spread to the nucleus through vocalization), while [w] in syllable-initial position is a solitary onset[21] (as illustrated in Bao 1990):

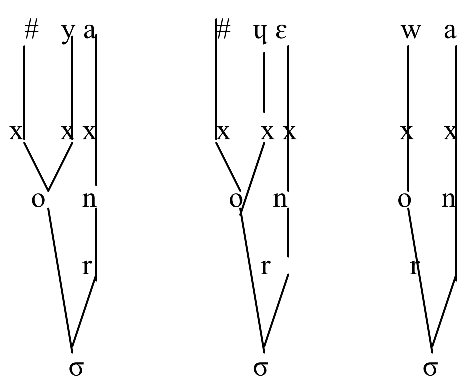

Figure 2: Hiearchical structure of syllables with “zero” onsets (Bao 1990).

[21] However, Duanmu (2007: 81) argues that there is no zero onset before any glide. See Section 2.3, p. 6.

Bao's analysis of May-ka suggests that the three high vowels [i], [y], and [u] must be preceded by their corresponding glides to derive the correct form[22]. For example, the word *liəŋ* 'order' would produce *l.ai tɕ.əŋ if it were initially of the constituency l.iəŋ, but the correct ljɛ.tɕjəŋ, if initially syllabified as lj.əŋ:

May-ka	l.əŋ	lj.əŋ
	l.əŋ l.əŋ	lj.əŋ lj.əŋ
	l.ai k.əŋ	lj.ay kj.əŋ
	*l.ai-tɕ.əŋ	ljɛ.tɕjəŋ

Finally, to account for another fanqie language, Man-t'a, Bao proposes the following generalization and corresponding syllable structure:

> If the vowel of the source syllable remains in the o-syllable [syllable that retains the onset], the o-syllable keeps the source tone (Bao 1990: 339).

[…[t [V S]$_r$]$_R$] where S=any segment that can serve as a coda and R is a higher branching node than both t(one) and r(ime).

This accounts for various observations on tonal patterns in the data. If the entire rime is targeted, the tonal quality will be replaced by whatever the rule stipulates. However, if a sub-rime constituent is targeted, as in Man-t'a, then vowel of the source syllable will remain in the o-syllable, e.g.:

Man-t'ama 55 >	man 55 t^ha 55	'mother'
pən 15 >	pən 15 t^hən 15	'book'
taw 51 >	tan 51 t^hɑo 51	'path'

Whereby the rules of Man-t'a are:

In the first syllable, insert [n] in the rime.

In the second syllable, replace the onset initial with [t^h].

3.3.2. Syllabic phonotactics

Lin (2007) posits the following two constraints on syllabic nuclei to account for what we have been referring to as apical vowels: a syllable must have a nucleus segment; a Standard Chinese nucleus

[22] An additional constraint against co-occurrence of [+round] in the onset and coda undoes this effect for the high back vowel. Data illustrating this will not be discussed here.

must be [+voice, +sonorant] (Lin 2007: 169). This implies that words like 纸 [tʂɹ̩]$_{214}$ 'paper' (in Lin's transcription) and 丝 [sɹ̩]$_{55}$ 'silk' (also Lin's transcription), have the underlying forms /tʂ/$_{214}$ and /s/$_{55}$, respectively[23]. A similar constraint against schwa in a simple V rime, explains the surfacing of a tense back vowel in syllables such as [lɤ] and [ʔɤ] (from /lə/ and /ə/, respectively). This constraint is posited on the grounds that a rime requires some length to manifest stress and/or tone, with a schwa not followed by a coda consonant being too weak to fulfill this function (Lin 2007: 174-175).

Recall from earlier that when a high front vowel or glide is followed by a nasal consonant differing in backness, a schwa is inserted between the two. (Duanmu 2007: 60-64) states this in terms of a constraint against segments in the rime having opposite feature values for [back] and [round], thereby excusing [ə] from a mismatch by virtue of its underspecification (see section 3.3.3 below). Lin has a special way of characterizing the generalization. Though schwa moves slightly front or back phonetically, depending on the following nasal, the effect is minuscule. On the assumption that schwa is unspecified for [back], Lin (2007) claims that [ə] assimilates to adjacent vowels or glides, but not to nasals, presumably for acoustic/auditory reasons Therefore, when there is a mismatch for [back] between a high vowel and a nasal underlyingly, the former syllabifies as a glide and a schwa is inserted to satisfy the constraint necessitating a nucleus. So an underlying form /piŋ/$_{55}$ 冰 'ice' has the surface form [pjəŋ]$_{55}$.

As the sequence *[yŋ] never occurs, this implies when /y/ resyllabifies, it splits into /iu/, syllabifying as [ju], e.g. qiong [tɕ^{hj}uŋ]$_{35}$ 'poor' < UR /tɕ^{h}yŋ/$_{35}$.[24] In this case no schwa need be inserted since the syllable now has the nucleus [u]. Compare the syllabification of two URs for /yŋ/$_{51}$ 用'to use' and /uŋ/$_{55}$ 'old man': [juŋ]$_{51}$ for the former, and [wəŋ]$_{55}$ for the latter. Lin makes the claim that this process is due to the complexity of the segment [y], which is both [-back] and [+round]. Similar cases of feature "unpacking" have been called upon to explain the behavior of nasal vowels in some languages (Kenstowicz 2003; LaCharite and Paradis 2005; Paradis and Prunet 2000).

[23] The sonorancy requirement also precludes Duanmu's positing of [ʐ] as the nucleus in these syllables.
[24] Note that for some speakers the vocalic nucleus is somewhat lowered to [tɕ^{hj}ɔŋ], reflected in the Pinyin *qiong*.

In fast speech, sometimes certain syllables will contract, usually in high frequency words or phrases in casual conversation (Lin 2007: 180-182). Often the onset segments of both syllables are present in the onset of the contracted form, with elements of the second syllable present in the coda. The contracted syllable usually takes the leftmost segments of the first syllable and the rightmost segments of the second in an effort to accommodate as many elements as possible. The result can sometimes be an otherwise illicit syllable, sometimes with unattested tonal values.

不 [pu]$_{35}$ 'not' + 要 [jɑu]$_{51}$ 'want' → 别 [pjɛ]$_{35}$ 'don't'
比较 [pi]$_{35}$[tɕjɑu]$_{214}$ → [pjɑu]$_{352}$ 'comparatively'
什么 [ʂən]$_{35}$[mə]$_{3}$ → [ʂəm]$_{353}$ 'what'

Finally, there is the famous r-suffixation (儿化) that applies to syllable rimes as a stylistic effect. Unlike a suffix like the nominal 子 [tsɿ], the suffix 儿 [ɚ], though written as an independent morpheme, attaches to the preceding syllable initiating somewhat complex alternations to the rime. We will skip over the details here, noting only that the suffix is incompatible with a [-back] segment and cannot combine to form a complex coda, leading to processes such as glide formation, mid vowel insertion, segment deletion, and merger (Lin 2007: 190). For detailed accounts see (Lin 2007: 182-189), (Lin 2004) and Duanmu (2007) Ch. 9).

3.3.3. Distribution and syllable gaps

Many of the missing syllable types can be ruled out by constraints on surface forms. Lin 2007 (p. 117-120) gives the following examples:

1.The segments in the rime must have the same value for [back]/[round]:

[in], [yn], [uŋ], [an], [ɑŋ], [ei], [ou], [ai], and [ɑu] are good

*[un], *[iŋ], *[yŋ], *[aŋ], *[eu], *[oi], and *[au] are bad

2. In a syllable that contains GVV, the high glide and the high vowel in the second part of the diphthong cannot be both [-back] or both [+round]:

[wai], [wei], [jou], and [jɑu] are good

*[jai], *[jei], *[ɥai], *[ɥai], *[wɑu], *[wou], *[ɥɑu], and *[ɥou] are bad

3. A labial consonant cannot be followed by a rounded glide [w] or [ɥ] when the vowel is unrounded:

[pwo], [p^hwo], [mwo], and [fwo] are good

*[pwa], *[p^hɥe], *[mwei], and *[fwan] are bad

4. A labial consonant cannot be followed by a mid vowel in a CV syllable.

[pwo], [p^hwo], [mwo], and [fwo] are good

*[pə], *[mɤ], *[fɤ], and *[p^ho] are bad

5. A glide cannot be followed directly by a high vowel differing in backness

[ji] and [wu] are good

*[ju] and *[wi] are bad

Lin attributes other missing syllable types (e.g. *[lwei], *[tia], *[kwəŋ]) to accidental gaps. By her criteria, if a native speaker judges a missing form as acceptable when created, rather than ungrammatical, then it must constitute an accidental gap (Lin 2007: 117).

Duanmu (2007) attempts to account for many of the syllabic gaps using three constraints. Given four choices for G, there are 100 combinations of (G)V(X), of which only 35 occur, which he shows in the following chart (Duanmu 2007: 59).

		Ø	j-	w-	ɥ-	
[-Ø]	i	+	(+)	--	--	[ji] = [i]
	u	+	--	(+)	--	[wu] = [u]
	y	+	--	--	(+)	[ɥy] = [y]
	ə	+	+	+	+	
	a	+	+	+	--	
[-n]	in	+	(+)	--	+	[jin] = [in]
	un	--	--	(+)[25]	--	[wun] = [un]
	yn	--	--	--	(+)	[ɥyn] = [yn]
	ən	+	+	+	--	
	an	+	+	+	+	
[-ŋ]	iŋ	--	(+)	--	--	[jiŋ] = [iŋ]
	uŋ	+	+	(+)	--	[wuŋ] = [uŋ]
	yŋ	--	--	--	(+)	[ɥyŋ] = [yŋ]
	əŋ	+	+	+	--	
	aŋ	+	+	+	--	

[25] It is not evident what the rhyme '–un' refers to, as no Chinese syllable is transcribed as such, either in Duanmu (2007) or Lin (2007). The closest equivalent is [-ən], which is already represented on the chart.

[-i]	ii	(+)	(+)	--	--	[ii], [jii] = [i]
	ui	--	--	(+)	--	[wui] = [ui]
	yi	--	--	--	(+)	[ɥyi] = [yi]
	əi	+	--	+	--	
	ai	+	+	+	--	
[-u]	iu	--	(+)	--	--	[jiu] = [iu]
	uu	(+)	--	(+)	--	[uu], [wuu] = [u]
	yu	--	--	--	(+)	[ɥyu] = [yu]
	əu	+	+	--	--	
	au	+	+	--	--	

The forms in parenthesis indicate forms that do not contrast with forms indicated to the right in the equated brackets. Accounting for this are two constraints Duanmu posits, Merge and G-spreading. The first simply merges two tokens of the same feature into one long feature; the second captures the generalization stated above that a high nuclear vowel spreads to the onset C, which works well with Duanmu's analysis of alveolopalatals noted above. Furthermore G-spreading is blocked when the onset is G or CG. A third constraint is posited, Rhyme-Harmony, which stipulates that VX cannot have opposite values in [round] or [back] on the grounds that to violate such would require a significant degree of articulatory effort (Duanmu 2007: 60). Rhyme-Harmony can thus explain the gaps in rows *[un], *[iŋ], *[yŋ], *[ui], *[yu], *[yi], and *[iu]. Merge, for its part, explains the non-contrastiveness of the forms listed to the side.

Duanmu makes some suggestions for the remaining forms. He points out that 16 of these forms involve the front glides. Possibly, the forms [ɥuŋ] and [iuŋ] could be identical under G-spreading. Also, by a process he calls "triphthong raising", which would cause the sequence [high][mid][high] to assimilate to [high][high][high] (cf. tone 2 sandhi below), the lack of forms *[ɥəu], *[wəu], *[ɥəi] and *[jəi] could be accounted for, as well as the lack of contrast between [wəi] ~ [wi] and [jəu] ~ [ju], which vary depending on the accompanying tone (see section 2.2). (Mid vowels between a glide and high vowel tend to delete when a syllable has a high tone, i.e. T1 or T2 (Duanmu 2007: 69 and references therein). Duanmu attributes this to laryngeal raising for a high tone, which produces a higher vowel, as opposed to laryngeal lowering on low tones, which pull the tongue down to a position for a low vowel.) Finally, a general constraint against an onset and coda sharing the feature [+round] can rule out forms like [ɥau] and

[wau] (as well as [ɥəu] and [wəu], which are explained under triphthong raising). This constraint has been noted by others (Bao 1990; Lin 2007), and can explain why under G-spreading the front glide [j] is the only glide to spread to onset position. Duanmu claims that these three constraints can rule out 65% of all non-occuring forms, as well as account for the existence of 77% of attested forms (Duanmu 2007: 64).

3.4 Tonal phonology

Mandarin exhibits a number of tonal processes, which we will only skim over here. The two most common changes are that Tone 3 changes from pitch value 214 to 21 when it appears before another tone, and Tone 4 changes from pitch value 51 to 53 before another tone.

The common analysis is that the mora is the tone-bearing unit (TBU). Each full syllable, that is each syllable with a tone other than the neutral tone, has two TBU's, with each tone feature associated with one mora. The neutral tone receives only one tone feature. The tones are given the following features in (Lin 2007: 194):

Tone:	Tonal Feature	Pitch Value	Moras
Tone 1	HH	55	2
Tone 2	MH	35	2
Tone 3	LL (before another tone)	21	2
	LH (in phrase final position) (simply L in Duanmu 2007)	214	2 (or 3 if 214)
Tone 4	HL (in phrase final position)	51	2
	HM (before another tone)	53	2

Table 6: Standard Mandarin tonal features (Lin 2007).

Note that tone 3 and tone 4 are simplified when they are followed by another tone, in that their pitch range and pattern is reduced. This is because a syllable in phrase final position is longer in duration and can preserve more tonal information than in non-final position (Duanmu 2007; Lin 2007: 197). Tone 3 is the only tone given the register feature [+murmur] in Duanmu (2007), but since it is the only L(L) tone, it is not distinctive.

Tone sandhi also occurs when certain tones or lexical items are adjacent to each other. The most well-known change is T3 sandhi, which occurs when two third tones are adjacent causing the first to change to T2, i.e. LHLH →MHLH, or 214214 → 35214. Phonetically, the first in the pair has an overall lower F0 than a true T2, but native speakers have been shown to be unaware of this property (Lin 2007: 197 and references therein). If we allow for an intermediate stage, whereby the first T3 changes to the usual LL before another tone, then the subsequent change to MH can be seen as a process of dissimilation in the environment of LLLH (Lin 2007: 198).

Things quickly become complicated when more than two third tones appear adjacent to each other. This is because the triggering of tone sandhi obeys a complex set of morpho-syntactic rules that also interact with metrical structure. This means that depending on one's bracketing of the constituents, you can have a significant number of varying surface patterns from the same underlying tonal sequence. Even when the same constituent bracketing applies, one is not always guaranteed the same surface pattern. (See below in Section 3.5 for Metrical Phonology.)

Another process that applies only in fast speech is T2 sandhi. Basically, after a first or second tone, the H from the first syllable spreads to replace the M of the second syllable when that syllable is T2, so that HLH becomes HHH. Duanmu argues that in this case the middle syllable lacks stress, and so is more prone to feature spreading (Duanmu 2007: 240). This can be illustrated in the following example:

还没完 'not yet finished'
[xai]35[mei]**35**[wan]35 → [xai]35[mei]**55**[wan]35

Other rules are more limited in scope. For example, there is a T4 dissimilation process which applies only to the lexical items 一 [ji]55, 不[pu]51, 七 [tɕi]55, and 八 [pa]55. According to Duanmu 2007, all of these tones belong to the historical entering tone, which ended in a stop. Duanmu gives the following sandhi patterns, with an example of how syntactic structure affects the outcome:

	Final	Before T4	Before T1, T2, and T3
[ji] 'one'	T1	T2	T4
[tɕi] 'seven'	T1	T1 (T2)	T1 (T4)
[pa] 'eight'	T1	T1 (T2)	T1 (T4)
[pu] 'not'	T4 (T1)	T2	T4

十一年	忙一年
T2-T1-T2 (*T2-T4-T2)	T2-T4-T2 (*T2-T1-T2)
[[shi yi] nian]	[mang [yi nian]]
ten one year	busy one year
'eleven years'	'busy for a year'

Also, in reduplication, the tone of the reduplicated syllable is lost and the overall syllable loses stress, causing a default insertion of the neutral tone. The process is somewhat different depending on the functional category of the reduplicated lexical item (e.g. adjectives vs. kinship terms).

The neutral tone is underlyingly toneless and receives its value from either the last feature of the reduced third and fourth tones, or by a process of default low tone insertion after the first and second tones. This means that it is low after T1 and T4, mid or low after T2, and mid or high after T3 (Lin 2007: 201-204).

3.5 Metrical phonology

Duanmu (2007) assumes that stress is sensitive to both moras and syllables, which he calls the Dual Trochee. He also claims that stressed syllables must be heavy, and that a foot must have at least two beats. He furthermore posits that Mandarin makes use of an empty beat, but only in phrase-final positions, where it is realized phonetically as a pause or lengthening of a preceding syllable, effects that diminish in any other positions (Duanmu 2007: 137). On page 139 he gives examples of good and bad feet in Mandarin:

Good feet (HH) & (HL)

x	x	
(σ σ)	(σ σ)	Syllabic foot
(μ μ). (μ μ)	(μμ).μ	Moraic foot
x x x		
heavy-heavy	heavy-light	
(HH)	(HL)	Shorthand

Bad feet (LL) & (LH)

x	x	
(σ σ)	(σ σ)	Syllabic foot
μ.μ	μ.(μ μ)	Moraic foot
	x	
light-light	light-heavy	
(LL)	(LH)	Shorthand

Table 7: Foot templates in Mandarin phonology (Duanmu 2007).

The following illustrates the Mandarin foot templates, including the empty beat Duanmu (2007:141):

(HL)	(HH)	H(HØ)
x	x	x
(σ σ)	(σ σ)	(σ (σ Ø)
(μμ).μ	(μμ).(μμ)	(μμ).(μμ).Ø
x	x x	x x
[paa.pa]	[tɕii.x^{w}aa]	[s^{w}uu.sɤɤ]
‘dad’	‘plan’	‘dorm’
爸爸	计划	宿舍

Table 8: Foot templates illustrating the empty beat (Duanmu 2007)

Duanmu cites a previous study that gives the following distribution of metrical types in Mandarin:

Pattern	Count	Percentage
(HL)	1,500	7.5%
(HH)	4,500	22.5%
H(HØ)	14,000	70.0%
All	20,000	100.0%

Table 9: Distribution of foot types in Standard Mandarin (Duanmu 2007).

Since each full syllable has two moras, a single syllable forms a moraic foot and has stress, whereas light syllables only have one mora and will remain unstressed. A foot is usually formed from the left, but a final syllable will usually form another foot utilizing the empty beat. So long as there are no stress clashes or free syllables in succession (i.e. not parsed into feet), other syllables will form binary feet. The following from (Duanmu 2007: 143) sketches possible foot structure, where S = strong stress, W = weak stress (to distinguish from light syllables with neutral tone) and H stands for a full syllable (i.e. a heavy moraic syllable):

Length	Pattern	Foot structure
2 syllables	WS	H(HØ)
3 syllables	SWS	(HH)(HØ)
4 syllables	SWWS	(HH)H(HØ)
5 syllables	SWSWS	(HH)(HH)(HØ
6 syllables	SWSWWS	(HH)(HH)H(HØ)
	SWWSWS	(HH)H(HH)(HØ)
7 syllables	SWSWSWS	(HH)(HH)(HH)(HØ)
	SWWSWWS	(HH)H(HH)H(HØ)

Metrical structure is used to account for various tone sandhi processes (especially T3 sandhi), as well as disyllabic requirements that often manifest themselves, e.g. in spoken names (Duanmu 2007: 177-179). Furthermore, such structure is often posited on the basis of morphosyntactic constituencies rather than metrical principles alone. I will briefly sketch Lin 2007's rules for parsing constituents into feet and how they relate to T3 sandhi and syntactic structure. As the examples are more complex than space allows, the reader is referred to Lin (2007: 205-210) for examples or to Duanmu (2007: Ch. 11) for a more complex, primarily stressed-based approach.

In essence, metrical structure begins by building disyllabic feet from left to right, beginning with the smallest morphosyntactic domain, i.e. within a word building up step by step to the phrasal level, keeping with left to right parsing. Then, unincorporated feet may combine with an adjacent foot to form what Lin calls a "superfoot". This usually consists of three syllables within a foot, but in fast speech may involve an even larger domain, such as four syllables (Lin 2007: 206). For words, feet are built up from the smallest domain, but for phrases, once a disyllabic foot is formed at the smallest domain, the process proceeds left to right for the entire phrase (Lin 2007: 214). Consider the following examples and how their constituent structures affect T3 sandhi:

找总统府	那种狗好？
zhǎo zǒngtǒng fǔ	něi zhǒng gǒu hǎo
T3 T3 T3 T3	T3 T3 T3 T3
[zhao [[zongtong] fu]]	[[[nei zhong] gou] hao]
T3 T2 T2 T3	T2 T3 T2 T3
search-president-palace	what-kind-dog-good
"Looking for the presidential palace"	"Which kind of dog is better?"

In the first example, the disyllabic foot [zongtong] is first analyzed as a single word so tone sandhi applies. Next the word for palace, [fu], is incorporated, forming the complex word 'presidential palace', and tone sandhi applies again. As the whole word is the object of the verb *zhao*, there is a major syntactic boundary between the two parts (i.e. between the verb *zhao* and the object *zongtong fu*), and after the verb is incorporated into the overall constituent structure no sandhi applies. In the second example, the smallest constituency is given a foot first and then the remaining syllables form another disyllabic foot, with sandhi applying within each foot (Lin 2007: 210-211).

4. Conclusion

Mandarin phonology, perhaps due to its lack of alternations, has traditionally not received the vigorous phonological analysis that some of its neighboring languages have. However, as can be seen above, especially within a constraint-based framework such as Optimality Theory, many interesting topics arise. Furthermore, within the realms of tonal and prosodic phonology, many issues still remain unresolved. In the next two chapters we will consider how the native phonology presented above comes into play when encountering potential loanwords from other languages.

CHAPTER 3: LOANWORD ADAPTATION IN MANDARIN PHONOLOGY

1 Introduction

Compared to neighboring languages like Japanese or Korean, for a major world language Chinese has received relatively little study in the loanword literature, possibly due to the near complete lack of alternations in the native phonology. However, in the formalism of Optimality Theory (Prince & Smolensky 1993/2004), the once uninteresting stipulations of loanword adaptation rules for Chinese can now be viewed as the activation of L1-inert constraints that play an active role in such linguistic tasks (Broselow et al. 1998; Miao 2005; Yip 1993). Across dialects, most studies have focused on either Mandarin or Cantonese, two mutually unintelligible varieties, though not all that dissimilar when it comes to patterns of adaptation (for overviews of the latter see Bauer 1985; Wong et al. 2009)[26].

This overview concerns itself primarily with issues in loanword adaptation pertaining to the Mandarin spoken in mainland China, although it is interesting to point out a study on the differences between Mainland and Taiwanese Mandarin in loanword adaptation (Lin 1998). Lin found that Mandarin in mainland China has a higher regard for faithfulness to phonemic details, whereas the Mandarin spoken in Taiwan prefers overall economy in adaptation, with liquids most likely to delete. That is, when foreign segments cannot transfer into the native phonology without violating well-formedness constraints on syllable structure, mainland Mandarin speakers choose to epenthesize, and thus retain segmental information, whereas Taiwanese Mandarin speakers simply delete. In OT terms this means there is a partial ranking of Max >> Dep in mainland Chinese, while there is a ranking of Dep >> Max in Taiwan, this despite the fact that the two grammars differ minimally in native phonologies. Such a phenomenon can be modeled straightforwardly in Optimality Theory as the interaction of constraints, inactive in the

[26] Also see Yang (2005) for an interesting study of loanwords from Chinese into the local variety of English spoken by bilinguals in the country, as evidenced by publications such as China Daily and Beijing Weekend.

native grammar, that exhibit different rankings between the two speech communities, though they differ minimally in terms of phonology (see (Yip 2002a) for further discussion).

2 Consonants

2.1 Miao (2005)

The most comprehensive study of Mandarin loanword phonology to date is Miao (2005), who focuses almost exclusively on consonantal adaptations in recent loans. In her introduction, she references many sources for historical loans before the twentieth century, but focuses on relatively recent words that are indicative of the modern language as spoken in mainland China. Miao claims that the majority of contact situations in China come about via bilinguals and specifically via the medium of writing, mostly from scholarly journals and magazines (Miao 2005: 9). She identifies four types of loans in modern Mandarin:

1. Phonemic loans (音译词): those loans that attempt to adopt a foreign item purely by phonetic approximation, with no regard to meaning.

Disney > 迪斯尼 [ti2.sz̩1.ni2] 'enlightenment-this-nun'
Sears > 西尔斯 [ɕi1.ɚ3.sz1] 'west-you-this'

2. Semantic loans (意译词): loans that basically ignore the phonemic structure of the source, adapting only the meaning of the borrowed term

A. Morpheme translation: a morpheme-by-morpheme translation

B. Holistic translation: the main idea of the borrowed word is adopted as a single lexical item

Microsoft < 微软 [wei1ruan3] 'small-soft'
Old Navy < 老海军 [lɑu3xai3tɕjən1] 'old-navy'

3. Graphic loans: loans adopted based on the orthography of the source language; mostly borrowings of Japanese terms via the shared use of Chinese characters (many of which were originally

historical Japanese borrowings of Chinese terms), or of individual letters of the Roman alphabet, e.g. CD or ATM

> Asahi (Japanese beer) 朝日 < [tʂɑu1.ɹ̩4] 'morning sun'
> CIO (Chief Information Officer: term of technology) < CIO [si.ji.ou][27]

4. Hybrid loans: a combination of one and two above, where a word will be adapted with a phonemic reference to the source word, but with a semantic morpheme added, either for meaning or prosodic requirements. This will sometimes take the form of a full phonemic loan plus a semantic morpheme, or a half phonemic/half semantic adaptation.

> AIDS < 爱滋病 [ai4.tsz̩1.pjəŋ4] 'love-generated sickness'
> Beer < 啤酒 [pi2.tɕju3] '*beer*-alcohol'

Miao's study focuses primarily on phonemic and hybrid loans, with reference to frequent semantic effects. She compiled a corpus of 2423 pre-existing loans that had entered the language since the 1950's, consisting of three source languages: English, German and Italian, with phonemic adaptation percentages of each language comprising 42%, 66% and 57% of each language's data, respectively. 61.85% of the English loans were found to be of American origin, while 15.55% were of British origin. The remainder fell into three categories: Canadian (3.14%), Australian (1.44%) and "unknown" (18.01%). The data were collected from Chinese-language websites (both in China and overseas, the latter catering to diaspora communities), advertisements in department stores in China, as well as bilingual dictionaries for the languages used.

Given these different adaptation approaches, as well as the sociolinguistic environment of China, many loans show some degree of variability in adapted forms, especially in earlier stages of borrowing. However, the tendency of a loan is most often to begin as a phonemic loan and end up as a semantic loan (Miao 2005: 36-38). In most cases, Miao assumes that "the input to Mandarin loanword phonology is the pronunciation of the source word in the donor language (Miao 2005: 47)." However, as Miao points out, this pronunciation may first be filtered through the medium of spelling systems (see below).

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[27] N.B. that such adaptation of Roman orthography-based graphic loans are read in their source pronunciations via Pinyin, resulting in otherwise illicit sound combinations. Cf. the expected [sz] for 'C'.

One of the key features of Mandarin loanword adaptation has to do with the native orthography. Being a syllabic, morphophonemic script, there is little room for violation of native syllable constraints or incorporation of foreign elements. This is in stark contrast to Cantonese, which lacks a standardized orthography and has been observed to fill in many "accidental gaps" (as opposed to those syllables ruled out on phonotactic grounds) in the native lexicon with syllables from borrowing (Bauer 1985)[28]. Likewise, each Chinese character chosen to represent a syllable of the source term has a semantic meaning by association. Miao (2005) points out multiple instances of this influence, where a perfectly acceptable phonemic translation will be passed up for a more appealing semantic fit, especially in the area of advertising for foreign companies and brand names, e.g. the adaptation of a mattress brand, Simmons, is [ɕi.məŋ.sz̩] rather than *[ɕi.mən.sz̩] because the character used to write the middle syllable, 梦, has the meaning 'dream'. In Miao's corpus, those words which had a greater chance of conveying crucial semantic content (e.g. adaptation of foreign brands) showed a greater tendency for variation and deviation from faithful adaptations.

Miao (2005) furthermore attributes the lack of phonetic details in loanword adaptation to the "sociolinguistic context of language borrowing…mainly through the medium of writing. Thus lexical borrowing into Mandarin relies heavily on spelling (Miao 2005: 55)." This can be seen in the adaptation of voiced/voiceless contrasts in the foreign source into the aspirated/unaspirated system of the native language: English aspiration, which is a phonetic detail in English, is adapted with some variation into Mandarin, but is by and large ignored in favor of a voiced-to-unaspirated/voiceless-to-aspirated cross-language mapping; German final obstruents are adapted as if voiced even though they are devoiced word-finally in the source language. Compare this with Paradis and Tremblay (2009), who elicited pronunciations of a corpus consisting of 223 borrowings from five Mandarin speakers. They found that 89.4% of English voiced stops were adapted as unaspirated in Mandarin, while 81.6% of voiceless unaspirated stops became aspirated in Mandarin. Such variability (particularly in faithfulness to

[28] However, Bauer (1985) and Yip (2002, 2006) give examples of even some native syllabic constraints being demoted to incorporate foreign terms with greater faithfulness to the foreign structure.

aspiration) is absent in Cantonese, which has had a much more extensive exposure to spoken English, and as such adapts all unaspirated English stops as unaspirated in the borrowing language.

All of these factors might lead one to believe that there is little of phonological interest in the study of Mandarin loanword adaptations. However, Miao crucially points out that:

> Although under the influence of various factors (e.g. semantic considerations), an unfaithful deviant structure may be chosen, the extent to which it can deviate from the expected substitute is determined by the degree of perceptual similarity between the input and output segments. (Miao 2005: 89)

This means that beneath the complications introduced by the writing system, as well as the sociolinguistic climate of China, there is still a level of phonological phenomena to be explored in the adaptation of loanwords. What is interesting is the type and degree of discrepancy that is allowed when deviation from the source is forced by various factors.

Miao focuses exclusively on consonantal adaptation, touching only on vowels in regards to epenthetic segments. As the current study is concerned with variation in vocalic adaptation, I will only mention a few notable observations from Miao (2005). Nonnative segments and phonotactics are adapted to fit the native phonological system (e.g. velar stops become alveolopalatal affricates before front vowels), and there appears to be an overall ranking of Ident[manner] >> Ident[place] in consonants, so a segment is more likely to change a feature for place than, say, nasality or continuancy (e.g. (Miao 2005: 50). This means that a consonant is more likely to be unfaithful to the source language's place feature, rather than to change a feature such as [sonorant] or [continuant]. (Miao uses the feature system of Spencer (1996), which utilizes a hierarchy of independent manner, place and laryngeal features.) Coda liquids more than half the time are adapted as [ɚ] to fit the native syllable structure, with [ɹ] showing a greater tendency to delete than does [l] (Miao 2005: 102). Miao sees this as a preference for the less marked segment, which is further supported by the fact that [ɹ] is sometimes adapted as [l], even though the native rhotic is minimally different than the English segment. On the other hand, this rounding may be a crucial element of perceptual adaptation, as will be suggested in Chapter 4 Section 3.3.

Perhaps more interesting for present purposes were violations of DEP in loanword adaptations. Miao found that in most cases where an epenthetic vowel was inserted to retain a segment in the input that would violate Mandarin syllable structure, the vowel would share features with the neighboring consonant, most commonly [labial]. As Miao points out, this is in keeping with the typological data analyzed by Uffmann (2006), who finds that insertion of a vowel sharing features with an adjacent segment is one of three attested means of epenthesis (cf. Adler's analysis of Hawaiian in Chapter 1 Section 4.2).

The back mid vowel [ɤ] is the segment most commonly occurring as an epenthetic, due to what Miao considers its neutral and variable status, and it therefore occurs after most [-labial] segments (Miao 2005: 124). After sibilants and retroflexes, the epenthetic is commonly an apical vowel, which by definition shares the articulatory place of the onset segment. As apicals never occur after palatal onsets in the native phonology, the front vowel [i] is found in epenthesis sites co-occuring with palatal onsets, e.g.

> [kai4.luo4.pʰ**u**3][29] > Gallup
> [xa1.m**u**3] > Hamm
> [fən1.pi4.t**ɤ**3] > Fenbid
> [fei1.ia4.tʰ**ɤ**] > Fiat
> [fɑŋ3.pi4.ʂ**ɹ̩**4] > Febreeze
> [ɑo4.ti2.s**z̩**1] > Otis
> [ɑo4.lan2.tɕʰ**i**2] > Orange

Formally, Miao sees this tendency as an undominated Dep(place) constraint which prohibits an epenthetic segment from having an independent place feature. Note that the features Miao considers in this analysis are [+labial] (matching labial consonants with round vowels), [-labial] (matching [ɤ] with nonlabial consonants), and [+palatal] (matching [i] with palatal segments), in additional to apical vowels sharing the same place of articulation with preceding consonants, as shown in the examples above. The back unrounded vowel [ɤ] tends to occur in all other environments. The insertion of a vowel sharing the same articulatory place is an effective means to enhance perceptual similarity between the source word

[29] I maintain Miao's transliteration. It differs only minimally in that the glides are represented with the vowels [i] and [o], rather than the consonants [j] and [w].

and adapted form, an occurrence Miao suggests as support for Steriade (1999)'s P-Map hypothesis (Miao 2005: 132-133). The tableaux from Miao (2005: 133) illustrate the Dep(place) constraint in effect:

(10) "Gallup" > "gai4-luo4-pu" [kai.lwo.p^hu]

gæləp	σ-Structure	Dep I-O(place)	Max I-O (C)	Dep I-O (V)
☞/kai.lwo.phu/				*
/kai.lwo.< >/			*!	
/kai.lwo.phi/		*!		

(11)"Maytag" > "mei3-tai4-ke4" [mei.t^hai.k^hɤ]

meɪtæg	σ-Structure	Dep I-O(place)	Max I-O (C)	Dep I-O (V)
☞/mei.t^hai.k^hɤ/				*
/mei.t^hai.< >/			*!	
/mei.t^hai.k^hu/		*!		

Miao (2005) backed up her findings with online adaptations elicited through a series of psycholinguistic experiments. In one task, participants were asked to rank possible adaptations of a fabricated English place name in terms of similarity. In other tasks, the participants provided their own adaptations for names, both in Chinese characters and in the native pinyin Romanization. The findings largely followed the generalizations from the corpus, with the exceptions that participants always epenthesized rather than deleted, with the preferred epenthetic segment being [o] rather than [u], and that only voiceless stops showed variation in aspiration, but never voiced. Miao further found that manner features, such as sonorancy and nasality, were more likely to be maintained than other features, like place or laryngeal features.

2.2 Hsieh, et al. (2005)

Recall that in Mandarin phonology, in the context of nasal codas (of which only [n] and [ŋ] are possible) the low vowel takes a relatively front allophone before the dental nasal, and a relatively back allophone before the velar nasal, called Rhyme Harmony by Duanmu (2007). More generally, Mandarin non-high vowels are unspecified for [back], receiving their value for this feature from adjacent segments--nasals in the case of coda consonants. The question naturally arises, what will be the deciding factor in adaptation, the vowel or the coda? Examining a loanword corpus of c. 600 items drawn from a dictionary, Hsieh, et al. (2005) found that the vowel, which is more salient than the nasal coda consonant

(Hsieh et al. 2005: 6-7), determines the adaptation of the coda nasal, even when the nasal coda is the site of the phonological contrast[30], e.g.:

clone > [kʰɤ.luŋ]	[n] > [ŋ]
microphone > [mai.kʰɤ.fɤŋ][31]	
economy > [ai.kʰɑŋ.nwo.mi]	
Angus > [an.kɤ.sz̩]	[ŋ] > [n]
Franklin > [fu.lan.kʰɤ.lin]	
Anguilla > [an.gwei.la]	

The data show that there is a greater faithfulness to vowels than to nasal contrasts in adaptation. Auditorally speaking, this could be because the nasal ending does not receive full closure (see Chapter 2 Section 2.1) and therefore relies on the vowel for perceptual cues, e.g. formant transitions indicating whether the nasal is coronal or dorsal (see theoretical analysis below). Interestingly, [back], precisely the feature that is underspecified in the native phonology, exhibits the most faithful mapping among vowels (see Lin 2008a; Lin 2008b: below).

Furthermore, /ɛn/ maps to [ən], not [jɛ], implying a DEP-GLIDE constraint, except when such a syllable is unattested (e.g. *[ən] or *[tən]) or rare in Mandarin, in which case the vowel height is altered, rather than the backness:

benzene > [pən]
convention > [kʰɑŋ.wən.ɕin]
pimento > [pʰi.mən.tʰa]
engine > [jin.tɕʰjəŋ] *[ən]
tendency > [tʰiŋ.tɤŋ.sɤ] *[tən], *[tin]

The authors use correspondence constraints E(nglish)-M(andarin) to formulate their analysis, with an undominated structure preservation constraint, Use-Ld-Syl:

Use-Ld-Syl >> Rhyme Harmony>>Id[back]E-M >> Id[C-Place-Coda] >> Id[back]

---

[30] Note that there is some variation in adaptation, four words with [ɑ] remain faithful to the nasal, thus changing the vowel: gondola, neon, cellon, and mont.

[31] The usual transcription of the pinyin syllable ‘feng’ is [fəŋ], however Hsieh et al.’s analysis seems to imply that they take syllables with a mid vowel-velar nasal combination to be [-ɤŋ]. All of their data are in pinyin orthography. See the adaptation of ‘tendency’ below.

However, faithfulness to the coda consonant rather than the vocalic features emerges for the central vowel [ʌ], supposedly because its F2 is not salient enough to make a front/back distinction. Also, unstressed reduced vowels defer faithfulness to the coda nasal (height is altered if the syllable does not exist)—again a supposed perceptual underspecification. In adapting English schwa there is an apparent preference for a [+high] vowel, maybe because high vowels are shorter than low vowels, and therefore less salient (Hsieh et al. 2005: 31). Their data contained no reduced vowels with a coda velar nasal.

Addison > [ɑ.ti.sun]
Bremen > [pu.lɤ.mun]
cosecant > [k^{h}ou.ɕi.kun]
perlon > [pei.lun] *lən
carron > [k^{h}a.lun]
Dalton > [tɑo.əɹ.tun] *dən

However, the authors' treatment of '–un' codas is somewhat suspicious, in that they take them to be phonetically [un], rather than a rime following a labial glide, Cwən or C^{w}ən, phonetically realized as [-wən] (cf. Duanmu 2007; Lin 2007). For example, in other transcriptions the adaptation of 'perlon' would be [pei.lwən], rather than [pei.lun]. If this is the correct representation, then the pattern is not as mysterious and also solves another problem raised in the article, namely words ending in English orthographic <–oon>. The authors question why such words are adapted as C[ong] instead of [dun, tun, sun, and lun]. They claim orthography, but by my observation the reason is that Mandarin lacks a simple [un] coda, so the words follow standard procedure in adapting them with faithfulness to the [+back] vowel.

Finally, to satisfy a bimoraic syllable constraint on stressed syllables, coda nasals are added to (C)V syllables preceding a nasal onset, although they are not determined by gemination or default insertion (where one might expect a coronal due to the markedness hiearchy), but by correlation with the tautosyllabic vowel, i.e the vowel of the first syllable in the resultant sequence (C)VN.NV. The underspecified wedge, however, doesn't have this effect.

amonal > [ɑ.mɑŋ.na] *[ɑ.man.na]
anarchy > [an.na.tɕ^{h}i]
economy > [ai.k^{h}ɑŋ.nwo.mi] *[ai.kan.nwo.mi]

Hsieh, et al. (2005) attributes Rhyme Harmony to an enhancement effect (Keyser and Stevens 2006; Stevens and Keyser 1989) used to identify the nasal coda's place of articulation (see similar work by Kenstowicz on Korean dialects, discussed in Chapter 1, section 5 above). Keyser and Stevens divide distinctive features into two classes, primary and secondary. Primary features are features that are salient by virtue of robust internal cues when implemented in segments (e.g. sibilant fricatives), whereas secondary features function mainly to "enhance" the implementation of the primary features by co-occurence, resulting in a maximized perceptual distance. An example from Stevens & Keyser (1989) is the enhancement of the primary feature [continuant] by the secondary feature [distributed]. They claim that [-continuant] segments are enhanced if the length of closure is short and the release rapid, resulting in an abrupt onset of acoustic energy at release (Stevens and Keyser: 90). The accompaniment of [-distributed] with [-continuant] allows a greater distance for pressure to build, resulting in a more salient burst at release. The exact opposite state of affairs hold when the features are changed from minus to plus, implying that a major role of [distributed] is to enhance the perceptual cues in implementing [continuant] (cf. Flemming 2002; Lindblom 1986: on Dispersion Theory).

Stevens & Keyser (1989) define saliency in terms of "contrasting acoustic properties associated with the presence or absence of some features [which] provide a stronger auditory response than those associated with other features (85)". Such effects have been studied by phoneticians in confusability tests and other perceptual experiments, and are generally supported by typological studies of exhibited contrasts in world languages. Stevens and Keyser give the example of the contrast between [t,s] and [t,t̪]. They claim the feature [continuant] to be more salient than [distributed] due to the former's "abrupt onset of energy over a range of frequencies preceded by an interval of silence or low amplitude…..leading to a distinctive response in the auditory system (85)." The feature [distributed], on the other hand, relies on an acoustic correlate in consonantal release, far more transient than that of continuants. Relative saliency is also affected by syllabic place and sonority sequencing, e.g. [pa] vs. [ba] is a stronger contrast than [ap] vs. [ab]; [aps] vs. [pas] is stronger than [aps] vs. [asp] (Steriade 2001b: 11).

In the Mandarin data, where the backness of the vowel determines the place of the nasal coda, Hsieh et al. claim that the vocalic feature [back] helps to distinguish the place of articulation of the less salient nasal by fronting the tongue body to accommodate a consonantal constriction at the alveolar ridge (the site of the coronal coda). They cite studies which show a significant difference in F2 (400-500 Hz) in the midpoint of low vowels preceding the different nasal codas. The F2 of the front vowel has a steady rise before the coronal nasal, and the back vowel's F2 has a flat trajectory before the dorsal. This difference is maintained even when the nasal is deleted intervocalically in casual speech (Hsieh et al. 2005: 47). They note also that these F2 values which are found before dorsals are found in open syllables containing low and mid vowels, the values being more distant from those found in pre-coronal nuclei. Finally, they cite reports that speakers can anticipate the upcoming nasal in experiments for non-high vowels, but not for the (contrastive) high vowels. This means that the cues are "not just a coarticulatory effect at the VC transition (Hsieh et al. 2005: 46). They conclude by questioning whether such effects have a basis in cross-linguistic speech perception and loanword adaptation phenomena.

3 Vowels

3.1 Lin (2008a,b)

Yen-hwei Lin has conducted more extensive analysis into the variable adaptation of vowels in Mandarin loanwords (Lin 2008a, 2008b). All variants follow the distributional/allophonic patterns of Mandarin (i.e. structure preservation), although she makes no mention of illicit syllable types (beyond consonant-vowel correlations) or tone-to-syllable matchings in her analysis of the data. She does, however, distinguish optimal outputs (which occur more frequently) from acceptable outputs (which occur less frequently, used only if the optimal output is compromised by other factors).

As in Hsieh, et al (2005)'s findings, Lin also found that vowel backness is more faithfully replicated than height and rounding. Deviation in height is tolerated but minimal, e.g. a high-mid or mid-low match is acceptable, but a high-low match is not. Vowels match adjacent segments in backness, no matter the height, but each case involves at least some deviation in the feature [high]. Finally, central vowels behave as if they are unspecified or ambiguous for backness. She gives the following variation scale from most variable to least variable:

mid vowels > low vowels > high vowels

Lin (2008b) gives an in-depth account of the distribution of vowel mapping which she drew from a variety of media, as well as her own observations as a native speaker. Lin (2008a) uses a much larger corpus drawn from dictionaries and includes statistical figures for rates of variation. Note that she uses the allophone [a_c] for the mid vowel /ə/ when surfacing in an open syllable, [wa_c] or [a_c], although she states that "for SM speakers, a [SM] low central vowel is perceptually not different or distinct enough from either a front or back low vowel to be classified as a separate category from low front or low back". (Lin 2008b: 374)

The following charts are from Lin (2008a:179, 181). Numbers indicate the number of tokens. For easy reference, I include Lin (2008a)'s chart of Mandarin vowels (differing slightly from Lin (2007)), and Lin (2008b)'s chart of "perceived" input vowel qualities:

	front unrounded	front rounded	central	back rounded
high	i	y		u
mid			ə	
low			a	

Table 10: Standard Mandarin phonemic vowel inventory assumed (Lin 2008a: 178)

	front unrounded	front rounded	central	back unrounded	back rounded
high	i	y			u
mid	e ei ɛ		ə	ɤ	o ou
low	a ai		a_c	ɑ	ɑu

Table 11: Standard Mandarin surface vowel representations (Lin 2008a: 178)

English	Stand Mand	Stand Mand	English	Stand Mand	Stand Mand
[i]536	[i]445 83%	[ei]50 9%	[u]492	[u]405 82%	[ou]44/ [wo]20 13%
[ɪ]1625	[i]1280 74%	[ei]144 9%	[ʊ]148	[u]109 74%	[ou]14/ [wo]7 14%
[eɪ]339	[ei]120 35%	[ai]71 21%	[oʊ]469	[ou]30/ [wo]235 57%	[u]59 13%
[ɛ]589	[ai] 159	[ei]110	[ɔ]600	[wo]210/	[ɑu]137

	/[a]30 32%	19%		[ou]5 36%	23%
[æ]847	[a]304 /[ai]47/ [ja]79 51%	[a$_c$]329 39%	[ɑ]605	[a$_c$]385 62%	[ɑ]100 17%
[ə]2106	[a$_c$]603 29%	[ə]322 15%	[ɚ]152	[wo]40 26%	[ɤ]28 18%
			[ʌ]155	[a$_c$]29 19%	[ə]29 19%
[aɪ]230	[ai]146/ [a]14 70%	[ei]23 10%	[aʊ]58	[ɑu]34/ [ɑ]8 72%	[wo]5 9%
			[ɔi]23	[wo.ji]6 26%	[wo]3 13%

Table 12: Most frequently used Standard Mandarin correspondents to English vowels (Lin 2008a: 179)

English	SM front	SM central	SM back	SM high	SM mid	SM Low	rounding mismatch
[i]536	96	2	2	84	14	2	2
[ɪ]1625	93	4	3	80	17	3	2
[eɪ]339	76	18	6	6	50	44	3
[ɛ]589	70	13	17	11	52	37	7
[u]492	1	1	98	83	16	1	3
[ʊ]48	0	3	97	74	22	4	4
[oʊ]469	1	4	95	13	74	13	17
[ɔ]600	3	19	78	6	52	42	38
[æ]847	52	41	7	0	7	93	1
[ɑ]847	11	65	24	1	7	92	4
[ə]2106	29	44	27	6	40	54	14
[ɚ]152	20	10	70	5	74	21	53
[ʌ]155	12	38	50	15	44	41	42
[aɪ]230	95	3	2	15	13	72	2
[aʊ]58	2	7	91	5	19	76	22
[ɔi]23	9	4	87	9	69	22	22

Table 13: Percentage of mappings between English and Mandarin vowel qualities. Note that [i] is adapted as [+front] 96% of the time, [+back] 2% of the time, and so on. The final column shows percentages of unfaithful mappings for the feature [round] (Lin 2008a: 181).

	front	central	back rounded	back unrounded
high	[-bk, +hi, -lo, -round]		[+bk, +hi, -lo, +round]	
mid	[-bk, -hi, -rd]	[-hi]	[+bk, -hi, +rd]	
low	[-bk, -hi, +lo, -round]			[+bk, -hi, +lo, -round]

Table 14: Proposed feature specifications for English input vowels in Mandarin borrowers' perception (Lin 2008b: 371).

Note that the mid central vowels are unspecified except for [-high] (to account for variation patterns), while high vowels are specified for [-low] to avoid a low vowel match for a high vowel input. Front and low vowels are specified for [-round] so that they do not map to [+round] outputs.

Besides greater faithfulness to the [back] dimension than other features, Lin (2008a,b) makes the following generalizations concerning vowel quality:

1. High and low vowels tend to stay high or low (at least 74% of the time)
2. Mid vowels (besides ou, and ɚ) match either mid (40-52%) or low
3. A front or low unrounded vowel is rarely matched with a rounded one, but a rounded vowel and a mid central unrounded vowel tolerate a rounding mismatch
4. [æ] sometimes maps to [je], but [ɑ] never to [wo], supposedly because of rounding. (This is contrary to Hsieh, et al.'s findings, which posits a high-ranking DEP-glide constraint. See section 2.2 above.)
5. [a_c] seems to be unspecified for [back] and can therefore be a match for either a front low or back low English vowel.
6. English central vowels [ɚ,ʌ,ə] are treated as neither front nor back and thus can be mapped to either front or back segments in Mandarin.

7a. Rounding mismatches usually only occur for back rounded mid vowels and dipthongs [ou, au, oi, and ɔ] and schwa.

7b. The most frequent rounding mismatches are ɚ (53%) ʌ (42%) and ɔ(38%)

Rounding mismatch variation from most variable to least:

[ɚ > ʌ > ɔ >au/oi>ou >ə >others (with ɛ next most frequent (7%))]

Essentially, as long as the output syllable is permissible and can be represented by a suitable character, and as long as vowel backness is parsed, deviation in rounding and minimal deviation in height are allowed, though rounding mismatches are more rare than mismatches in height. As features go, high maps to high, low to low, but mid to either high or low, but with only minimal mismatches. Low vowels and central vowels have more variable matches than high vowels or mid non-central vowels. There is also the question of why no English input maps to Mandarin [y]. As Lin points out, her analysis allows for this unattested phenomenon[32]. One might expect English [ju] to map to Mandrin [y], but by my intuition the likely outcome would be [ju] > [joʊ]. The closest example I could find in the literature was from Miao (2005) in the Italian adaptation of 'Juventus' to [**jou2**.wən2.tʰu2.sʐ̩1], a syllable that has sometimes been transcribed as [iu], as Miao herself transcribes it (my transcription follows Lin (2007), which differs from Duanmu (2007) only in that the latter uses [ə] as the medial vowel).

Rounding mismatches occur less frequently than height deviation, therefore the following ranking is evident:

Ident[back] >> Ident[round] >> Ident[high]

Among these mismatches, mid back rounded ([o, ou]) and mid central unrounded ([ə]), as well as the back low rounded diphthong [ɑu], most commonly mismatch for rounding. Mid central vowels exhibit the highest degree of variation, however [a_c] often matches to a front or back low vowel.

Finally, not all non-central vowels have the same variation patterns; some mismatch more than others, while vowels with better perceptual contrasts and saliency are more faithfully adapted, e.g:

tense vowels vary less than lax vowels

high vowels vary less than mid vowels

high/low vary less in height than mid

The following questions are raised by Lin's findings: what is the nature of the input for mid vowels in loanword adaptation, why is vowel height/rounding less salient than backness, and what phonetic or phonological factors influence the assymetry in variation (e.g. acoustic similarity, syllable restrictions, prosody and tone, etc.)? Lin points out that most languages have height contrasts but some lack backness contrasts, while there is more variation in height than backness. The tendency of Mandarin vowel adaptation tends to be the opposite of these priorities, although she cites evidence from previous studies on speech errors that are more in alignment with her own findings in Mandarin loanword

[32] Hsieh, et al. (2005) do give one form, [mɑŋ.ɕyn] from English 'monsoon', although this may not be an effect of a vowel-to-vowel mapping as much as a preference for [ɕ] which by a native constraint must appear only with front vowels/glides. Nonetheless, while such adaptations may not be unattested, they are very rare.

adaptation (e.g. Zwicky and Zwicky 1986). Furthermore, other studies find that manner features are more faithful than place features in consonantal adaptation. Finally, Lin's data are from varied sources and therefore may reflect variation in the source of the loanword. To my knowledge, no psycholinguistic experiments have tested these findings in on-line adaptations. As Lin points out, it would be interesting to see how much native speakers make a distinction between optimal and acceptable outputs.

3.2 Yip (2002, 2006)

Finally, another author's study on vowels in loanword adaptations in Cantonese might be interesting to consider as a parallel. Using data from previous studies, in addition to data she elicited herself from six native speakers, Yip (2002, 2006) looks at, among other things, the mapping of English [æ] and [ə] into Cantonese, which lacks both vowels. She conducts an experiment in which she asks native speakers to match one of the two English vowels onto the closest Cantonese rime. She finds that the choice of vowel is dependent on various perceptual and phonological factors. When there is more than one satisfactory acoustic match for an English vowel, other phonological factors turn out to be the decisive factor. Formally, this means that for each English vowel, more than one Cantonese vowel will satisfy a correspondence constraint (actually, a family of loanword-specific constraints Yip calls Mimic) between the two. Depending on the environment, a different vowel may be chosen as the match to a single English source vowel. Specifically, in open syllables the native grammar requires a long vowel, and in closed, stop-final syllables, a short vowel. Before a nasal both long and short vowels are permitted. Vowel length is not contrastive in the following environments, so there are no short counterparts to the long vowels mentioned, or vice versa. Based on acoustic similarity (i.e. F1 and F2 values), the following preferences are posited:

1. open syllables
   [æ]: 1st choice: [ɛ:]
   acceptable alternatives: [a:], [œ:]
   attestation: [ɛ:], but more commonly [a:]
   [ə]: 1st choice: [œ:]
   acceptable alternatives: [a:]
   attestation: [a:]
2. closed, stop-final syllables
   [æ]: 1st choice: [ɪ], [ɐ]

acceptable alternatives: none
attestation: [ɪ] all times except once

[ə]: 1st choice: [ø], [ɐ]
acceptable alternatives: none
attestation: [ø]

3. before a nasal

[æ]: 1st choice: [ɛ:]
acceptable alternatives: [a:], [ɪ]
attestation: [ɛ:], [a:]

[ə]: 1st choice: [a:], [ɐ]
acceptable alternatives: [ø] between coronals[33]
attestation: [ɐ], [ø] between coronals

If the loanword adapter is using perceptual cues to drive adaptation, then this should imply the physical presence of both the borrowing and source language speakers. Yip (2002) argues that the exclusion of [œ] and [ø] in most cases, and the preference of [a:] over [ɛ:] in open syllables, might then be explained by visual cues: the strong visual cue of rounding for [œ:], and jaw lowering plus spread lips for [ɛ:], cause speakers to go with the more distant acoustic match for the English vowels, rather than such a mismatch on visual cues (cf. studies on the McGurk effect). However, Yip (2006) cites data from Kera and Mauritian Creole that cast doubt on this analysis. Furthermore, statistical effects may play a role in that [ɛ:] is rare in open syllables, except after coronal sibilants.

Yip also finds that when two options match in vocalic quality and length, it is quality that matters more, since [æ] matches to either [ɛ:] and [a:], but not [ɪ]. When the acoustic quality is essentially the same, as it is for [ɐ] and [a:], there appears to be a preference to match length, as when [ə] maps to [ɐ] over [a:].

In Cantonese closed syllables, only short vowels can carry the high tone needed for mapping English primary stress, which is an obligatory effect. This means that for an English stressed syllable containing a long vowel or diphthong, Cantonese will choose a short vocalic nucleus to avoid violation of native phonotactic constraints. In this environment, [æ] is a close match to both Cantonese [ɪ] and [ɐ], but in all but one case the former is chosen, showing a preference to match backness over height when both

[33] A native process of non-low back vowel fronting causes this preference, as is evidenced in schwa mapping.

vowels are an otherwise close acoustic fit. Even though [ɛ:] would be a closer fit acoustically, it is dispreferred on the grounds just mentioned, which Yip formalizes with the constraint[34]:

*V:O[5]: No long vowels before obstruents with a high tone (i.e. tone 5).

Finally, due to the general lack of epenthesis or deletion, vowel quality does not seem as important to maintain as does the presence or absence of a segment, implying highly ranked Max and Dep constraints[35]. The following tableaux from Yip (2002) illustrate her analysis of the data:

(12) Length is less important than quality

/æ/	Mimic-Quality	Mimic-Length
☞ ɛ:		*
☞ a:		*
ɪ	*!	

(13) When quality differences are negligible, length determines outcome

/ə/	Mimic-Quality	Mimic-Length
☞ ɐ		
a:		*!

(14) Vowel quality is less important than prosody

/$k^he{:}k^5$/ > 'cake'	Mimic-Tone	*V:O5	Mimic-Quality	Mimic-Length
☞ $k^hɪk^5$			*	*
$k^hɛ{:}k^5$		*!		
$k^hɛ{:}k^4$	*!			

(15) The role of Max and Dep (N.B. $k^ha{:}t$ is the perception of RP English 'card')

/$k^ha{:}t$/ > 'card'	Mimic-Tone	Max	Dep	*V:05	Mimic-Quality	Mimic-Length
☞ $k^hɐt^5$					*	*
$k^ha{:}t^5$				*!		
$k^ha{:}^{55}$ ti:			*!			
$k^ha{:}^{55}$		*!				
$k^ha{:}t^4$	*!					

[34] Note that Cantonese does have variants that allow the syllable structure to be compromised. Yip claims this constitutes a separate stratum of the native lexicon, which we will not explore here.
[35] Yip (2005) points out that Max and Dep can be violated to save highly salient consonants, such as fricatives.

4. Tone

4.1 Wu (2005)

In adapting English stress to Chinese dialects, there is a general association of F_0 peaks in English with High tone in the adapting language. Using a corpus of data from a dictionary of loanwords, Wu (2005) observes the following generalizations in tonal adaptations in Standard Mandarin (p. 230):

1. Stressed monosyllabic words in the English source are adapted with Falling tone.
2. The initially stressed syllable of English disyllabic words tends to be adapted with High level or Rising tone.
3. When the stress of the English source word does not occur initially, tone assignment on the stressed position will resort to acoustic similarity while Rising and High level tone are preferred for the initial syllable.
4. Salient consonants (those with robust internal cues, e.g. sibilant fricatives) are assigned syllable nodes and undergo epenthesis. They are assigned L tone, with the exception of [s] cases.

Furthermore, out of 100 example syllables, there was an asymmetry regarding tonal preferences: Tone 2 (rising) (43.1%), Tone 1 (high level) (28.4%), Tone 3 (falling-rising) (17.6%), and Tone 4 (falling) (10.8%) (Wu 2006: 233). Wu uses the constraint Ident-Lex to specify the need to map to a pre-existing syllable in the Chinese lexicon, and the following three constraints to formalize English-to-Mandarin tonal mapping:

Parse(tone): Every (output) tone is associated to a TBU
Spec(tone): Every TBU is associated to a tone
Linearity: Input precedence relations in a tone melody are preserved in the output.

Citing previous studies on tone loans, Wu points out that faithfulness to vocalic features tends to take precedence over faithfulness to tonal features, with Chinese stipulating that any output must obey the Ident-Lex constraint:

(16) Ident-Lex >> Ident-V >> Ident-T

/valve/	Ident-Lex	Ident-V	Ident-T
☞ a. fa2			*
b. fu4		*!	
c. fa4	*!		

The remainder of Wu's paper explores the role that non-contrastive, phonetic attributes of the source language play in assigning tone to Mandarin syllables. Using the notion of a "tonal depressor" common in the tonogenesis literature, she notes that cross-linguistically voiced consonantal onsets have the effect of lowering F_0, while voiceless consonants raise the value slightly, with aspirated obstruents causing a slightly lower F_0 transition than unaspirated[36]. This results in a higher degree of adaptation of tone 2 (which has the tonal features LH in Wu's analysis since it rises from a lower to a high pitch value—this differs minimally from Lin (2007)'s MH feature specification, but more significantly from Duanmu (2007)'s H specification, the latter based solely on register) on syllables with an initial aspirated consonant as well as on sonorants.

These patterns match the native language preference for the second tone (LH) to appear mostly on syllables beginning with sonorants, and the first tone (H) on unaspirated obstruent-initial syllables (Wu 2006: 239-240). Wu goes on to discuss certain syllable-to-tone lexical gaps, such as the fact that many syllables with sonorant onsets are incompatible with high tones, and many CVN syllables with initial aspirated consonants fail to carry tone 2. Furthermore, in Mandarin there is a weak tendency for tone 2 to be carried on diphthongs or VN codas, whereas tone 1 most often anchors to single-vowel nuclei. The greater tendency is for contour tones to be carried out over longer nuclei[37]. As she points out, despite the usual treatment in Autosegmental Phonology, "tones cannot be considered in isolation from the segments on which they are realized (Wu 2006: 234-235)."

[36] However, [f] is somewhat intermediary, having a slightly lower F0 than other voiceless sounds, but still higher than voiced sounds. The observation on aspiration seems to be less reliable cross-linguistically, but Wu (2005) cites previous studies that show it to be true at least for Mandarin.

[37] This does, however, raise the question of how the fact that there is obligatory vowel lengthening in CV syllables, as discussed in Duanmu (2007), plays a role (or doesn't) in this patterning.

Wu (2005) points out a fact that is interesting in regard to Paradis & Tremblay (2009). The latter claims that there is a seemingly random matching between aspiration in English to aspiration in Mandarin, this despite the fact that English voiced stops are more closely related to unaspirated Mandarin stops, and should therefore map consistently between languages. In a corpus study they found that 81.6% of voiceless English stops in an unaspirated position were adapted into Mandarin as aspirated stops, with similar occurrences for word-final unreleased stops. However, Wu (2005) claims that the tonal depressor-environments of English (the drop in F_0 after a voiced initial) are adapted as the rising tone 2 in Mandarin, which then drives the onset of the syllable in question to be adapted as aspirated (Wu 2006: 239). Not only does this complicate Paradis & Tremblay's statement, but it also calls into question the ranking of Ident-C >> Ident-V >> Ident-T that is posited in other studies (e.g. Miao 2005).

Since these systematic gaps in the lexicon may reinforce an adaptation bias, Wu makes the following predictions concerning tonal adaptation (p. 242):

	Initial Consonant		
	[-spread glottis, -sonorant]	[+spread glottis, -sonorant]	[+sonorant]
CV	H (tone 1)	?	LH (tone 2)
CVN	H	?	LH
CVV	H	?	LH

Since there are no lexical gaps corresponding to tones on syllables beginning with an aspirated obstruent, as there are for sonorant-initial and unaspirated obsturent-initial consonants, adaptations pertaining to the second column will stand less of a chance for a steadfast adaptation rule and exhibit more variable adaptation. In a psycholinguistic study, Wu's predictions were more or less borne out. The patterns observed in the native phonology, as well as in corpus data, matched these predictions. However, there was only a weak link between nucleus length and tone specification (see footnote 10).

A few other observations were noted as well. Epenthetic vowels usually map to a low tone, except when following [s], presumably because of its high frequency (generalization four above). Monosyllabic words are often adapted with a falling tone because of the English HL citation melody (generalization two above). Wu notes that all of these patterns differ from previous studies on Cantonese which show a fairly default tone assignment (Kenstowicz and Suchato 2006; Kiu 1977). She attributes this to orthographic influences on Mandarin, which are not present in Cantonese (or Taiwanese), and therefore block the introduction of new syllable types.

4.2 Hsieh (2005)

Wu (2005)'s results are interesting to compare with the results of Hsieh (2005). Hsieh looked at the mapping of Japanese pitch accent onto Taiwanese tone and found that there is a similar process between Taiwanese speakers' acquisition of Japanese as a second language and how they adapt loanwords from Japanese[38]. Rather than any observable faithfulness to Japanese pitch contours, Taiwanese appears to utilize a default process that is based on position within the word and rime structure. This manifests itself as a foreign accent, prosodically speaking, in learning Japanese as a second language

Taiwanese has four tones, H, M, L, LM, and HL, as well as two "checked tones" $H^{ʔ}$ and $M^{ʔ}$, the latter of which occur on syllables closed by an obstruent or glottal stop. There is a constraint against contour tones on a checked syllable. Japanese CV and CVO syllables are assigned a level tone (with variable dropping of the coda consonant), while CVV and CVN syllables are adapted with falling tone, but only if there is one such syllable within a word. Furthermore, word-final open syllables undergo glottal stop insertion, due to the perception of duration. (In Japanese, word final long vowels shorten phonetically, whereas Taiwanese uses checked syllables to map final monomoraic Japanese syllables, since checked syllables are monomoraic in the native phonology.) In a violation of structure preservation, Japanese words with more than one bimoraic syllable are adapted with a non-lexical MH tone on the initial syllable, a process which also occurs when an initial CVV or CVN syllable is followed by more than one CV or CVO syllable. The result is what Hsieh refers to as a "tonal plateau", with contour tones only at the edges and level tones in the middle (p. 8):

[38] Taiwanese being the Southern Min dialect spoken natively in Taiwan, not to be confused with the dialect of Mandarin spoken after 1949. The two dialects are mutually incomprehensible.

	Initial	Medial	Final
CV/CVO	M/ M^{ʔ} if >2σ H/H^{ʔ} elsewhere	H/H^{ʔ}	M^{ʔ}/L
CVV/CVN	MH if >3σ, or followed by CVV/CVN HL elsewhere	H if >3σ	HL (except for CVV)

Hsieh posits a ranking of relevant autosegmental constraints to account for these adaptations, but what is interesting to point out is that Taiwanese, a tonal language, appears to be "tone deaf" in dealing with Japanese pitch accent (cf. Hsieh and Kenstowicz 2006). As Hsieh points out, Taiwanese is known in the literature as having one of the most complicated morphosyntactic tone sandhi systems in the world. The failure to map the simple H vs. L distinction in Japanese pitch accent is a remarkable example of how "non-native percepts may not be reliably replicated with native categories (Hsieh 2006: 22)." Given the complexity of the Taiwanese tonal system, the failure to match Japanese pitch-accent to Taiwanese tone could not possibly be due to perception; there is simply no attempt to do such.

Hsieh attributes this to the fact that native Taiwanese monomorphemic, polysyllabic words are almost nonexistent, while the Japanese loans, with their lexically-specified pitch contours[39], can only be parsed as monomorphemic, despite their polysyllabic structure. As such, the speakers cannot gain access to the lexical representation of the source, and tone is assigned by basis of syllable weight and overall prosodic structure of the Japanese word, with native sandhi constraints determining the tonal patterns. That is, rather than faithfully parsing from morpheme-to-syllable as in the native grammar, a novel method of tone assignment is utilized, based on phonetic and prosodic cues, whereby tones are assigned to distinguish Japanese syllable types.

5 Lexical effects

Finally, Luke & Lau (2008) is an interesting study on Cantonese loanword phonology. It shows that word class has a systematic effect on the often-cited minimal word requirement of the native phonology, which has been shown to play a large role in loanword adaptation (Silverman 1992; Yip 1993;

[39]For an argument in favor of predictable accentual patterns in Japanese based on the native constraint ranking see Kubozono (2006).

2002a: among others). What they found is that many of the monosyllabic forms that resulted from loanword truncation are specific to verbal and adjectival forms. In older times, most of the loanwords into Cantonese were nouns, whereas in more recent times the number of adjectives and verbs has risen sevenfold. With only four exceptions, Luke & Lau's study found that all truncated verbs and adjectives were monosyllabic, while truncated nouns were bisyllabic (Luke and Lau 2008: 352). Furthermore, when a particular word could function as either a noun or a verb, it was always the latter that would be truncated to a monosyllable. Adjectives were found to pattern closely with verbs in this respect. To my knowledge, no similar studies have examined Mandarin for such patterns, but the authors do discuss in some detail disyllabicity in Mandarin, noting statistics offered by Duanmu (2000) that show 73% of basic verbs (i.e. core vocabulary items that have been in the language for quite some time) to be monosyllabic, versus only 2% of verbs that are of modern origins. They note that the passing of the "monosyllabic tendency" in Mandarin has not applied to Cantonese, which "seems to be alive and kicking" in the contemporary language.

CHAPTER 4: EXPERIMENTAL STUDY OF MANDARIN ADAPTATION OF ENGLISH MID VOWELS

1. Introduction

This chapter presents the results from an experiment conducted to compare the findings of previous researchers on Mandarin loanword adaptation to the data elicited from on-line adaptations of foreign words by native Mandarin speakers. Many phenomena have been attested, from patterned vowel variation (Lin 2009a, 2009b), to precedence of the feature [back] in retaining features of the source word (Hsieh et al. 2007; Lin 2009a, 2009b), to predictable adaptations of tones word-initially (Wu 2005), disyllabic minimal word preferences (Silverman 1992 for Cantonese; Broselow et al. 1998), and place-assimilated epenthetic vowels (Miao 2005). Some of these studies conducted their own psycholinguistic experiments, and this experiment aims to further corroborate or present conflicting evidence to previous findings, while controlling for age, gender, and dialectal factors.

An interesting question may be relevant to this task, namely that since Mandarin lacks all of the codas being tested, will they affect the vowel at all, since they will either resyllabify through epenthesis or simply delete? If there is an effect, it implies that the vowel is adapted within the environment of a closed syllable, but if not it may imply that the coda is repaired before the vowel is mapped to a native category. That is, in the former scenario we see a purely perceptual effect of anticipatory assimilation, whereas in the latter we could argue that the phonology directly impinges on the vowel in a single parse. Much of the loanword literature focuses on the role of perception and levels of processing (i.e. a separate perception grammar from production), as well as issues of multi-stratal effects in optimality theoretic grammars.

Section 2 will present the design, while Section 3 analyzes the results of the experiment for factors such as laryngeal setting, word size, epenthesis patterns and vowel variation. Section 4 discusses the implications of the data and concludes the thesis. Data from each individual participant can be found in appendices B and C.

2. Experimental design

2.1 Stimuli

Vowels to be tested for variation
    2 monophthongs and 1 diphthong: [ɛ, ʌ, oʊ]

Rhyme environments to be tested:
    sonorant codas:
        2 places of articulation: [-m, -l]
    obstruent codas:
        2 places of articulation: [-p, -t]
    open syllable: Ø

Prosodic environment for all tokens:
    disyllabic words with primary stress on initial syllable, secondary stress on second syllable

Total tokens:
    45 + 5 filler (this includes 3 repetitions of each type: 5 codas X 3 vowels X 3 reps)

Table 15: Stimuli used in experiment.

To keep the total tokens below 60, I narrowed down the vowels and environments to the above categories. The vowels were chosen by giving preference to those that showed the most variation in Lin's studies of corpora, viz. the mid and central vowels. The mid-vowels, [ɛ], [ʌ] and the diphthong [oʊ] can be seen to exhibit significant variation in the charts from Lin (1998a), found in full in Chapter 3 Section 3.1.

I made the decision to use nonce words instead of real place names for two reasons. First, if the word is fabricated it may reduce the tendency for semantic adaptation described by Miao (2005) and others. With no internal morphological constituency to consider, speakers may be inclined to give a more "pure" phonological adaptation. Secondly, if participants happen to be familiar with a given place name, then they would rely on its standard translation, rather than adapting it based on their own perception. Of course, participants may still rely on analogy to standardized translations (as indeed one speaker informed me afterward), but the choice of nonce words not only allows me to control the phonological environment, but may reduce paralinguistic interference in the task.

Furthermore, in narrowing down vowels, it is more convenient to discount the vowels [ə, ɔ] as the former could not appear in the same environment as [ʌ], and the latter shows a great deal of dialectal variation in the source language, English. Likewise, [ʌ] has the added advantage of being able to appear in stressed position, as do all of the other vowels. Finally, the back diphthongs show more variation that the front, since [ɔɪ] has no practical counterpart in Mandarin, omitting it maintains some consistency in the possibilities and preferred strategies for adaptation.

As Hsieh, et al. (2007) have already performed an in-depth analysis of nasal codas in Mandarin adaptation, it seemed logical to omit possible Mandarin nasal codas from the English stimuli, leaving only the coda [m]. Also, as rhotacized rimes exhibit a great degree of dialectal variation in Mandarin (with speakers from Beijing more likely to utilize them than speakers of other dialects), it further made sense to eliminate [ɹ] as a stimulus coda.

The second syllable of each token was a common English "place" morpheme, either –ville, -berg, or -ton. There was no anticipated effect that these secondary syllables would have on the tokens, and as such they were randomly attached to the targeted syllables. As mentioned earlier, the resultant tokens were nonce words, designed to minimize reliance on pre-existing knowledge of place-name adaptations.

Finally, the onset consonants were voiceless aspirated stops, [p^h, t^h, k^h]. They were attached to rhymes arbitrarily, resulting in [p^hʌ-], [t^hoʊ-], and [k^hɛ-]. It should be noted that, due to syllabic constraints, the first and third syllable have no obvious counterparts in the Mandarin grammar, unlike the second, and therefore one may expect more variable mapping for the former than the latter. These environments guarantee that there will be a conflict between preserving consonants versus vowels for [k^hɛ], and that a Mandarin syllable will have to be chosen that does not exactly match the English word for [p^hʌ].

In the literature, no environmental effect on the vowel has been shown to originate outside the rhyme, except when there is an onglide. Wu (2005) does show an effect that initial consonants have on tone as a function of laryngeal settings, but this appears not to bias the vowel. The results of my experiment will be compared with those of Wu's to see how these tendencies hold up. She found that initially-stressed syllables of English disyllabic words (i.e. the same environment I am testing) adapt with either a high level tone (Tone 1) or a rising tone (Tone 2). Aspirated obstruents show a slight preference to adapt to Tone 2, as the F_0 is depressed in transition from an aspirated onset. Furthermore, in the native grammar there are no obvious lexical gaps for syllables beginning with aspirated obstruents for either Tone 1 or Tone 2, so a certain degree of variation is expected. (In Wu's experiment, participants adapted such syllables with the first tone 165/360 times (46%) and with the second tone 195/360 times (54.2%).) However, overall, it does not seem this will affect the choice of vowel, as most researchers agree that Mandarin has the ranking Ident-C >> Ident-V >> Ident-T.

Below is a token list without second syllables (the fourth column served as filler for experimental purposes):

[kʰɛm]	[tʰoʊm]	[pʰʌm]	[tʰi]
[kʰɛl]	[tʰoʊl]	[pʰʌl]	[kʰut]
[kʰɛp]	[tʰoʊp]	[pʰʌp]	[pʰam]
[kʰɛt]	[tʰoʊt]	[pʰʌt]	[tʰal]
[kʰɛ]	[tʰoʊ]	[pʰʌ]	[kʰi]

The following tables give some indication as to phonetic similarity between the values for F1 and F2 of the speaker on the recording and those given in Zee & Lee (2001) for female Beijing Mandarin speakers. Unfortunately, no values are given in Zee & Lee for the Mandarin high-mid vowels [ei] and [ou], which, as we will see later, turn out to be the most interesting absences in vocalic adaptation.

vowel	F1 mean	F2 mean
[i]	401.24	3036.76
[y]	423.84	2327.36
[ɤ]	426.52	1314.42
[u]	345.02	758.68
[a]	1104.04	1593.64
[ə]	852.24	1432.84
[ɚ]	443.18	1736.34
[ɹ̩]	376.28	1680.32
[ɻ̩]	392.80	1929.02

Table 16: Average F1 amd F2 for female speakers of Beijing Mandarin (Zee & Lee 2001).

	f1 mean	f2 mean
[ɛ]	594.80	1731.87
[ʌ]	589.73	1158
[oʊ]	487.73	1157.13

Table 17: Average formant values for English stimuli.

2.2 Participants

Native speakers of standard Mandarin were recruited for participation in the experiment. Efforts were made to reduce the effects of dialectal variation, even within Mandarin (as opposed to mutually unintelligible dialects such as Wu or Southern Min), by only recruiting speakers who have lived all their lives in Northern China. Out of eight participants, four are from Beijing, while the other four include speakers from the nearby cities of Tianjin and Shijiazhuang, as well as the relatively more distant Shandong and Jilin provinces.

All speakers were females, ranging in age from 23 (three participants) to 30 years of age (two participants). The average age of all eight was approximately 26. All had received Bachelor's degrees in their native country and had traveled to the United States to pursue higher educational degrees, arriving between the ages of 22 (five participants) and 26 (one participant), on average 23 at age of arrival. All except one are currently enrolled in MA or Phd programs at the University of Georgia. Participants had minimal exposure to English outside the classroom before coming to the US, and at least half report using English primarily in a classroom setting here in the United States. A more detailed demographic description can be found with each speaker's response sheet in the appendices.

2.3 Procedure

For presentation of stimuli, a native speaker of English was recorded reading in citation form all of the stimuli to be used in the experiment. The speaker, being a professor of phonetics and phonology, was able to control for dialectal accent and produced a sufficiently “standard” rendering of the nonce words. The tokens were recorded using the computer program Audacity in a sound-attenuated recording booth, and then spliced into individual files using the Praat program. All later acoustic analysis was also performed in Praat.

The tokens were presented in a Powerpoint slideshow, mainly for ease of presentation. In order to accomodate participants' schedules, the experiment was presented on my laptop in various places on campus, and in the case of four participants, at their place of residence (three of the participants shared an apartment). All participants except two listened to the presentation across Sony MDR-V150 Dynamic Stereo headphones, the exceptions finding the disturbance of their hair by the headphones to be a significant distraction from the task. All sessions were administered free of external distractions, with only the participant, myself, and in one case a single other person, present.

The program consisted of an instruction screen, prompting the participants to imagine that they are writing a letter home to a relative who can only read Chinese characters, and that the participant would like to report on recent travel in the US (i.e. to the faux place names presented as stimuli). The participants were told that only the sounds of the responses were to be considered by the researcher, to reduce previously attested procedural stress; though it was emphasized that they should give the translation that seemed most naturally Chinese. Beforehand, I also conveyed the instructions to the participants casually and explained that I was testing how Mandarin speakers translate words from English that they have never previously encountered.

The 50 stimuli were presented in random order, following four practice stimuli at the beginning, and an optional break was built into the presentation, which no participants utilized. A response sheet with the carrier sentence (which translates to "last Saturday I traveled to ____________")

上个星期六我去_____________________________________旅游了.

was provided for writing answers, with the first practice question, the stimulus being a well-known English place name (Boston), already filled in for further clarification of procedures. After the presentation, during which I was on hand but inconspicuous, the participants filled out a sheet of demographic information and then generally chatted with me about their relationship with English and the US and the nature of my research.

All responses were later transcribed in the form found in the appendices using the Pocket Oxford Chinese-English dictionary (Manser et al. 2003), with all characters checked for correct phonetic form. The results were then arranged by hand into the statistical form found in Section 3 and the appendices.

3. Data analysis

The following section gives a detailed description of the results of the experiment. It should be noted that Participant 7 failed to provide answers for two of the stimuli, leaving absent the initial sylllable. She later claimed she couldn't think of an appropriate adaptation. In both cases the syllable was [pʰʌl], containing a dark /l/ coda, which is problematic for Chinese speakers when producing English as a second language. All of the figures cited have taken these two absent forms into account.

3.1 Laryngeal adaptations

3.1.1 Aspiration

The following figures give the value of mismatches of aspiration between English source words and their Mandarin adaptations:

[+spr glottis] matched to [-spr glottis] (word-initial environment)

Speaker 1:	4% (2/50)	Speaker 5:	14% (7/50)
Speaker 2:	12% (6/50)	Speaker 6:	28% (14/50)
Speaker 3:	4% (2/50)	Speaker 7:	28% (14/48)
Speaker 4:	4% (2/50)	Speaker 8:	16% (8/50)

[-spr glottis] matched to [+spr glottis] (epenthetic-syllable environment)

Speaker 1:	42% (8/17)	Speaker 5:	57.1% (8/14)
Speaker 2:	66.7% (2/3)	Speaker 6:	50% (2/4)
Speaker 3:	100% (12/12)	Speaker 7:	28.6% (2/7)
Speaker 4:	94.1% (16/17)	Speaker 8:	62.5% (10/16)

Table 18: Percentage of mismatches in aspiration on obstruents (number of instances in parentheses).

Note that for the epenthetic environment, only those syllables with initial consonants specified for [spr glottis] were considered. Other syllables such as [mu] or [əɹ] were not counted. Across all tokens, including the fillers (which were considered in assessing laryngeal adaptations), the word-initial consonant was aspirated, while the coda consonant of each syllable would have been unreleased. The latter would have formed the onset of the epenthesized syllable if the segment was retained rather than deleted.

The disregard for source language aspiration, a non-contrastive feature of English, generally matches Paradis & Tremblay (2009). In their study of 198 instances of aspirated stops in English, they found 11 to be adapted as non-aspirated, 11.6% of the data, while out of 198 occurrences of non-aspirated stops in English loans, 84 were adapted as aspirated in Mandarin, 81.6% of the entire corpus (Paradis & Tremblay 2009: 8). The authors took this to reflect a phonological, rather than a phonetic mapping, where English [-voice] maps to Mandarin [+spr glottis], and vice versa. Therefore, the allophonic information of [+spr glottis] in English, which only appears on [-voice] stops, is unimportant to Mandarin speakers in loanword adaptation. Their figure is a relatively higher degree of mismatch than what my results show, but the numbers are still fairly close.

One thing the authors do not appear to consider, however, is syllable position. In their article, only fourteen examples are given to illustrate [-spr glottis] mapping to [+spr glottis]. All are either syllable-final or syllable-initial in an unstressed position. It could be that those syllabic and prosodic environments both play some role as well. Neither my, nor their, sudy looks specifically at how unaspirated stops in cluster position compare with those that appear as finals or initials of unstressed syllables. Perhaps there is simply more attention given to prominent positions in the source, such as word-initial position, than there is to less salient environments, such as codas. This would then add at least some effect of perceptual cues to the adaptation process.

However, perhaps the most important observation to be made here is that individual speakers varied significantly in their adaptations. While some showed generally low rates of mismatches (Speaker 7), others were quite high (see Speakers 3 and 4 for epenthetic syllables). This is even more important for word-initial adaptations, as a phonological account along the lines of Paradis & Tremblay fails to account for why 28% of both Speaker 6 and Speaker 7 break from the [-voice] to [+spr glottis] mapping pattern. The patterns in corpus studies may therefore reflect the idiosyncracies of the original speaker's adaptations, rather than a fixed property of Mandarin speakers' (loanword) phonology.

3.1.2 Tone

Tone 1					
Speaker 1	9/50	(18%)	Speaker 5	24/50	(48%)
Speaker 2	17/50	(34%)	Speaker 6	38/50	(76%)
Speaker 3	33/50	(66%)	Speaker 7	17/48	(35.4%)
Speaker 4	18/50	(36%)	Speaker 8	22/50	(44%)
Tone 1 total	178/398	(44.7%)			
Tone 2					
Speaker 1	9/50	(18%)	Speaker 5	1/50	(2%)
Speaker 2	7/50	(14%)	Speaker 6	4/50	(8%)
Speaker 3		0%	Speaker 7	15/48	(31.2%)
Speaker 4		0%	Speaker 8	22//50	(44%)
Tone 2 total	41/398	(10.3%)			
Tone 3					
Speaker 1	19/50	(38%)	Speaker 5	11/50	(22%)
Speaker 2	15/50	(30%)	Speaker 6		0%
Speaker 3	6/50	(12%)	Speaker 7	16/48	(33.4%)
Speaker 4	14/50	(28%)	Speaker 8	12/50	(24%)
Tone 3	93/398	(23.4%)			
Tone 4					
Speaker 1	13/50	(26%)	Speaker 5	14/50	(28%)
Speaker 2	11/50	(22%)	Speaker 6	8/50	(16%)
Speaker 3	11/50	(22%)	Speaker 7		0%
Speaker 4	18/50	(36%)	Speaker 8	11/50	(22%)
Tone 4 total	86/398	(21.6%)			

Table 19: Adaptation of tone for word-initial voiceless aspirated stops.

Table 20 gives the percentages among speakers for tonal adaptation in choice of the best syllabic fit for the initial (stressed) syllable of the stimuli. As we can see, the first tone is the preferred match, with the third and fourth tones being more or less equally preferred second choices. This differs from Wu's (2005) findings, which pointed towards the following hierarchy: Tone 2 (43.1%), Tone 1 (28.4%), Tone 3 (17.6%), and Tone 4 (10.8%). As Wu pointed out, high or rising tones, both carrying the feature High, are used for adapting the primary stress, especially when the onset consonant is voiceless and aspirated. However, in my data only the first tone is a good match for the F_0 peak of the source word. Tone 2 is by far the least preferred option, being closer to the percentage of fourth tones that turned up in Wu's corpus data. Tone 3 and Tone 4 are both considerably more preferable in my data. One explanation for this could be a statistical bias inherent in the task. Since speakers tended to choose a particular syllable and reuse it for most instances of the same type, if that initial choice were, for example, Tone 3, then most of the latter tokens would also be adapted as such.

Another possibility may be related to the overall frequency of tone-to-syllabic mappings in Mandarin. Recall from Table 4 in Chapter 2 Section 2.2 that Tone 2 appears on only 225 different syllables, as opposed to Tone 1 (337), Tone 3 (316) and Tone 4 (347). In the process of lexical retrieval, participants may have been influenced by this frequency discrepancy, whether or not its origins lie in acoustic influences from syllable-initial consonants.

Tone1					
	Speaker 1	0%	Speaker 5		0%
	Speaker 2	0%	Speaker 6		0%
	Speaker 3	0%	Speaker 7	2/21	(9.5%)
	Speaker 4	0%	Speaker 8	1/20	(5%)
	Tone 1 total	3/159 (1.8%)			
Tone 2					
	Speaker 1	0%	Speaker 5	5/24	(20.8%)
	Speaker 2	1/13 (7.7%)	Speaker 6	3/5	(60%)
	Speaker 3	0%	Speaker 7	3/21	(14.3%)
	Speaker 4	0%	Speaker 8	3/20	(15%)
	Tone 2 total	15/159 (9.4%)			
Tone 3					
	Speaker 1	15/23 (65.2%)	Speaker 5	13/24	(54.2%)
	Speaker 2	9/13 (69.2%)	Speaker 6		0%
	Speaker 3	20/27 (74%)	Speaker 7	12/21	(57.1%)
	Speaker 4	19/26 (73%)	Speaker 8	6/20	(30%)
	Tone 3 total	93/159 (58.4%)			
Tone 4					
	Speaker 1	3/23 (13%)	Speaker 5	6/24	(25%)
	Speaker 2	2/13 (15.4%)	Speaker 6	2/5	(40%)
	Speaker 3	7/27 (25.9%)	Speaker 7	1/21	(4.8%)
	Speaker 4	7/26 (26.9%)	Speaker 8	8/20	(40%)
	Tone 4 total	36/159 (22.6%)			
Tone 0					
	Speaker 1	5/23 (21.7%)	Speaker 5		0%
	Speaker 2	1/13 (7.6%)	Speaker 6		0%
	Speaker 3	0%	Speaker 7	3/21	(14.3%)
	Speaker 4	0%	Speaker 8	2/20	(10%)
	Tone 0 total	11/159 (6.9%)			

Table 20: Adaptation of tone for syllables resulting from epenthesized coda consonants.

Table 20 shows the choice of tone for the epenthetic syllable. Here the statistics become more regular, especially for participants from Beijing[40]. Besides Speaker 6, there is a strong tendency for third or fourth tone adaptation on epenthetics. The general assumption in the literature is that epenthetic elements not present in the source language tend to be less salient, so as to maintain a greater degree of source similarity. On this assumption we might expect the neutral tone (Tone 0) or some tone of less prominence to be chosen. The data presented here do not abide by this principle. The neutral tone is only adapted roughly seven percent of the time, all on the syllable 得 [tɤ] when retaining the coda [t] through epenthesis. On the other hand, Tone 3, the most perceptually salient tone in isolation (Duanmu (2007:237) cites previous researchers who assign it three moras), is the overwhelming preference in almost 60% of cases. However, the epenthetic syllable is obviously not in isolation, so that in normal speech it would be realized as 21, a near level low tone. One could argue that this is less salient than Tone 4's 51 pitch drop, but the latter is preferred here to Tone 2's more subtle 35 rise. Further research on the relative salience of Mandarin tones (for example whether a drop is less perceptible than a rise, or whether high tones are more salient than low tones and what effects environment may have on this), is needed for explanation.

Finally, it is an interesting coincidence that tones 2 and 4 retain more or less the same percentages as the initial tone. If some other factor is blocking adaptation of Tone 1 in favor of Tone 3 on epenthetic syllables, one could possibly conclude that not only the place feature on epenthetic vowels is copied from the previous vowel, but also the tonal feature as well. However, a cursory glance at the data shows that this is not the case. The occurrence of, for example, a second tone-initial syllable in no way guarantees a second-tone epenthetic syllable when the latter is used. Again, this may be influenced by relative frequency in the language, but further research on tone distribution is needed.

[40] I know of no way in which Beijing Mandarin differs from other Mandarin dialects in terms of tone, however.

3.2 Prosodic adaptations

3.2.1 Word length and metrical factors

2 syllables	85/398	(21.4%)
3 syllables	204/398	(51.3%)
4 syllables	105/398	(26.4%)
5 syllables	4/398	(1%)
average word length of data: 3.07 syllables		

Table 21: Percentages of adaptations by word size across all speakers.

Table 21 gives the results of average word length by number of syllables. Recall from section 3.5 that full syllables (i.e. syllables carrying a lexical tone) prefer disyllabic feet. Though Duanmu (2007) analyzes Mandarin as quantity sensitive to account for vocal lengthening in open syllables, in polysyllabic words, feet form at the syllabic level. Surprisingly, the overwhelming choice for adaptation here is three syllables, rather than a more metrically elegant two or four. The nature of the stimuli prevented any tests for a minimal word requirement, as all tokens were disyllabic to begin with. Also recall that in an extensive corpus study cited in Duanmu (2007) (see Chapter 2 section 2.4), it was found that trisyllabic words make up only three percent of the data, while quadrisyllabic words account for less than one percent. In the data here, the favored choice is three syllables, with the runner up coming in at four syllables, the exact opposite of the native vocabulary.

One factor that may be influencing the number of syllables is the specific place morpheme. The morpheme '-ton' had a relatively easy match in Mandarin, with its simple margins and coronal nasal coda. In many established loanwords, the character 顿 [twən4] is already used, as in 波士顿 'Boston' [pwo.ʂʐ̩.twən] and 华盛顿'Washington' [xwa.ʂəŋ.twən]. Most participants chose this character for such words. Conversely, the morpheme '-berg' contains two coda consonants that could be repaired by epenthesis[41], while '-ville' has an illicit coda and a standard adaptation 威尔 [wei2.əɹ2], used by many

[41] Presumably, the Mandarin syllable with a rhotic rhyme is considered too perceptually different, or too associated with stylistic register, to serve as candidate adaptations.

speakers. It may also be noted that only one speaker consistently used the adaptation 堡 [pao3] for '-berg', even though it occurs in the well-known place name 'Pittsburg' 匹丝堡 [pʰi3.sʐ1.pao3].

Even beyond these complicating factors for assessing metrical constraints, individual speakers exhibited an apparent free variation for the disyllabic morphemes. For example, Speaker 1 usually adapted [-berg] as [pwo2.kɤ2.əɹ3], however sometimes this would be shortened to [pwo2.kɤ2], particularly when the first syllable resulted in epenthesis. However, pentasyllabic words were also attested, such as [pʰa4.phu3.pwo2.kɤ2.əɹ3] > 'pupberg' and [pʰa4.tɤ0.pwo2.kɤ2.əɹ3] > 'putberg'. Speaker 7 is another example of seemingly random adaptations of '-berg' as [pwo2], [pwo2.kɤ2], and [pwo2.əɹ3], regardless of resultant word size. However, it is safe to say that in all cases, a word resulting in more than four syllables was generally avoided. Even when being put in a position to epenthesize more often, there is still a trade-off between how much can be retained and how long a resultant word may be.

This phenomenon appears to be further evidence for Lin's (1998) findings that Mainland Chinese speakers have a preference for maintaining segmental information, presumably at the expense of metrical constraints driving disyllabicity. These patterns can be seen in the differences in adaptation between Mainland [nei.tʰa.ni.ja.hu] versus Taiwan [nei.thɑŋ.ja.hu] > Netanyahu, and [ʂa.ta.mu hou.sai.jin] versus [ʂa.tan.hu.ʂəŋ] > Saddam Hussein (Lin 1998: 8). When given more information to parse, a ranking of Ident-C >> Parse-Syllable seems to emerge.

Perhaps another way to reconcile this preference for tri-syllables is by resorting to Duanmu's analysis of an empty beat. If we can assume that disyllabic and quadrisyllabic feet are of the type (HH).(HH) (see Chapter 2 section 3.5 for explanation of notation), then trisyllabic words may be (HH).(HØ), where the final syllable may lengthen phonetically or pause in non-final position to utilize an empty beat, purportedly 70% of the overall vocabulary, according to Duanmu (2007) (see Chapter 2 Section 3.5). The discrepancy between this strong tendency for feet of the type H(H.Ø) and it's relation to odd-syllabled words (rare in the vocabulary) has perhaps not been previously considered in the literature. At any rate, if we analyse the tri-syllabic responses given here as the type (HH).(HØ), then perhaps the tendency does not seem so inelegant after all.

3.2.2 Epenthesis patterns

Another complicated issue that needs further analysis is the method of employing epenthesis to save illicit codas. Tables 1-3 show the percentages of adaptations for each environment, where Ø.Ø stands for an occurrence in which no epenthesis occurred and the initial syllable was left open; Ø.C for when the illicit coda was epenthesized leaving an open coda; S.C as a case when the coda epenthesizes and the initial syllable is closed by a sonorant (either a velar nasal or bilabial glide in diphthongs); and S.Ø when the initial syllable is adapted with a sonorant consonant, but no epenthesis occurs. The C generally corresponds to the coda of the initial target syllable, [m], [p], [t], and for [l] it was generally realized as the syllable [əɹ], with one speaker adapting it as [lwo]. See Appendix C for data presented per speaker.

	__m	__l	__p	__t	all environ
Ø.Ø	0%	8.3%	12.5%	33.3%	13.5%
Ø.C	45.8%	79.2%	75%	33.4%	63.5%
S.C	12.5%	12.5%	12.5%	4.2%	10.4%
S.Ø	41.7%	0%	0%	8.3%	12.5%

Table 22. Epenthesis patterns for words with [ɛ]

	__m	__l	__p	__t	all environ
Ø.Ø	4.2%	54.5%	20.8%	43.4%	30.1%
Ø.C	37.5%	22.7%	79.2%	56.5%	50.5%
S.C	20.8%	13.6%	0%	0%	8.6%
S.Ø	37.5%	9%	0%	0%	11.8%

Table 23. Epenthesis patterns for words with [ʌ]

	__m	__l	__p	__t	all environ
Ø.Ø	4.2%	66.7%	25%	54.2%	37.5%
Ø.C	16.7%	12.5%	70.8%	45.8%	36.5%
S.C	33.4%	0%	0%	0%	8.3%
S.Ø	45.9%	20.8%	4.2%	0%	17.7%

Table 24. Epenthesis patterns for words with [oʊ]

In some cases a misperception of the unreleased stop occurred, so that [t] might be adapted as epenthesized [p] (Speaker 7), or [p] as [t] (Speakers 3 and 4), or sometimes even in one instance, [t] as [k] (Speaker 8). Though [w] is often a substitute for English coda [l] (also attested in Chinese-accented SL speech), it always occurred as the second member of a diphthong and never as the initial of an epenthesized syllable. Furthermore, there are cases of a perceived intrusive stop, as in speaker 4's epenthesis of [p] in 'pumton' as [p^{h}a4.p^{h}u3.t^{h}an3] and 'kemton' as [k^{h}ai3.p^{h}u3.twən4], and speaker 8's perception of 'pumton' and 'pumville' as [p^{h}ɑŋ2.pwo2.twən4] and [p^{h}ɑŋ2.pwo2.wei1.əɹ3], respectively.

It is interesting to consider the adaptations of words for which the initial syllable ends in the nasal [m]. Among the given codas, it is by far the least likely to delete, at least leaving a nasal feature in adaptation. In many instances, the nasal quality of the coda is preserved with a permissible Mandarin coda (chosen to match the backness of the vowel, or, following schwa, a velar nasal), while the source nasal [m] is still resyllabified in an epenthetic syllable. For example, Speaker 1 adapts 'kemville' as [k^{h}ən3.mu3.wei2.əɹ3], Speaker 2 adapts 'tomeville' as [t^{h}ɑŋ1.mu3.wei1.əɹ3], and Speaker 3 adapts 'pumberg' as [p^{h}an1.mu3.pwo2.kɤ2]. As mentioned in Chapter 3 section 2.2, Hsieh et al. (2007) note the insertion of nasal codas before syllables beginning with a nasal, which they ascribe to an attempt at making the first syllable bimoraic. However, by Duanmu (2007) and others' analyses, even an open syllable carries two moras by lengthening the vowel, so long as that syllable carries a tone. As the data from my experiment show, there are many open syllables before nasal onsets, e.g. Speaker 1's [k^{h}a3.mu3.twən4] > 'kemton', or Speaker 5's [p^{h}a4.mu3.wei1.ər3] > 'pumville'. One tentative explanation may be that, since only nasal consonants can close a syllable in Mandarin, some speakers may insert a nasal in English closed syllables, either perceptually or in production. This is borne out not only by impressionistic observations of some Chinese speakers' second language speech, but also by data such as Speaker 4's adaptations of 'tollville' and 'tollberg' as [t^{h}uŋ1.wei2.əɹ3] and [t^{h}uŋ1.pwo2.kɤ2], respectively, or speaker 2's adaptations of 'kettville' to [k^{h}an3.wei1.əɹ3] and 'kettberg' to [k^{h}an3.t^{h}ɤ4.pwo2.kɤ2].

What would be more interesting is if there were a direct correlation between the phonetic effects of the coda sonorant and its likelihood to be retained or deleted. However, an informal measurement of the duration of the tokens' coda sonorants and their corresponding epenthesis patterns pointed toward no convincing results. Mostly, the differences in duration were less than a hundredth of a millisecond.

Furthermore, the shortest duration for a nasal coda occurs in ‘kemville’, which retains a nasal in coda position, as opposed to ‘pumburg’ which is second longest in duration, but leaves no trace of the nasal in coda position just as often as does ‘kemville’. For tokens with dark [l], any trace of the coda segment is deleted almost 75% of the time after [oʊ] and almost as often after [ʌ], however the duration is not appreciably shorter than after [ɛ], which most often retains the liquid through epenthesis.

For [l] it is likely that the higher rates of deletion are a product of less salient formant transitions from the vowel to coda, resulting in perception of an open syllable. For [n] it may have more to do with the overall energy dispersed throughout the nasal cavity. Though all vowels are nasalized before nasal codas in English, they exhibit different patterns in adaptation. By using a specially designed mask to aerodynamically measure airflow through the nasal and oral cavities, Zhang (2000) finds that the relative degree of nasalization on vowels in Mandarin dictates whether the feature [nasal] will be retained or not in Beijing [əɹ]-suffixation. Perhaps a similar effect dictates the mode of epenthesis for nasal codas here. Only more technical research could decide.

At any rate, it is worth pointing out that, just as with loanwords in White Hmong (see Golston & Yang (2001) in Chapter 1 Section 3), deletion of any segment is problematic for certain theories. LaCharite & Paradis (2005) find an overwhelming bias against deletion of entire segments in loanword adaptation, yet in the present data it may apply to segments up to 66% of the time. Furthermore, that the environment appears to play a role in whether a segment deletes or not, despite the fact that the isolating native grammar supplies no cause for deletion, implies that phonetic details may factor in whether or not a segment is preserved in adaptation.

Finally, one may question the implications epenthesis patterns for the nasal [m] have for perceptually-based models. While Mandarin does not allow [m] in coda position, it does allow other nasal consonants. While Steriade (2001) avoids formulating a perceptibility metric in discussion of her P-Map hypothesis (she focuses, rather, on how such a module would interact with the phonological grammar), there is the tacit understanding that a feature change for place would be a closer perceptual match than epenthesis to repair an illicit coda. However, there is a significant tendency in the present data to choose the latter, resulting in a syllable not present in the source, as well as a rhyme differing in segmental and featural composition.

3.3 Vocalic adaptation

Finally, we can turn to the choice of vowel mapping in English-to-Mandarin loanword adaptation. As presented in the literature review, a great deal of variation occurs in adapting vowels, more so than in consonants. The following tables illustrate the results obtained in this investigation:

	__m	__l	__p	__t	__]σ	all environ
[ai]	37.5%	29.2%	70.8%	75%	62.5%	55%
[a]	45.8%	66.7%	29.2%	25%	37.5%	40.8%
[i]	12.5%	---	---	---	---	2.5%
[ə]	4.2%	---	---	---	---	.83%
[ɤ]	---	4.2%	---	---	---	.83%

Table 25: Percentage of vowel choice in adaptation of [ɛ]

	__m	__l	__p	__t	__]σ	all environ
[a]	45.8%	13.6%	87.5%	79.2%	79.2%	61.9%
[wo]	4.2%	40.9%	---	8.3%	8.3%	11.9%
[ai]	---	---	12.5%	12.5%	12.5%	7.6%
[ɑ]	33.4%	---	---	---	---	6.8%
[ɑu]	---	27.2%	---	---	---	5.1%
[ə]	16.7%	---	---	---	---	3.4%
[u]	---	18.2%	---	---	---	3.4%

Table 26: Percentage of vowel choice in adaptation of [ʌ]

	__m	__l	__p	__t	__]σ	all environ
[wo]	20.8%	50%	62.5%	66.7%	70.8%	54.2%
[u]	66.7%	20.8%	12.5%	8.3%	8.3%	23.4%
[ou]	---	29.2%	20.8%	25%	20%	19.1%
[ɑ]	8.3%	---	---	---	---	1.6%
[ə]	4.2%	---	---	---	---	.83%
[ɤ]	---	---	4.2%	4.2%	---	.83%

Table 27: Percentage of vowel choice in adaptation of [oʊ]:

A few points are worth noting. First, all tokens of [ai] in Table 26 are from the same speaker, and so reflect individual preference more than a greater generalization of Mandarin speakers. Second, [i] appears as a variant in Table 25 in the environment [k_m] for three different speakers, which may mean that the speaker of the recording had a higher vowel for 'kemberg' than for other [ɛ] tokens. However, the F1 for the token 'kemberg' is only 587 Hz, compared to that of 'kemton' (593 Hz), and the even lower 'kemville' (576 Hz). If this is the result of a syllabic constraint, however, it is not obvious why only one token of [kɛm] was adapted by a raising, rather than lowering, of vowel height. Furthermore, it is unclear why the dipthong [ei] was not utilized, as [kei] and [kʰei] are attested syllables. One possible explanation could be that [kʰei] is a rare syllable. Though given as a possible syllabic type in Lin (2007) and Duanmu (2007) (he uses the example 剋 [kʰei1] 'to reprimand[42]'), it is not common enough to appear in the Oxford Pocket Dictionary (Manser et al. 2003). In Chapter 3 Section 2.2, I mention how Hsieh et al (2005) use this as an explanation for why vowel height is altered in their corpus data, their Use-Ld-Syll constraint driving structure preservation, known in Wu (2005) as Ident-Lex. On the other hand, while [kei] is certainly a commonly occurring syllable, its use would require a break from the pattern of adopting word-initial aspirated stops as aspirated Mandarin stops. As we have seen elsewhere, it is preferable to depart further from vocalic similarity than consonantal.

Over all environments, Table 28 shows the patterns of vowel-to-vowel mapping. Part of Lin's (2009a) data is repeated for comparison in Table 29. In the table for my data the subscripted number is the overall number of responses received from all participants combined, while in the table for Lin's data, it is the number of occurrences of the given vowel across the corpus used in the study.

English	Mandarin	Mandarin	Mandarin
[ɛ]$_{120}$	[ai]$_{66}$ 55%	[a]$_{49}$ 40.8%	[i]$_{3}$ 2.5%
[ʌ]$_{118}$	[a]$_{73}$ 61.9%	[wo]$_{13}$ 11.9%	[ai]$_{9}$ 7.6%
[oʊ]$_{120}$	[wo]$_{65}$ 54.2%	[u]$_{28}$ 23.4%	[ou]$_{23}$ 19.1%

Table 28: The most frequently used Mandarin variants for English vowels.

[ɛ]589	[ai] 159 /[a]30 32%	[ei]110 19%
[ʌ]155	[a$_c$]29 19%	[ə]29 19%
[oʊ]469	[ou]30/ [wo]235 57%	[u]59 13%

Table 29: Common variants used in adapting English vowels (1st column) to Mandarin vowels (2nd and 3rd columns) (Lin 2009a). ([a$_c$] stands for a more centralized low vowel found in open syllables)

[42] Alhough Duanmu (2007) uses this example, and Lin (2007) also allows for this syllable type, native speakers have informed me that the actual pronunciation is [kʰɤ1], a fact corroborated by my Input Method Editor used for typing Chinese characters.

As pointed out in Chapter 2 Sections 3.1 and 3.2.1, due to a systematic gap before velars, [ɛ] cannot map to mid or low except by changing the initial consonant, as was done in three instances of [kɛm-] > [tɕin]. This could explain why the glide + vowel combination [iɛ] was never used in mapping, as a change in the initial consonant is avoided at the expense of unfaithful vowel mapping. As we can see, [ai] is the dominant mapping; however this is less frequent when the syllable is closed by a sonorant. It is not that this environment causes less resyllabification, or results in higher rates of coda retention, as Table 22 shows. We find the same percentage of closed syllables after epenthesis before [m] as we do [l], but more adaptations to [a] before [l] than [m]. This means the adaptation of [a] vs. [ai] is not driven by moraic restrictions. Rather, it seems the nature of the sonorant coda plays some role in biasing adaptation. The question of why [a] should appear more often before the vowel-like [l] coda is left open to discussion.

Again, the pre-liquid environment is the one exception in adaptation of [ʌ]. In all environments [a] is the favorite choice, but before [l] it is adapted as [wo] 27% more of the time. Otherwise, [wo] is not very favored, trailing [a] by nearly 50%. It is easy to rule out the mapping of [ʌ] to [ɤ], as there are no syllables in mandarin such as *[pɤ] or *[p^{h}ɤ]. In fact, [ə], which accounts for the only variant beyond [a] in Lin's data, standing at 19% of all tokens, cannot occur in open syllables either; it is only found before nasals and [ɹ]. In my data, [ə] only appears before [m]; however [ɹ] is never considered an option for closing the first syllable, not even before [l]. Still, the question remains open as to why it appears so often in Lin's data, but is lowered to [a] in mine.

Turning to [oʊ], the most logical match would be the Mandarin diphthong [ou]. Nonetheless, it only maps as such 19% of the time, and never before a nasal. The most common mapping is to [wo], which wins out just over half the time. Lin groups these two variants together, however [ou] only accounts for 30 of the 265 tokens that make up the 57% of her data. The question arises as to why [wo] is more favorable than [ou], or to put it differently, why an onglide seems the better match than an offglide. Lin (p.c.) suggests that this preference may be caused in part by the subphonemic unrounding of [o] in the Mandarin diphthong. (See Chapter 2 Section 3.2.3; the underlying mid vowel phoneme /ə/ receives its rounding and backness from the following /u/, but varies from little to no rounding in most speakers' surface forms.); According to Lin (p.c.), "if English [ou] is perceived as [+round], then [wo] is perhaps a better match in terms of rounding." Also, recall from Chapter 2 Section 2.1 that in Miao (2005), English [ɹ] is often adapted as Mandarin [l], which may have as much to do with the difference in rounding between the two languages as with her posited tendency toward an unmarked structure.

As for [u], which scores high before [m] (where [ou] never appears) my result of 23% is somewhat comparable to Lin's 13%. Many of these occurrences appear before the velar nasal [ŋ]. Written as <-ong> in pinyin, the transcription as [uŋ] is slightly problematic (though most authors adopt it), as an English rendering of "oong" is not a close approximation. Norman (1988) transcribes it as [ϖN] (with a uvular nasal), and claims it to be "not as low as that in the finals uo and ou", claiming the [u] to be justified more on phonological grounds (Norman 1988: 143). This would imply that the value for this syllable is intermediate between [u] and [o], perhaps a more tense [ʊ]. Exact acoustic information for this final is not available to me at this time.

Finally, we can consider the (un)faithfulness to vowels in terms of distinctive features. Table 30 shows the outcome in a table after Lin (2009a) (repeated in Table 31 below my data):

English	M front	M central	M back	M high	M mid	M low	rounding mismatch
[ɛ]120	58% 69	42% 50	<1% 1	3% 3	0%	96% 115	0%
[ʌ]118	8% 9	65% 77	22% 26	3% 4	15% 18	76% 90	15% 18
[oʊ]120	0%	<1% 1	99% 119	23% 28	75% 90	2% 2	3% 4

Table 30. Feature mappings for English to Chinese vowels, where [a] in a diphthong is [+front, +low] and [a] in an open syllable is [0 back, +low].

English	SM front	SM central	SM back	SM high	SM mid	SM Low	rounding mismatch
[ɛ]589	70	13	17	11	52	37	7
[ʌ]155	12	38	50	15	44	41	42
[oʊ]469	1	4	95	13	74	13	17

Table 31. Percentages of mismatches per feature between English (1st column) and Mandarin (Lin 2009a)

As can be seen, aside from the column for “frontness”, our results are quite different. On a scale of backness (the first three columns), the data from my experiment result in fewer instances of a vowel crossing the entire phonetic space. Only one token adapted [ɛ] as a back vowel, and less than half as a central vowel. However, despite this, Lin turned up far fewer adaptations as a central vowel, resulting in an overall higher faithfulness to the feature value [-back] for [ɛ]. As discussed above, the environment, viz. following a velar stop, may have pushed more adaptations to violate identity to frontness. The wider variety of environments that most likely obtained in Lin’s corpus survey probably accounts for the discrepancy between results. For the other two vowels, my results showed a greater faithfulness in adaptation, where [ʌ] was most of the time a central vowel and [oʊ] all but once a back vowel.

On the height dimension our results diverge even further. Although [oʊ] was somewhat more similar, adapting faithfully as mid 75% of the time (though my results had it raising more often than Lin’s), [ɛ] literally never adapted as mid, overwhelmingly lowering to [a], while in Lin’s data this only occurred 37% of the time. This again relates to the syllabic environment: as [k^hɛ] is not a permissible combination, it must either raise to [i] (as it did three times) or lower to [a]. As mentioned earlier, it is unknown why the diphthong [ei] was never considered an option. Finally, the mid vowel [ʌ] also lowered, this time only ¾ of the time, but still a significant portion of unfaithful mappings. Though no Mandarin syllables allow a central vowel to follow [p], non-low alternatives exist in the unattested [p^hei], [p^hwo], and [p^hou]. However, such adaptations would have sacrificed the faithfulness to the feature [back], which, as in Lin’s and Hsieh et al’s (2007) findings, comes at a greater cost than violating identity to [high].

In summary, once the syllabic constraint against [Kɛ] is factored out, the data provided in my experiment found speakers to be more faithful to the vocalic features [back] and [round] than in Lin’s study, but much less so for the feature [high]. The latter appears to be the result of an intricate interplay between syllabic constraints and higher priority to the backness of the vowel rather than its height. This means that the segmental environment plays an important role in determining the mapping of vowels between languages. The multi-winner tableaux found in Lin (2009a,b) might result in less variation once they are considered in their wider syllabic environment.

4. Discussion and Conclusion

4.1 Limitations in the study

Previous studies in loanword adaptation have focused on the difference between recent and older loans, and how the latter change over time. The data presented here give the extreme of synchronic adaptation. Therefore, we may expect some differences from the literature, even those studies that focused on only 20th century loans. Unlike the present study, the loanwords attested in corpus studies reflect a diversity of speakers from different dialectal backgrounds, under different sociological and political circumstances, across a wide variety of age groups.

The tightly controlled test group used in this experiment (Northern Mainland females between 20 and 30) has its advantages, not the least of which is a factoring out of dialectal influence that may have played a role in much of the data used in previous corpus studies. However, it is likewise limiting in that we do not see accurately how various demographic factors play a role in real-world loanword adaptations. We have also artificially factored out the influence of orthography to see how purely perceptual adaptations operate, but we know from the literature, particularly Miao (2005) that a majority of loans in Mandarin enter the language through written media.

In a similar vein, the differences between corpus and experimental data may account for some discrepancies observed between the present and previous studies, especially those that lacked their own adaptation experiments. Likewise, the choice of using nonce words instead of real words, despite its adavantage of limiting certain paralinguistic factors, may also give rise to unpredictable differences between my data and that of previous studies.

Finally, little attention was given to the linguistic competence of my participants in the source language. Some speakers represented extremes, with Speaker 2 likely having the lowest competence and Speakers 1 and 6 having the highest. (See Appendix B for individuals' personal information.) No analysis was attempted for patterns matching these criteria, though it does appear that Speaker 2 showed a greater tendency to close initial syllables with a nasal segment, irrespective of the coda segment. This effect is a well known aspect of Chinese ESL speakers' speech. The correlation between Mandarin-specific interlanguage aspects and loanword adaptation would be an interesting topic for future research.

Overall, a larger study with different control groups would be needed for more informative data. The study would also have benefited from more sophisticated acoustic analysis to examine some of the ostensible acoustic effects the stimuli had on participants'adaptations. Similarly, more perceptual experiments in the areas of tone, syllabic environment effects and vowel similarity are needed to support such claims.

4.2 Comparison with previous studies

In general, there are no dramatic surprises in the experimental data, but quite a few adaptations that may have implications for other studies. In terms of laryngeal settings, findings fairly closely match the literature, but in turn open more questions. Viewed the same as Paradis & Tremblay (2009), aspiration seems a mostly unimportant detail in adapting English into Mandarin, despite the contrastive nature of [spr glottis] in the native phonology. However, it is unclear whether this is due to phonological category-to-category mapping, or is a function of syllabic place and/or environmental cues. What effect faithfulness to onset segments, as opposed to coda segments, has on adaptation choice is worth considering. To shed further light on this subject, future studies may compare obstruents in both environments, as well as in cluster position.

Tonal adaptation follows the familiar pattern of a high tone on a stressed/aspirated syllable; however the relative abundance of the third tone is somewhat strange, perhaps even more so on epenthesized syllables. The exact reason may be rooted in the nature of tonal perception, or it could be something more paralinguistic, for example the characters 普 [p^{h}u3] and 姆 [mu3] may be more frequent for syllables beginning with [p] or [m], and thus a likely choice when preserving a coda segment via epenthesis. Perceptual, as well as corpora, studies may be able to give further insight on the reasons behind this.

The average word size of the results is perhaps at least slightly surprising, considering the figures given by Duanmu (2007) in Chapter 2 Section 2.4. The preferred adaptation in my data was three syllables, even though Duanmu's citations showed it to be a fairly low percentage of the vocabulary. This of course may have more to do with the second syllable of the token words, as their own codas may drive further epenthesis. As mentioned in the intorduction of Chapter 3, Lin (1998) shows that Mainland Chinese tend to opt more for preserving elements from the foreign input, rather than deleting them like their Taiwanese counterparts. Though disyllabic words are preferred in the native vocabulary, given the nature of the stimuli, there was perhaps too much information to be lost in pursuing disyllabic adaptations. On the other hand, the adaptations may serve as evidence for more abstract categorization, such as Duanmu's (2007) analysis using an empty beat in parsing metrical feet.

One area ripe for future study is the seemingly random patterning of epenthesis. There appear to be no fast conclusions about what drives speakers to preserve a coda segment as opposed to deleting it, and what implications this has for perceptually-based models. Liquids appear to delete more often after back vowels, presumably due to weak transition cues, but this is not a guarantee for all speakers. Likewise, unreleased stops have a mixed percentage of adaptations; in some cases they are more likely to delete than their sonorant counterparts (as after [ɛ]), but in other cases less likely, with [t] overall more likely to delete than [p]. Finally, the nasal [m] is the least likely to completely disappear, perhaps due to more robust transition cues and the coloring of the nuclear vowel.

The results of this experiment mostly match the results of Lin (2009a,b), with a few discrepancies in sonorant environments. That the results presented here are generally more faithful (once syllabic considerations of the stimuli are factored out) may reflect the more tightly controlled demographic group (all speakers from standard dialectal areas), or the control for a single speaker in presenting the stimuli, or simply just the result of a much smaller database. The major finding is that English-to-Mandarin vowel adaptations cannot be considered in isolation from the segmental and syllabic environment. In Lin's study, vowels were considered in isolation, apart from the syllabic/segmental environment of the loans; the fact that certain syllable types are missing, and that others are subject to well-formedness constraints, may explain the numerous adaptations for a single English vowel. Future studies should take into account both the phonetic environment of the source word and the native phonotactic and syllabic constraints that factor into the adaptation process.

4.3 Implications for models of loanword adaptation

This study seems to point toward models of loanword phonology that incorporate both perceptual and phonological factors (see Chapter 1 Section 4 for previous studies). While there was a slight tendency for speakers to resort to a formulaic pattern of adaptation, choosing one vowel and generally using it in most occurrences (implying a categorical mapping), some of the vowels showed a considerable influence of the coda consonant. That having been said, syllabic (and thus, phonological) considerations play the greatest role in altering aspects of the input; though as mentioned in Chapter 3, this may have much to do with the role of orthography in choosing an acceptable adaptation.

If individual speakers seem to exhibit random patterns in their faithfulness to certain vocalic features, it may be because in the native grammar there is little evidence for the ranking of most faithfulness features, like the Ident constraints or Max and Dep. With little to no morphological alternations, the ranking of faithfulness constraints could be too low to have been fixed, and with a variable ranking, it makes sense that there would be varying results when incorporating foreign forms into the native vocabulary.[43] Likewise, especially when it comes to adapting pharyngeal settings, speakers show a great deal of variation between each other. Observations based on corpora may more accurately capture the diversity of the speakers who are responsible for adapting the words in the first place. That being said, the tendency to preserve faithfulness to consonants (especially those word-initially) over vowels, and to preserve the feature [back] more faithfully than [high] does seem to be a reliable outcome for all Chinese speakers, thus pointing to an inherent quality of the Mandarin phonological system.

As for phonetic influences on the data, once the greater consideration for choosing a pre-existing, permissible syllable are met, some of the finer points of adaptation may show the role non-contrastive features play in the process. This is perhaps most striking in the adaptation of [t^hou] to [t^hwo], rather than

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[43] See Antilla and Cho (1998) for a standard theory on variation in Optimality Theory.

the more obvious [t^hou], due to the derounding of the medial element for most Mandarin speakers. Similarly, the rates of epenthesis point toward the influence of formant transitions between the vowel and segments in the syllabic coda, implying that more salient transitions help to preserve consonants, as is commonly claimed in the literature (e.g. Silverman (1992), Yip (2002, 2006), et al.). The relative salience of the coda consonants themselves may also play some role, as nasals, having their acoustic energy more widely dispersed across the syllable, are almost always preserved, whereas stops and liquids shower a higher rate of deletion.

4.4 Possiblities for future research

As mentioned above in regards to limitations, larger experimental studies with more diverse control groups would yield a greater understanding of the patterns (or lack of patterns) that emerge in Mandarin loanword phonology. Besides this, the role that frequency effects play in loanword adaptation seems to be another area that deserves special attention. In choosing a syllable, and perhaps in choosing a tone, there is the possibility that the more commonly that syllable/tone occurs in the native grammar, the more likely it will be chosen in adaptation, even if a closer match exists in the form of a rarer syllable.

The question also arises: what is the interplay in Mandarin loanword phonology between the frequency at which a particular syllable occurs and how frequently that syllabic type is used in the orthography? To put it differently, one syllabic type may be quite rare in Mandarin in that only a small number of characters represent such a composition. But if that character is widely used, even if limited to the loanword vocabulary, does this bias its selection over a syllable type that is represented by a much greater number of characters, and thus a wider range of options for adapting foreign words? Specialized studies combining corpus and experimental data are needed to draw any conclusions.

I can only close by echoing some observations from Lin (2009a,b) on observing some of the same results as above. While certain perceptual studies and reports on unintentional puns (e.g. Zwicky & Zwicky (1986)) show the feature [back] to be more stable than other vocalic features, there is not a lot of evidence to ground this tendency of loanword adaptation in perceptual explanations. As Lin points out, if we assume that vowel systems have evolved over time to reflect ease of perception (as do Lindblom

(1986), Ohala (1990), Flemming (2002) and others), more vowel systems contrast height than backness, with more levels of contrast having been documented for the former than the latter. However, if perception also drives loanword adaptation, backness seems the more important phonetic correlate than does height. While [back] may be taken to be a primary feature for theoretical models (cf. Hsieh et al (2005)), more work needs to be done in the fields of acoustics and speech perception, as well as psycholinguistics and typology studies to better explain these tendencies in foreign loanword adaptation.

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APPENDIX A: PHONOLOGICAL FEATURES

1. Lin (2007: 140-142) (Lin lists feature values for both English and Mandarin example segments)

Features	Examples
Laryngeal Features	
[voice]/[-voice]	[b]/[p]
[+aspirated]/[-aspirated]	[ph]/[p]
Place Features	
Labial	[p] [m] [f]
Coronal: [+anterior]	[t] [n] [ts]
Coronal: [-anterior]	[tʂ] [ʃ]
Coronal: [-anterior] & [-back, +high]	[tɕ] [tɕh] [ɕ]
Dorsal:	[k] [x]
Manner Features	
[+consonantal]	[t] [s] [n] [l]
[-consonantal]	[j] [w] [i] [u]
[+sonorant]	[m] [l] [w] [ɹ]
[-sonorant]	[t] [s] [ts]
[+continuant]	[ʂ] [f] [l] [ɹ]
[-continuant]	[p] [n]
[+nasal]	[n] [m]
[-nasal]	[d] [b]
[+lateral]	[l]
[-lateral]	[ɹ] [t] [f]
Vocalic Features	
[+high]	[i] [y] [u]
[+low]	[a] [æ] [ɑ]
[-high] [-low]	[e] [o] [ə]
[-back] Coronal	[i] [y] [e]
[+back] Dorsal	[u] [o] [ɑ]
[+round] Labial	[u] [o] [y]
[-round]	[a] [i] [e]

2. Duanmu (2007: 46-47)

Feature/ Articulator	i	u	y	ə	a
[high]	+	+	+	-	-
[low]	-	-	-	-	+
[back]	-	+	-		
[round]	-	+	+		-
Dor	√	√	√	√	√
Cor	√		√		
Lab		√	√		

Feature/ Articulator	p	p^h	f	m	t	t^h	ts	ts^h	s	n	l	tʂ	$tʂ^h$	ʂ	ʐ	k	k^h	x	ŋ
[stop]	+	+	+	+	+	+	+	+	-			+	+	-	-	+	+	-	
[fric]	-	-	+	-	-	-	+	+	+	-	-	+	+	+	+	-	-	+	-
[voice]		-	-	+		-		-	-	+	+		-	-	+		-	-	+
[asp]	-	+			-	+	-	+				-	+			-	+		
[nasal]																			+
[ant]					+	+	+	+	+			-	-	-	-				
[lat]											+								
Dor																√	√	√	√
Cor				√	√	√	√	√	√	√	√	√	√	√	√				
Lab	√	√	√																

(N.B. Duanmu's chart does not include the alveolopaltals, as they are not considered separate phonemes, but he gives them the feature specification [+fric, +cor, +dors].

APPENDIX B: RESPONSES OF INDIVIDUAL PARTICIPANTS

(Filler tokens are given in bold font)
Participant 1

1. k^{h}ɛm.vɪl	肯母维尔	[k^{h}ən3.mu3.wei2.əɹ3]
2. t^{h}oʊm.bɚg	佟伯格尔	[tuŋ4.pwo2.kɤ2.əɹ3]
3. p^{h}ʌm.t^{h}n	旁普顿	[p^{h}ɑŋ2.p^{h}u3.twən4]
4. p^{h}ʌl.vɪl	跑维尔	[p^{h}ɑu3.wei2.əɹ3]
5. t^{h}oʊl.vɪl	投维尔	[t^{h}ou2.wei2.əɹ3]
6. k^{h}ɛ.bɚg	卡伯格尔	[k^{h}a3.pwo2.kɤ2.əɹ3]
7. p^{h}ʌ.t^{h}n	帕顿	[p^{h}a4.twən4]
8. k^{h}ɛm.bɚg	坎[44]伯格尔	[k^{h}an3.pwo2.kɤ2.əɹ3]
9. t^{h}oʊm.t^{h}n	汤普顿	[t^{h}ɑŋ1.phu3.twən4]
10. k^{h}ɛp.bɚg	卡普伯格	[k^{h}a3.p^{h}u3.pwo2.kɤ2]
11. p^{h}ʌm.vɪl	旁维尔	[p^{h}ɑŋ2.wei2.əɹ3]
12. k^{h}ut.vɪl	酷得维尔	[k^{h}u4.tɤ0[45].wei2.əɹ3]
13. t^{h}oʊp.vɪl	托普维尔	[t^{h}wo1.p^{h}u3.wei2.əɹ3]
14. k^{h}ɛ.t^{h}n	卡顿	[k^{h}a3.twən4]
15. p^{h}ʌl.bɚg	破伯格尔	[p^{h}wo4.pwo2.kɤ2.əɹ3]
16. p^{h}ʌt.ʔn	帕恩	[p^{h}a4.ən1]
17. t^{h}oʊ.vɪl	托维尔	[t^{h}wo1.wei2.əɹ3]
18. k^{h}ɛl.t^{h}n	卡尔顿	[k^{h}a3.əɹ3.twən4]
19. p^{h}ʌm.bɚg	旁伯格	[p^{h}ɑŋ2.pwo2.kɤ2]
20. t^{h}oʊt.vɪl	托得维尔	[t^{h}wo1.tɤ0.wei2.əɹ3]
21. t^{h}oʊp.bɚg	托普顿	[t^{h}wo1.phu2.twən4]
22. p^{h}ʌp.vɪl	帕伯维尔	[p^{h}a4.pwo2.wei2.əɹ3]
23. t^{h}i.bɚg	踢伯格尔	[t^{h}i1.pwo2.kɤ2.əɹ3]
24. k^{h}ɛt.vɪl	凯特维尔	[k^{h}ai3.t^{h}ɤ4.wei2.əɹ3]
25. p^{h}ʌl.t^{h}n	跑顿	[p^{h}ɑu3.twən4]
26. k^{h}ɛl.vɪl	凯尔维尔	[k^{h}ai3.əɹ3.wei2.əɹ3]
27. k^{h}ɛt.bɚg	凯特博格	[k^{h}ai3.t^{h}ɤ4.pwo2.kɤ2]
28. t^{h}oʊm.vɪl	佟维尔	[tuŋ4.wei2.əɹ3]
29. t^{h}oʊ.t^{h}n	投顿	[t^{h}ou2.twən4]
30. p^{h}ʌt.vɪl	帕得维尔	[p^{h}a4.tɤ0.wei2.əɹ3]
31. t^{h}oʊt.bɚg	投得伯格	[t^{h}ou2.tɤ0.pwo2.kɤ2]
32. p^{h}ʌp.t^{h}n	帕普顿	[p^{h}a4.p^{h}u3.twən4]
33. k^{h}ɛl.bɚg	凯尔伯格	[k^{h}ai3.əɹ3.pwo2.kɤ2]

[44] The character actually written had the ‘mountain’ radical rather than the ‘earth’ radical to the left side. The pronunciation is the same.
[45] This character has a few different pronunciations, [tei3.], [tei2.], [tɤ]. A native speaker informs me that when no meaning is conveyed, the last is the usual pronunciation.

34. p^{h}ɑm.vɪl 胖维尔 [p^{h}ɑŋ4.wei2.əɹ3]
35. k^{h}ɛt.ʔn 凯特恩 [k^{h}ai3.t^{h}ɤ4.ən1]
36. t^{h}oʊl.bɚg 投伯格尔 [t^{h}ou2.pwo2.kɤ2.əɹ3]
37. p^{h}ʌp.bɚg 帕普伯格尔 [p^{h}a4.phu3.pwo2.kɤ2.əɹ3]
38. k^{h}ɛm.t^{h}n 卡母顿 [k^{h}a3.mu3.twən4]
39. p^{h}ʌ.vɪl 帕维尔 [p^{h}a4.wei2.əɹ3]
40. t^{h}oʊ.bɚg 投伯格尔 [t^{h}ou2.pwo2.kɤ2.əɹ3]
41. k^{h}i.t^{h}n 起顿 [tɕ^{h}i3.twən4]
42. p^{h}ʌt.bɚg 帕得伯格尔 [p^{h}a4.tɤ0.pwo2.kɤ2.əɹ3]
43. t^{h}oʊt.ʔn 托顿 [t^{h}wo1.twən4]
44. p^{h}ʌ.bɚg 帕伯格尔 [p^{h}a4.pwo2.kɤ2.əɹ3]
45. t^{h}oʊl.t^{h}n 投顿 [t^{h}ou2.twən4]
46. k^{h}ɛp.vɪl 凯普维尔 [k^{h}ai3.p^{h}u3.wei2.əɹ3]
47. t^{h}ɑl.t^{h}n 涛顿 [t^{h}ɑu1.twən4]
48. k^{h}ɛ.vɪl 卡维尔 [k^{h}a3.wei2.əɹ3]
49. t^{h}oʊp.bɚg 投普伯格尔 [t^{h}ou2.pu3.pwo2.kɤ2.əɹ3]
50. k^{h}ɛp.t^{h}n 卡普顿 [k^{h}a3.phu3.twən4]

Participant 1 is a 30 year old female Phd student from Shandong, who received her MA in China. She was 25 when she first came to the US, having spent five years here, and has never traveled to any other English-speaking countries. She has only studied English in school and began speaking it when she arrived here. She estimates her daily usage to eight hours a day, mainly in class. She speaks a Mandarin dialect (so-called “flavored Mandarin”) of Shandong, Yantaihua (烟台话).

Participant 2

1. k^{h}ɛm.vɪl 堪威尔 [k^{h}an1.wei1.əɹ3]
2. t^{h}oʊm.bɚg 托波格 [t^{h}wo1.pwo1.kɤ2]
3. p^{h}ʌm.t^{h}n 波顿 [pwo1.twən4]
4. p^{h}ʌl.vɪl 波威尔 [pwo1.wei1.əɹ3]
5. t^{h}oʊl.vɪl 托威尔 [t^{h}wo1.wei1.əɹ3]
6. k^{h}ɛ.bɚg 堪波格 [k^{h}an1.pwo1.kɤ2]
7. p^{h}ʌ.t^{h}n 帕顿 [p^{h}a4.twən4]
8. k^{h}ɛm.bɚg 堪波格 [k^{h}an1.pwo1.kɤ2]
9. t^{h}oʊm.t^{h}n 托母顿 [t^{h}wo1.mu3.twən4]
10. k^{h}ɛp.bɚg 坎波得 [k^{h}an3.pwo1.tɤ0]
11. p^{h}ʌm.vɪl 庞威尔 [p^{h}ɑŋ2.wei1.əɹ3]
12. **k^{h}ut.vɪl** 库威尔 [k^{h}u4.wei1.əɹ3]
13. t^{h}oʊp.vɪl 土威尔 [t^{h}u3.wei1.əɹ3]
14. k^{h}ɛ.t^{h}n 坎顿 [k^{h}an3.twən4]
15. p^{h}ʌl.bɚg 波伯格 [pwo1.pwo2.kɤ2]
16. p^{h}ʌt.ʔn 波顿 [pwo1.twən4]
17. t^{h}oʊ.vɪl 托威尔 [t^{h}wo1.wei1.əɹ3]
18. k^{h}ɛl.t^{h}n 坎尔顿 [k^{h}an3.əɹ3.twən4]
19. p^{h}ʌm.bɚg 庞伯格 [p^{h}ɑŋ2.pwo1.kɤ2]
20. t^{h}oʊt.vɪl 托得威尔 [t^{h}wo1.tɤ0.wei1.əɹ3]
21. t^{h}oʊp.bɚg 特波顿 [t^{h}ɤ4.pwo1.twən4]
22. p^{h}ʌp.vɪl 帕威尔 [p^{h}a4.wei1.əɹ3]
23. **thi.bɚg** 替伯格 [t^{h}i4.pwo2.kɤ2]
24. k^{h}ɛt.vɪl 坎威尔 [k^{h}an3.wei1.əɹ3]
25. p^{h}ʌl.t^{h}n 伯尔顿 [pwo2.əɹ3.twən4]
26. k^{h}ɛl.vɪl 坎尔威尔 [k^{h}an3.əɹ3.wei1.əɹ3]
27. k^{h}ɛt.bɚg 坎特伯格 [k^{h}an3.t^{h}ɤ4.pwo2.kɤ2]
28. t^{h}oʊm.vɪl 汤姆威尔 [t^{h}ɑŋ1.mu3.wei1.əɹ3]
29. t^{h}oʊ.t^{h}n 托儿顿 [t^{h}wo1.əɹ3.twən4]
30. p^{h}ʌt.vɪl 帕特威尔 [p^{h}a4.t^{h}ɤ4.wei1.əɹ3]
31. t^{h}oʊt.bɚg 土伯格 [t^{h}u3.pwo2.kɤ2]
32. p^{h}ʌp.t^{h}n 帕波顿 [p^{h}a4.pwo1.twən4]
33. k^{h}ɛl.bɚg 坎尔伯 [k^{h}an3.əɹ3.pwo2.]
34. **p^{h}ɑm.vɪl** 帕姆威尔 [p^{h}a4.mu3.wei1.əɹ3]
35. k^{h}ɛt.ʔn 坎顿 [k^{h}an3.twən4]
36. t^{h}oʊl.bɚg 托伯格 [t^{h}wo1.pwo2.kɤ2]
37. p^{h}ʌp.bɚg 帕伯格 [p^{h}a4.pwo2.kɤ2]
38. k^{h}ɛm.t^{h}n 坎母顿 [k^{h}an3.mu3.twən4]
39. p^{h}ʌ.vɪl 波威尔 [pwo1.wei1.əɹ3]
40. t^{h}oʊ.bɚg 图波格 [t^{h}u2.pwo1.kɤ2]
41. **k^{h}i.t^{h}n** 凯顿 [k^{h}ai3.twən4]
42. p^{h}ʌt.bɚg 帕伯格 [p^{h}a4.pwo2.kɤ2]
43. t^{h}oʊt.ʔn 图顿 [t^{h}u2.twən4]

44. p^{h}ʌ.bɚg	帕波格	[p^{h}a4.pwo1.kɤ2]
45. t^{h}oʊl.t^{h}n	图尔顿	[t^{h}u2.əɹ3.twən4]
46. k^{h}ɛp.vɪl	坎波威尔	[k^{h}an3.pwo1.wei1.əɹ3]
47. t^{h}ɑl.t^{h}n	托顿	[t^{h}wo1.twən4]
48. k^{h}ɛ.vɪl	坎威尔	[k^{h}an3.wei1.əɹ3]
49. t^{h}oʊp.bɚg	图伯格	[t^{h}u2.pwo1.kɤ2]
50. k^{h}ɛp.t^{h}n	坎伯顿	[k^{h}an3.pwo2.kɤ2]

Participant 2 is a 27 year old female Phd student from Shijiazhuang, Hebei province, who received her MA in China. She was 26 when she first arrived in the US, has been here six months, and has never visited another English-speaking country. She has only studied English in school, and began speaking it in the US. Between graduation of high school and her decision to travel here (which wasn't exactly her decision), she did not study English and made very little use of it. She estimates her daily usage of English to be two hours a day in class.

Participant 3

1. k^{h}ɛm.vɪl	开姆威尔	[k^{h}ai1.mu3.wei1.əɹ3]
2. t^{h}oʊm.bɚg	通博格	[t^{h}uŋ1.pwo2.kɤ2]
3. p^{h}ʌm.t^{h}n	畔姆顿	[p^{h}an4.mu3.twən4]
4. p^{h}ʌl.vɪl	普威尔	[p^{h}u3.wei1.əɹ3]
5. t^{h}oʊl.vɪl	吐[46]威尔	[t^{h}u3.wei1.əɹ3]
6. k^{h}ɛ.bɚg	开博格	[k^{h}ai1.pwo2.kɤ2]
7. p^{h}ʌ.t^{h}n	派顿	[p^{h}ai4.twən4]
8. k^{h}ɛm.bɚg	开姆博格	[k^{h}ai1.mu3.pwo2.kɤ2]
9. t^{h}oʊm.t^{h}n	通姆普顿	[t^{h}uŋ1.mu3.p^{h}u3.twən4]
10. k^{h}ɛp.bɚg	开特博格	[k^{h}ai1.t^{h}ɤ4.pwo2.kɤ2]
11. p^{h}ʌm.vɪl	潘威尔	[p^{h}an1.wei1.əɹ3]
12. k^{h}ut.vɪl	库特威尔	[k^{h}u4.t^{h}ɤ4.wei1.əɹ3]
13. t^{h}oʊp.vɪl	托普威尔	[t^{h}wo1.p^{h}u3.wei1.əɹ3]
14. k^{h}ɛ.t^{h}n	开顿	[k^{h}ai1.twən4]
15. p^{h}ʌl.bɚg	普尔博格	[p^{h}u3.əɹ3.pwo2.kɤ2]
16. p^{h}ʌt.ʔn	派顿	[p^{h}ai4.twən4]
17. t^{h}oʊ.vɪl	托威尔	[t^{h}wo1.wei1.əɹ3]
18. k^{h}ɛl.t^{h}n	开尔顿	[k^{h}ai1.əɹ3.twən4]
19. p^{h}ʌm.bɚg	潘姆博格	[p^{h}an1.mu3.pwo2.kɤ2]
20. t^{h}oʊt.vɪl	托特威尔	[t^{h}wo1.t^{h}ɤ4.wei1.əɹ3]
21. t^{h}oʊp.bɚg	托普顿	[t^{h}wo1.phu3.twən4]
22. p^{h}ʌp.vɪl	派普威尔	[p^{h}ai4.phu3.wei1.əɹ3]
23. t^{h}i.bɚg	蒂尔顿	[ti4.pwo2.kɤ2]
24. k^{h}ɛt.vɪl	开特威尔	[k^{h}ai1.t^{h}ɤ4 wei1.əɹ3]
25. p^{h}ʌl.t^{h}n	普尔顿	[p^{h}u3.əɹ3.twən4]
26. k^{h}ɛl.vɪl	开尔威尔	[k^{h}ai1.əɹ3.wei1.əɹ3]
27. k^{h}ɛt.bɚg	开特博格	[k^{h}ai1.t^{h}ɤ4 pwo2.kɤ2]
28. t^{h}oʊm.vɪl	托姆威尔	[t^{h}wo1.mu3.wei1.əɹ3]
29. t^{h}oʊ.t^{h}n	托尔顿	[t^{h}wo1.əɹ3.twən4]
30. p^{h}ʌt.vɪl	派特威尔	[p^{h}ai4.t^{h}ɤ4.wei1.əɹ3]
31. t^{h}oʊt.bɚg	托特博格	[t^{h}wo1.t^{h}ɤ4 pwo2.kɤ2]
32. p^{h}ʌp.t^{h}n	派普顿	[p^{h}ai4.phu3.twən4]
33. k^{h}ɛl.bɚg	开尔博格	[k^{h}ai1.əɹ3 pwo2.kɤ2]
34. p^{h}ɑm.vɪl	潘姆威尔	[p^{h}an1.mu3.wei1.əɹ3]
35. k^{h}ɛt.ʔn	凯顿	[k^{h}ai3.twən4]
36. t^{h}oʊl.bɚg	吐博格	[t^{h}u3.pwo2.kɤ2]
37. p^{h}ʌp.bɚg	派普博格	[p^{h}ai4.p^{h}u3.pwo2.kɤ2]
38. k^{h}ɛm.t^{h}n	开姆顿	[k^{h}ai1.mu3.twən4]
39. p^{h}ʌ.vɪl	派威尔	[p^{h}ai1.wei1.əɹ3]
40. t^{h}oʊ.bɚg	托博格	[t^{h}wo1.pwo2.kɤ2]

[46] This character may carry two tones which distinguish between the meanings ‘spit’ (3rd tone) and ‘vomit’ (fourth tone).

41. k^{h}i.t^{h}n	基顿	[tɕi1.twən4]
42. p^{h}ʌt.bɚg	派特博格	[p^{h}ai4.t^{h}ɤ4.pwo2.kɤ2]
43. t^{h}oʊt.ʔn	托顿	[t^{h}wo1.twən4]
44. p^{h}ʌ.bɚg	派博格	[p^{h}ai4.pwo2.kɤ2]
45. t^{h}oʊl.t^{h}n	托尔顿	[t^{h}wo1.əɹ3.twən4]
46. k^{h}ɛp.vɪl	开普威尔	[k^{h}ai1.phu3.wei1.əɹ3]
47. t^{h}ɑl.t^{h}n	涛顿	[t^{h}ɑu1.twən4]
48. k^{h}ɛ.vɪl	开威尔	[k^{h}ai1.wei1.əɹ3]
49. t^{h}oʊp.bɚg	托特博格	[t^{h}wo1.t^{h}ɤ4.pwo2.kɤ2]
50. k^{h}ɛp.t^{h}n	开普顿	[k^{h}ai1.p^{h}u3.twən4]

Participant 3 is a 23 year old female Master's student from Beijing, who received her Bachelor's degree in China. She came to the US when she was 22, having been here six months and never traveled to another English-speaking country. She has only studied English in school, though when she was a child her grandparents, who studied overseas and worked as interpreters, exposed her to some English and French before primary school. She estimates her daily English usage at three hours a day, relegated to class and a part time job in UGA Food Services.

Participant 4

1. k^{h}ɛm.vɪl	堪维尔	[k^{h}an1.wei2.əɹ3]
2. t^{h}oʊm.bɚg	通博格	[t^{h}uŋ1.pwo2.kɤ2]
3. p^{h}ʌm.t^{h}n	帕普坦	[p^{h}a4.p^{h}u3.t^{h}an3]
4. p^{h}ʌl.vɪl	帕维尔	[p^{h}a4.wei2.əɹ3]
5. t^{h}oʊl.vɪl	通维尔	[t^{h}uŋ1.wei2.əɹ3]
6. k^{h}ɛ.bɚg	凯博格	[k^{h}ai3.pwo2.kɤ2]
7. p^{h}ʌ.t^{h}n	帕坦	[p^{h}a4.t^{h}an3]
8. k^{h}ɛm.bɚg	堪博格	[k^{h}an1.pwo2.kɤ2]
9. t^{h}oʊm.t^{h}n	通普坦	[t^{h}uŋ1.p^{h}u3.t^{h}an3]
10. k^{h}ɛp.bɚg	凯特博格	[k^{h}ai3.t^{h}ɤ4.pwo2.kɤ2]
11. p^{h}ʌm.vɪl	帕姆维尔	[p^{h}a4.mu3.wei2.əɹ3]
12. k^{h}ut.vɪl	库特维尔	[k^{h}u4.t^{h}ɤ4.wei2.əɹ3]
13. t^{h}oʊp.vɪl	托普维尔	[t^{h}wo1.p^{h}u3.wei2.əɹ3]
14. k^{h}ɛ.t^{h}n	凯坦	[k^{h}ai3.t^{h}an3]
15. p^{h}ʌl.bɚg	普博格	[p^{h}u3.pwo2.kɤ2]
16. p^{h}ʌt.ʔn	帕坦	[p^{h}a4.t^{h}an3]
17. t^{h}oʊ.vɪl	托维尔	[t^{h}wo1.wei2.əɹ3]
18. k^{h}ɛl.t^{h}n	凯尔坦	[k^{h}ai3.əɹ3.t^{h}an3]
19. p^{h}ʌm.bɚg	帕姆博格	[p^{h}a4.mu3.pwo2.kɤ2]
20. t^{h}oʊt.vɪl	托特维尔	[t^{h}wo1.t^{h}ɤ4.wei2.əɹ3]
21. t^{h}oʊp.bɚg	托普顿	[t^{h}wo1.p^{h}u3.twən4]
22. p^{h}ʌp.vɪl	帕普维尔	[p^{h}a4.p^{h}u3.wei2.əɹ3]
23. t^{h}i.bɚg	蒂博格	[ti4.pwo2.kɤ2]
24. k^{h}ɛt.vɪl	凯特维尔	[k^{h}ai3.t^{h}ɤ4.wei2.əɹ3]
25. p^{h}ʌl.t^{h}n	帕尔顿	[p^{h}a4.əɹ3.twən4]
26. k^{h}ɛl.vɪl	凯尔维尔	[k^{h}ai3.əɹ3.wei2.əɹ3]
27. k^{h}ɛt.bɚg	凯特博格	[k^{h}ai3.t^{h}ɤ4.pwo2.kɤ2]
28. t^{h}oʊm.vɪl	通姆维尔	[t^{h}uŋ1.mu3.wei2.əɹ3]
29. t^{h}oʊ.t^{h}n	托顿	[t^{h}wo1.twən4]
30. p^{h}ʌt.vɪl	帕普顿	[p^{h}a4.p^{h}u3.twən4]
31. t^{h}oʊt.bɚg	托特博格	[t^{h}wo1.t^{h}ɤ4.pwo2.kɤ2]
32. p^{h}ʌp.t^{h}n	帕普顿	[p^{h}a4.p^{h}u3.twən4]
33. k^{h}ɛl.bɚg	凯尔博格	[k^{h}ai3.əɹ3.pwo2.kɤ2]
34. p^{h}ɑm.vɪl	帕姆维尔	[p^{h}a4.mu3.wei2.əɹ3]
35. k^{h}ɛt.ʔn	凯顿	[k^{h}ai3.twən4]
36. t^{h}oʊl.bɚg	通博格	[t^{h}uŋ1.pwo2.kɤ2]
37. p^{h}ʌp.bɚg	帕普博格	[p^{h}a4.p^{h}u3.pwo2.kɤ2]
38. k^{h}ɛm.t^{h}n	凯普顿	[k^{h}ai3.p^{h}u3.twən4]
39. p^{h}ʌ.vɪl	怕比尔	[p^{h}a4.pi3.əɹ3]
40. t^{h}oʊ.bɚg	通博格	[t^{h}uŋ1.pwo2.kɤ2]
41. k^{h}i.t^{h}n	蒂顿	[ti4.twən4]
42. p^{h}ʌt.bɚg	帕普博格	[p^{h}a4.p^{h}u3.pwo2.kɤ2]
43. t^{h}oʊt.ʔn	托顿	[t^{h}wo1.twən4]

44. p^{h}ʌ.bɚg	帕 博 格	[p^{h}a4.pwo2.kɤ2]
45. t^{h}oʊl.t^{h}n	托 尔 顿	[t^{h}wo1.əɹ3.twən4]
46. k^{h}ɛp.vɪl	凯 维 尔	[k^{h}ai3.wei2.əɹ3]
47. t^{h}ɑl.t^{h}n	托 尔 顿	[t^{h}wo1.əɹ3.twən4]
48. k^{h}ɛ.vɪl	凯维尔	[k^{h}ai3.wei2.əɹ3]
49. t^{h}oʊp.bɚg	托特博格	[t^{h}wo1.t^{h}ɤ4.pwo2.kɤ2]
50. k^{h}ɛp.t^{h}n	凯普顿	[k^{h}ai3.p^{h}u3.twən4]

Participant 4 is a 23 year old female Master’s student from Tianjin, who received her Bachelor’s degree in China. She came to the US when she was 22, having been here eight months and never traveled to another English-speaking country. She speaks the “flavored Mandarin” dialect of Tianjin (天 津 话), a city less than an hour from Beijing, in addition to Standard Mandarin. She has only studied English in school, particularly reading and writing skills prior to college, where she first began to learn speaking and listening skills. She estimates her daily usage of English to three hours a day, in class and at the dining hall. She used a Chinese-English dictionary to look up a few of the characters during the experiment.

An interesting point to note is that she began translating the place morpheme ‘-ton’ as the aspirated 坦[t^{h}an3], but later changed to the more common 顿[twən4]. She told me that she considered going back and changing all of the former.

Participant 5

1. k^{h}ɛm.vɪl	开姆威尔	[k^{h}ai1.mu3.wei1.ər3]
2. t^{h}oʊm.bɚg	腾堡	[t^{h}əŋ2.pɑu3]
3. p^{h}ʌm.t^{h}n	帕姆敦	[p^{h}a4.mu3.twən1]
4. p^{h}ʌl.vɪl	保罗威尔	[pɑu3.lwo2.wei1.ər3]
5. t^{h}oʊl.vɪl	托威尔	[two1.wei1.ər3]
6. k^{h}ɛ.bɚg	开堡	[k^{h}ai1.pɑu3]
7. p^{h}ʌ.t^{h}n	帕敦	[p^{h}a4.twən1]
8. k^{h}ɛm.bɚg	金堡	[tɕin1.pɑu3]
9. t^{h}oʊm.t^{h}n	托姆敦	[two1.mu3.twən1]
10. k^{h}ɛp.bɚg	凯普堡	[k^{h}ai3.p^{h}u3.pɑu3]
11. p^{h}ʌm.vɪl	帕姆威尔	[p^{h}a4.mu3.wei1.ər3]
12. k^{h}ut.vɪl	酷德威尔	[k^{h}u4.tɤ2.wei1.ər3]
13. t^{h}oʊp.vɪl	托普威尔	[t^{h}wo1.p^{h}u3.wei1.ər3]
14. k^{h}ɛ.t^{h}n	凯特	[k^{h}ai3.t^{h}ɤ4]
15. p^{h}ʌl.bɚg	保罗堡	[pɑu3.lwo2.pɑu3]
16. p^{h}ʌt.ʔn	帕顿	[p^{h}a4.twən4]
17. t^{h}oʊ.vɪl	托威尔	[t^{h}wo1.wei1.ər3]
18. k^{h}ɛl.t^{h}n	凯尔顿	[k^{h}ai3.əɹ3.twən1]
19. p^{h}ʌm.bɚg	帕姆堡	[p^{h}a4.mu3.pɑu3]
20. t^{h}oʊt.vɪl	托德威尔	[t^{h}wo1.tɤ2.wei1.ər3]
21. t^{h}oʊp.bɚg	托普顿	[t^{h}wo1.p^{h}u3.twən4]
22. p^{h}ʌp.vɪl	帕布威尔	[p^{h}a4.pu4.wei1.ər3]
23. t^{h}i.bɚg	替堡	[t^{h}i1.pɑu3]
24. k^{h}ɛt.vɪl	凯德威尔	[k^{h}ai3.tɤ2.wei1.ər3]
25. p^{h}ʌl.t^{h}n	保罗顿	[pɑu3.lwo2.twən4]
26. k^{h}ɛl.vɪl	凯尔威尔	[k^{h}ai3.əɹ3.wei1.ər3]
27. k^{h}ɛt.bɚg	凯特堡	[k^{h}ai3.t^{h}ɤ4.pɑu3]
28. t^{h}oʊm.vɪl	托姆威尔	[t^{h}wo1.mu3.wei1.ər3]
29. t^{h}oʊ.t^{h}n	托顿	[t^{h}wo1.twən4]
30. p^{h}ʌt.vɪl	帕特威尔	[p^{h}a4.t^{h}ɤ4.wei1.ər3]
31. t^{h}oʊt.bɚg	托德堡	[t^{h}wo1.tɤ2.pɑu3]
32. p^{h}ʌp.t^{h}n	帕布顿	[p^{h}a4.pu4.twən4]
33. k^{h}ɛl.bɚg	凯尔堡	[k^{h}ai3.əɹ3.pɑu3]
34. p^{h}ɑm.vɪl	帕姆威尔	[p^{h}a4.mu3.wei1.ər3]
35. k^{h}ɛt.ʔn	凯顿	[k^{h}ai3.twən4]
36. t^{h}oʊl.bɚg	托堡	[t^{h}wo1.pɑu3]
37. p^{h}ʌp.bɚg	帕布堡	[p^{h}a4.pu4.pɑu3]
38. k^{h}ɛm.t^{h}n	开姆顿	[k^{h}ai1.mu3.twən4]
39. p^{h}ʌ.vɪl	帕威尔	[p^{h}a4.wei1.ər3]
40. t^{h}oʊ.bɚg	托堡	[t^{h}wo1.pɑu3]
41. k^{h}i.t^{h}n	嘉顿	[tɕja1.twən4]
42. p^{h}ʌt.bɚg	帕布堡	[p^{h}a4.pu4.pɑu3]
43. t^{h}oʊt.ʔn	托顿	[t^{h}wo1.twən4]

44. p^{h}ʌ.bɚg	帕布堡	[p^{h}a4.pu4.pɑu3]
45. t^{h}oʊl.t^{h}n	托顿	[t^{h}wo1.twən4]
46. k^{h}ɛp.vɪl	开普威尔	[k^{h}ai1.p^{h}u3.wei1.ər3]
47. t^{h}ɑl.t^{h}n	托顿	[t^{h}wo1.twən1]
48. k^{h}ɛ.vɪl	开威尔	[k^{h}ai1.wei1.ər3]
49. t^{h}oʊp.bɚg	托普堡	[t^{h}wo1.p^{h}u3.pɑu3]
50. k^{h}ɛp.t^{h}n	开普顿	[k^{h}ai1.p^{h}u3.twən4]

Participant 5 is a 23 year old Master’s student from Beijing, who received her Bachelor’s degree in China. She came to the U.S. when she was 22, having been here almost ten months, she has never traveled to another English-speaking country. She claims to have learned English mainly in school, and attended some supplementary classes after school to further her study. She estimates her daily usage of English at three to four hours, mainly while in class, shopping and eating. Her grandmother speaks a dialect of Shanxi.

It is interesting to note that, while most participants were consistent in their use of a character to represent the same syllable, with the syllable [t^{h}n] sometimes alternating between two different characters, Participant 5 alternates more freely, in the process changing both aspiration and tone in her choice of characters. See, for example nos. 1, 6, 38, 46 & 50 for [k^{h}ai1] versus nos. 10, 14, 18, 24, 26, 27, 33 & 35 for [k^{h}ai3]. Also nos. 10, 13, 21, 49 & 50 [p^{h}u3] versus 22, 32, 37, 42 & 44 [pu4].

Participant 6

1. k^{h}ɛm.vɪl	刊维尔	[k^{h}an1.wei2.əɹ3]
2. t^{h}oʊm.bɚg	通博格	[t^{h}uŋ1.pwo2.kɤ2]
3. p^{h}ʌm.t^{h}n	彭通	[p^{h}əŋ2.t^{h}uŋ1]
4. p^{h}ʌl.vɪl	坡维尔	[p^{h}wo1.wei2.əɹ3]
5. t^{h}oʊl.vɪl	多维尔	[two1.wei2.əɹ3]
6. k^{h}ɛ.bɚg	开博格	[k^{h}ai1.pwo2.kɤ2]
7. p^{h}ʌ.t^{h}n	波特	[pwo1.t^{h}ɤ4]
8. k^{h}ɛm.bɚg	金博	[tɕin1.pwo2]
9. t^{h}oʊm.t^{h}n	通特	[t^{h}uŋ1.t^{h}ɤ4]
10. k^{h}ɛp.bɚg	开波博	[k^{h}ai1.pwo2.pwo2]
11. p^{h}ʌm.vɪl	彭维尔	[p^{h}əŋ2.wei2.əɹ3]
12. k^{h}ut.vɪl	酷维尔	[k^{h}u4.wei2.əɹ3]
13. t^{h}oʊp.vɪl	多维尔	[two1.wei2.əɹ3]
14. k^{h}ɛ.t^{h}n	开腾	[k^{h}ai1.t^{h}əŋ2]
15. p^{h}ʌl.bɚg	颇博尔	[p^{h}wo1.pwo2.əɹ3]
16. p^{h}ʌt.ʔn	颇腾	[p^{h}wo1.t^{h}əŋ2]
17. t^{h}oʊ.vɪl	多维尔	[two1.wei2.əɹ3]
18. k^{h}ɛl.t^{h}n	开腾	[k^{h}ai1.t^{h}əŋ2]
19. p^{h}ʌm.bɚg	腾博尔	[t^{h}əŋ2.pwo2.əɹ3]
20. t^{h}oʊt.vɪl	多维尔	[two1.wei2.əɹ3]
21. t^{h}oʊp.bɚg	多波腾	[two1.pwo1.t^{h}əŋ2]
22. p^{h}ʌp.vɪl	怕维尔	[p^{h}a4.wei2.əɹ3]
23. t^{h}i.bɚg	替博尔	[t^{h}i1.pwo2.əɹ3]
24. k^{h}ɛt.vɪl	开维尔	[k^{h}ai1.wei2.əɹ3]
25. p^{h}ʌl.t^{h}n	波腾	[pwo1.t^{h}əŋ2]
26. k^{h}ɛl.vɪl	开维尔	[k^{h}ai1.wei2.əɹ3]
27. k^{h}ɛt.bɚg	开特博尔	[k^{h}ai1.t^{h}ɤ4.pwo2.əɹ3]
28. t^{h}oʊm.vɪl	通维尔	[t^{h}uŋ1.wei2.əɹ3]
29. t^{h}oʊ.t^{h}n	多腾	[two1.t^{h}əŋ2]
30. p^{h}ʌt.vɪl	怕维尔	[p^{h}a4.wei2.əɹ3]
31. t^{h}oʊt.bɚg	托博尔	[two1.pwo2.əɹ3]
32. p^{h}ʌp.t^{h}n	怕腾	[p^{h}a4.t^{h}əŋ2]
33. k^{h}ɛl.bɚg	开尔伯	[k^{h}ai1.əɹ3.pwo2]
34. p^{h}ɑm.vɪl	彭维尔	[p^{h}əŋ2.wei2.əɹ3]
35. k^{h}ɛt.ʔn	开腾	[k^{h}ai1.t^{h}əŋ2]
36. t^{h}oʊl.bɚg	多博格	[two1.pwo2.kɤ2]
37. p^{h}ʌp.bɚg	帕博格	[p^{h}a4.pwo2.kɤ2]
38. k^{h}ɛm.t^{h}n	开明腾	[k^{h}ai1.mjəŋ2.t^{h}əŋ2]
39. p^{h}ʌ.vɪl	帕维尔	[p^{h}a4.wei2.əɹ3]
40. t^{h}oʊ.bɚg	托博格	[t^{h}wo1.pwo2.kɤ2]
41. k^{h}i.t^{h}n	基腾	[tɕi1.t^{h}əŋ2]
42. p^{h}ʌt.bɚg	帕特博格	[p^{h}a4.t^{h}ɤ4.pwo2.kɤ2]
43. t^{h}oʊt.ʔn	多腾	[two1.t^{h}əŋ2]

44. p^{h}ʌ.bɚg	帕博格	[p^{h}a4.pwo2.kɤ2]
45. t^{h}oʊl.t^{h}n	多腾	[two1.t^{h}əŋ2]
46. k^{h}ɛp.vɪl	开维尔	[k^{h}ai1.wei2.əɹ3]
47. t^{h}ɑl.t^{h}n	涛腾	[t^{h}ɑu1.t^{h}əŋ2]
48. k^{h}ɛ.vɪl	开维尔	[k^{h}ai1.wei2.əɹ3]
49. t^{h}oʊp.bɚg	通博格	[t^{h}uŋ1.pwo2.kɤ2]
50. k^{h}ɛp.t^{h}n	开破腾	[k^{h}ai1.pwo2.t^{h}əŋ2]

Participant 6 is a 30 year old female from Jilin City, Jilin, who received her Bachelor's in China and a Master's degree in the US. She came to the US when she was 22, having been here eight years; she has never traveled to another English-speaking country. She studied English mainly in school, but chatted with Americans online while still in China, in addition to attending supplementary classes. She almost entirely uses English in her daily life, being married to an American, and only speaks Chinese when calling family. She graduated from the University of Georgia in 2003, and has since worked in the community.

Perhaps interesting is the seemingly random choice between translating the place morpheme '-berg' as either [pwo2.kɤ2] or [pwo2.əɹ3]; that is, either deleting the liquid or deleting the post-sonorant stop.

Participant 7

1. k^{h}ɛm.vɪl	卡姆喂	[k^{h}a3.mu3.wei4]
2. t^{h}oʊm.bɚg	通博克	[t^{h}uŋ1.pwo2.k^{h}ɤ4]
3. p^{h}ʌm.t^{h}n	彭姆顿	[p^{h}əŋ2.mu3.twən4]
4. p^{h}ʌl.vɪl	**喂哦	**participant did not provide target syllable**
5. t^{h}oʊl.vɪl	投喂哦	[t^{h}ou2.wei4.ɔ4]
6. k^{h}ɛ.bɚg	卡博各	[k^{h}a3.pwo2.kɤ4]
7. p^{h}ʌ.t^{h}n	叭顿	[pa1.twən4]
8. k^{h}ɛm.bɚg	卡姆各	[k^{h}a3.mu3.kɤ4]
9. t^{h}oʊm.t^{h}n	通姆顿	[t^{h}uŋ1.mu3.twən4]
10. k^{h}ɛp.bɚg	卡扑克	[k^{h}a3.p^{h}u1.k^{h}ɤ4]
11. p^{h}ʌm.vɪl	叭姆喂尔	[pa1.mu3.wei4.əɹ3]
12. k^{h}ut.vɪl	古得喂尔	[ku3.tɤ0.wei4.əɹ3]
13. t^{h}oʊp.vɪl	投各喂尔	[t^{h}ou2.kɤ4.wei4.əɹ3]
14. k^{h}ɛ.t^{h}n	卡通	[k^{h}a3.t^{h}uŋ1]
15. p^{h}ʌl.bɚg	**博	**participant did not provide target syllable**
16. p^{h}ʌt.ʔn	叭顿	[pa1.twən4]
17. t^{h}oʊ.vɪl	投喂尔	[t^{h}ou2.wei4.əɹ3]
18. k^{h}ɛl.t^{h}n	卡尔顿	[k^{h}a3.əɹ3.twən4]
19. p^{h}ʌm.bɚg	叭姆各	[pa1.mu3.kɤ4]
20. t^{h}oʊt.vɪl	投得喂	[t^{h}ou2.tɤ0.wei4]
21. t^{h}oʊp.bɚg	投普顿	[t^{h}ou2.p^{h}u3.twən4]
22. p^{h}ʌp.vɪl	叭普喂	[pa1.p^{h}u3.wei4]
23. t^{h}i.bɚg	替博各	[t^{h}i1.pwo2.kɤ4]
24. k^{h}ɛt.vɪl	卡得喂尔	[k^{h}a3.tɤ0.wei4.əɹ3]
25. p^{h}ʌl.t^{h}n	叭尔顿	[pa1.əɹ3.twən4]
26. k^{h}ɛl.vɪl	卡尔喂尔	[k^{h}a3.əɹ3.wei4.əɹ3]
27. k^{h}ɛt.bɚg	卡不尔	[k^{h}a3.pu4.əɹ3]
28. t^{h}oʊm.vɪl	通姆喂尔	[t^{h}uŋ1.mu3.wei4.əɹ3]
29. t^{h}oʊ.t^{h}n	投顿	[t^{h}ou2.twən4]
30. p^{h}ʌt.vɪl	叭不[47]喂尔	[pa1.pu2.wei4.əɹ3]
31. t^{h}oʊt.bɚg	投不各	[t^{h}ou2.pu2.kɤ4]
32. p^{h}ʌp.t^{h}n	叭不顿	[pa1.pu2.twən4]
33. k^{h}ɛl.bɚg	卡儿博	[k^{h}a3.əɹ2.pwo2]
34. p^{h}ɑm.vɪl	叭姆喂尔	[pa1.mu3.wei4.əɹ3]
35. k^{h}ɛt.ʔn	卡通	[k^{h}a3.t^{h}uŋ1]
36. t^{h}oʊl.bɚg	投不各	[t^{h}ou2.pu2.kɤ4]
37. p^{h}ʌp.bɚg	叭不各	[pa1.pu2.kɤ4]
38. k^{h}ɛm.t^{h}n	卡姆顿	[k^{h}a3.mu3.twən4]
39. p^{h}ʌ.vɪl	叭喂尔	[pa1.wei4.əɹ3]
40. t^{h}oʊ.bɚg	投不各	[t^{h}ou2.pu2.kɤ4]
41. k^{h}i.t^{h}n	替顿	[t^{h}i1.twən4]

[47] A tone sandhi rule changes the phonemic 4th tone of [pu] to a 2nd tone before another 4th tone.

42. p^{h}ʌt.bɚg	叭不各	[pa1.pu2.kɤ4]
43. t^{h}oʊt.ʔn	投顿	[t^{h}ou2.twən4]
44. p^{h}ʌ.bɚg	叭博各	[pa1.pwo2.kɤ4]
45. t^{h}oʊl.t^{h}n	投顿	[t^{h}ou2.twən4]
46. k^{h}ɛp.vɪl	卡喂儿	[k^{h}a3.wei4.əɹ2]
47. t^{h}ɑl.t^{h}n	投顿	[t^{h}ou2.twən4]
48. k^{h}ɛ.vɪl	卡喂儿	[k^{h}a3.wei4.əɹ2]
49. t^{h}oʊp.bɚg	投不各	[t^{h}ou2.pu2.kɤ4]
50. k^{h}ɛp.t^{h}n	卡扑顿	[k^{h}a3.p^{h}u1.twən4]

Participant 7 is a 25 year old female Master's student from Beijing, who received her Bachelor's degree in China. She came to the US when she was 24, having been here nine months; she has never traveled to another English-speaking country. She predominantly uses English in her daily life here, hanging out with friends and in class, etc. She mostly uses Chinese when talking to her parents at night. She has studied English since middle school, but claims to have made much improvement when she began making American close American friends in college. She spoke extensively about her keen cultural and linguistic interest in America and seemed to be a highly motivated second-language learner.

Participant 8

1. k^{h}ɛm.vɪl	坎威尔	[k^{h}an3.wei1.əɹ3]
2. t^{h}oʊm.bɚg	通堡	[t^{h}uŋ1.pɑu3]
3. p^{h}ʌm.t^{h}n	旁伯顿	[p^{h}ɑŋ2.pwo2.twən4]
4. p^{h}ʌl.vɪl	堡威尔	[pɑu3.wei1.əɹ3]
5. t^{h}oʊl.vɪl	托威尔	[two1.wei1.əɹ3]
6. k^{h}ɛ.bɚg	凯伯格	[k^{h}ai3.pwo2.kɤ4]
7. p^{h}ʌ.t^{h}n	帕顿	[p^{h}a4.twən4]
8. k^{h}ɛm.bɚg	金伯尔	[tɕin1.pwo2.əɹ3]
9. t^{h}oʊm.t^{h}n	通顿	[t^{h}uŋ1.twən4]
10. k^{h}ɛp.bɚg	凯特伯尔	[k^{h}ai3.t^{h}ɤ4.pwo2.əɹ3]
11. p^{h}ʌm.vɪl	旁伯威尔	[p^{h}ɑŋ2.pwo2.wei1.əɹ3]
12. khut.vɪl	酷特威尔	[k^{h}u4.t^{h}ɤ4.wei1.əɹ3]
13. t^{h}oʊp.vɪl	托克威尔	[two1.k^{h}ɤ4.wei1.əɹ3]
14. k^{h}ɛ.t^{h}n	开听	[k^{h}ai1.t^{h}jəŋ1]
15. p^{h}ʌl.bɚg	泊[48]伯尔	[p^{h}wo1.pwo2.əɹ3]
16. p^{h}ʌt.ʔn	怕顿	[p^{h}a4.twən4]
17. t^{h}oʊ.vɪl	托威尔	[t^{h}wo1.wei1.əɹ3]
18. k^{h}ɛl.t^{h}n	克尔顿	[k^{h}ɤ4.əɹ3.twən4]
19. p^{h}ʌm.bɚg	旁伯尔	[p^{h}ɑŋ2.pwo2.əɹ3]
20. t^{h}oʊt.vɪl	托克威尔	[two1.k^{h}ɤ4.wei1.əɹ3]
21. t^{h}oʊp.bɚg	托克顿	[two1.k^{h}ɤ4.twən4]
22. p^{h}ʌp.vɪl	帕伯威尔	[p^{h}a4.pwo2.wei1.əɹ3]
23. t^{h}i.bɚg	替伯尔	[t^{h}i1.pwo2.əɹ3]
24. k^{h}ɛt.vɪl	凯特威尔	[k^{h}ai3.t^{h}ɤ4.wei1.əɹ3]
25. p^{h}ʌl.t^{h}n	泊顿	[p^{h}wo1.twən4]
26. k^{h}ɛl.vɪl	凯尔威尔	[k^{h}ai3.əɹ3.wei1.əɹ3]
27. k^{h}ɛt.bɚg	凯尔伯格	[k^{h}ai3.əɹ3.pwo2.kɤ4]
28. t^{h}oʊm.vɪl	通威尔	[t^{h}uŋ1.wei1.əɹ3]
29. t^{h}oʊ.t^{h}n	托顿	[t^{h}wo1.twən4]
30. p^{h}ʌt.vɪl	帕特威尔	[p^{h}a4.t^{h}ɤ4.wei1.əɹ3]
31. t^{h}oʊt.bɚg	偷伯	[t^{h}ou1.pwo2]
32. p^{h}ʌp.t^{h}n	帕伯顿	[p^{h}a4.pwo2.twən4]
33. k^{h}ɛl.bɚg	凯尔伯	[k^{h}ai3.əɹ3.pwo2]
34. p^{h}ɑm.vɪl	旁泊威尔	[p^{h}ɑŋ2.p^{h}wo1.wei1.əɹ3]
35. k^{h}ɛt.ʔn	凯顿	[k^{h}ai3.twən4]
36. t^{h}oʊl.bɚg	托伯	[t^{h}wo1.pwo2]
37. p^{h}ʌp.bɚg	帕泊伯尔	[p^{h}a4.p^{h}wo1.pwo2.əɹ3]
38. k^{h}ɛm.t^{h}n	坎普顿	[k^{h}an3.p^{h}u3.twən4]
39. p^{h}ʌ.vɪl	帕威尔	[p^{h}a4.wei1.əɹ3]
40. t^{h}oʊ.bɚg	托伯尔	[two1.pwo2.əɹ3]
41. khi.thn	吉顿	[tɕi2.twən4]

[48] This character has two pronunciations, [p^{h}wo1] and [pwo4].

42. p^{h}ʌt.bɚg	帕特伯尔	[p^{h}a4.t^{h}ɤ4.pwo2.əɹ3]
43. t^{h}oʊt.ʔn	偷顿	[t^{h}ou1.twən4]
44. p^{h}ʌ.bɚg	帕伯尔	[p^{h}a4.pwo2.əɹ3]
45. t^{h}oʊl.t^{h}n	偷顿	[t^{h}ou1.twən4]
46. k^{h}ɛp.vɪl	凯特威尔	[k^{h}ai3.t^{h}ɤ4.wei1.əɹ3]
47. t^{h}ɑl.t^{h}n	陶钝	[t^{h}ɑu1.twən4]
48. k^{h}ɛ.vɪl	凯得威尔	[k^{h}ai3.tɤ0.wei1.əɹ3]
49. t^{h}oʊp.bɚg	偷得怕克	[t^{h}ou1.tɤ0.pwo2.k^{h}ɤ4]
50. k^{h}ɛp.t^{h}n	开普顿	[k^{h}ai1.p^{h}u3.twən4]

Participant 8 is a 26 year old female Phd student from Beijing, who received her Bachelor's degree in China and her Master's degree in the U.S. at the University of Georgia. She came to the U.S. when she was 22 years old, having lived here four years; she has never traveled to another English-speaking country. She estimates her daily English usage to four hours a day, mainly in class and among friends. She has studied English since primary school (3rd grade) and was an English major in college.

APPENDIX C: ADDITIONAL DATA FOR INDIVIDUALS

Table 1. Vowels and codas used in adaptation.

			not from Beijing		*from Beijing*
[ɛ]	___m]$_\sigma$	nos. 1(-ville), 8(-berg), 38(-ton)			
		Speaker 1	ən, an, a	Speaker 5	ai, in, ai
		Speaker 2	an, an, an	Speaker 3	ai, ai, ai
		Speaker 6	an, in, ai	Speaker 7	a, a, a
		Speaker 4	ai, ai, ai	Speaker 8	an, in, an
	___l]$_\sigma$	nos. 18(ton), 26(ville), 33(berg)			
		Speaker 1	a, ai, ai	Speaker 5	ai, ai, ai
		Speaker 2	an, an, an	Speaker 3	ai, ai, ai
		Speaker 6	ai, ai, ai	Speaker 7	a, a, a
		Speaker 4	ai, ai, ai	Speaker 8	ɤ, ai, ai
	___p]$_\sigma$	nos. 10(-berg), 46(-ville), 50(-ton)			
		Speaker 1	a, ai, a	Speaker 5	ai, ai, ai
		Speaker 2	a, ai, a	Speaker 3	ai, ai, ai
		Speaker 6	ai, ai, ai	Speaker 7	a, a, a
		Speaker 4	ai, ai, ai	Speaker 8	ai, ai, ai
	___t]$_\sigma$	nos. 24(-ville), 27(-berg), 35(-ton)			
		Speaker 1	ai, ai, ai	Speaker 5	ai, ai, ai
		Speaker 2	an, an, an	Speaker 3	ai, ai, ai
		Speaker 6	ai, ai, ai	Speaker 7	a, a, a
		Speaker 4	ai, ai, ai	Speaker 8	ai, ai, ai
	___]$_\sigma$	nos. 6(-berg), 14(-ton), 48(-ville)			
		Speaker 1	a, a, a	Speaker 5	ai, ai, ai
		Speaker 2	an, an, an	Speaker 3	ai, ai, ai
		Speaker 6	ai, ai, ai	Speaker 7	a, a, a
		Speaker 4	ai, ai, ai	Speaker 8	ai, ai, ai
[ʌ]					
	___m]$_\sigma$	nos.3(-ton), 11(-ville), 19(-berg)			
		Speaker 1	ɑŋ, ɑŋ, ɑŋ	Speaker 5	a, a, a
		Speaker 2	wo, ɑŋ, ɑŋ	Speaker 3	an, an, an
		Speaker 6	əŋ, əŋ, əŋ	Speaker 7	əŋ, a, a
		Speaker 4	a, a, a	Speaker 8	ɑŋ, ɑŋ, ɑŋ
	___l]$_\sigma$	nos. 4(-ville), 15(-berg), 25(-ton)			
		Speaker 1	ɑu, wo, ɑu	Speaker 5	ɑu, ɑu, ɑu
		Speaker 2	wo, wo, wo	Speaker 3	u, u, u
		Speaker 6	wo, wo, wo	Speaker 7	*, *, a
		Speaker 4	a, u, a	Speaker 8	ɑu, wo, wo

___p]$_\sigma$	nos. 22(-ville), 32(-ton), 37(-berg)		
Speaker 1	a, a, a	Speaker 5	a, a, a
Speaker 2	a, a, a	Speaker 3	ai, ai, ai
Speaker 6	a, a, a	Speaker 7	a, a, a
Speaker 4	a, a, a	Speaker 8	a, a, a
___t]$_\sigma$	nos. 16(-ton), 30(-ville), 42(-berg)		
Speaker 1	a, a, a	Speaker 5	a, a, a
Speaker 2	wo, a, a,	Speaker 3	ai, ai, ai
Speaker 6	wo, a, a	Speaker 7	a, a, a
Speaker 4	a, a, a	Speaker 8	a, a, a
___]$_\sigma$	nos. 7(-ton), 39(-ville), 44(-berg)		
Speaker 1	a, a, a	Speaker 5	a, a, a
Speaker 2	a, wo, a	Speaker 3	ai, ai, ai
Speaker 6	wo, a, a	Speaker 7	a, a, a
Speaker 4	a, a, a	Speaker 8	a, a, a
	not from Beijing	*from Beijing*	

[oʊ]

___m]$_\sigma$	nos. 2(-berg), 9(-ton), 28(-ville)		
Speaker 1	uŋ, ɑŋ, uŋ	Speaker 5	əŋ, wo, wo
Speaker 2	wo, wo, ɑŋ	Speaker 3	uŋ, uŋ, wo
Speaker 6	uŋ, uŋ, uŋ	Speaker 7	uŋ, uŋ, uŋ
Speaker 4	uŋ, uŋ, uŋ	Speaker 8	uŋ, uŋ, uŋ
___l]$_\sigma$	nos. 5(-ville), 36(-berg), 45(-ton)		
Speaker 1	ou, ou, ou	Speaker 5	wo, wo, wo
Speaker 2	wo, wo, u	Speaker 3	u, u, wo
Speaker 6	wo, wo, wo	Speaker 7	ou, ou, ou
Speaker 4	uŋ, uŋ, wo	Speaker 8	wo, wo, ou
___p]$_\sigma$	nos. 13(-ville), 21(-ton), 49(-berg)		
Speaker 1	wo, wo, ou	Speaker 5	wo, wo, wo
Speaker 2	u, ɤ, u	Speaker 3	wo, wo, wo
Speaker 6	wo, wo, uŋ	Speaker 7	ou, ou, ou
Speaker 4	wo, wo, wo	Speaker 8	wo, wo, ou
___t]$_\sigma$	nos. 20(-ville), 31(-berg), 43(-ton)		
Speaker 1	wo, ou, wo	Speaker 5	wo, wo, wo
Speaker 2	wo, u, u	Speaker 3	wo, wo, wo
Speaker 6	wo, wo, wo	Speaker 7	ou, ou, ou
Speaker 4	wo, wo, wo	Speaker 8	wo ou, ou
___]$_\sigma$	nos. 17(-ville), 29(-ton), 40(-berg)		
Speaker 1	wo, ou, ou	Speaker 5	wo, wo, wo
Speaker 2	wo, wo, u	Speaker 3	wo, wo, wo
Speaker 6	wo, wo, wo	Speaker 7	ou, ou, ou
Speaker 4	wo, wo, uŋ	Speaker 8	wo, wo, wo

Epenthesis patterns in adaptation

n = [ŋ], p = [p] or [p^h], t = [t] or [t^h], r = [əɹ], l = [lwo], Ø = no segment

not from Beijing *from Beijing*

[ɛ]

___m]$_\sigma$	nos. 1(-ville), 8(-berg), 38(-ton)		
Speaker 1	n.m / n.Ø / Ø.m	Speaker 5	Ø.m / n.Ø / Ø.m
Speaker 2	n.Ø / n.Ø / n.m	Speaker 3	Ø.m / Ø.m / Ø.m
Speaker 6	n.Ø / n.Ø / Ø.mjəŋ	Speaker 7	Ø.m / Ø.m / Ø.m
Speaker 4	n.Ø / n.Ø / Ø.p	Speaker 8	n.Ø / n.Ø / n.p

___l]$_\sigma$	nos. 18(ton), 26(ville), 33(berg)		
Speaker 1	Ø.r / Ø.r / Ø.r	Speaker 5	Ø.r / Ø.r / Ø.r
Speaker 2	n.r / n.r / n.r	Speaker 3	Ø.r / Ø.r / Ø.r
Speaker 6	Ø.Ø / Ø.Ø / Ø.r	Speaker 7	Ø.r / Ø.r / Ø.r
Speaker 4	Ø.r / Ø.r / Ø.r	Speaker 8	Ø.r / Ø.r. / Ø.r

___p]$_\sigma$	nos. 10(-berg), 46(-ville), 50(-ton)		
Speaker 1	Ø.p / Ø.p / Ø.p	Speaker 5	Ø.p / Ø.p / Ø.p
Speaker 2	n.p / n.p / n.p	Speaker 3	Ø.t / Ø.p / Ø.p
Speaker 6	Ø.p / Ø.Ø / Ø.p	Speaker 7	Ø.p / Ø.Ø / Ø.p
Speaker 4	Ø.t / Ø.Ø / Ø.p	Speaker 8	Ø.t / Ø.t / Ø.p

___t]$_\sigma$	nos. 24(-ville), 27(-berg), 35(-ton)		
Speaker 1	Ø.t / Ø.t / Ø.t	Speaker 5	Ø.t / Ø.t / Ø.Ø
Speaker 2	n.Ø / n.t / n.Ø	Speaker 3	Ø.t / Ø.t / Ø.Ø
Speaker 6	Ø.Ø / Ø.t / Ø.Ø	Speaker 7	Ø.t / Ø.Ø / Ø.Ø
Speaker 4	Ø.t / Ø.t / Ø.Ø	Speaker 8	Ø.t / Ø.r / Ø.Ø
	not from Beijing		*from Beijing*

[ʌ]

___m]$_\sigma$	nos.3(-ton), 11(-ville), 19(-berg)		
Speaker 1	n.p / n.Ø / n.Ø	Speaker 5	Ø.m / Ø.m / Ø.m
Speaker 2	Ø.Ø / n.Ø / n.Ø	Speaker 3	n.m / n.Ø / n.m
Speaker 6	n.Ø / n.Ø / n.Ø	Speaker 7	Ø.m / Ø.m / Ø.m
Speaker 4	Ø.p / Ø.m / Ø.m	Speaker 8	n.p / n.p /n.Ø

___l]$_\sigma$	nos. 4(-ville), 15(-berg), 25(-ton)		
Speaker 1	w.Ø / Ø.Ø / w.Ø	Speaker 5	w.l / w.l / w.l
Speaker 2	Ø.Ø / Ø.Ø / Ø.r	Speaker 3	Ø.Ø / Ø.r / Ø.r
Speaker 6	Ø.Ø / Ø.Ø / Ø.Ø	Speaker 7	** / ** / Ø.r
Speaker 4	Ø.Ø / Ø.Ø / Ø.r	Speaker 8	Ø.Ø / Ø.Ø / Ø.Ø

___p]$_\sigma$	nos. 22(-ville), 32(-ton), 37(-berg)		
Speaker 1	Ø.p / Ø.p / Ø.p	Speaker 5	Ø.p / Ø.p / Ø.p
Speaker 2	Ø.Ø / Ø.p / Ø.Ø	Speaker 3	Ø.p / Ø.p / Ø.p
Speaker 6	Ø.Ø / Ø.Ø / Ø.Ø	Speaker 7	Ø.p / Ø.p / Ø.p
Speaker 4	Ø.p / Ø.p / Ø.p	Speaker 8	Ø.p / Ø.p / Ø.p

___t]$_\sigma$	nos. 16(-ton), 30(-ville), 42(-berg)		
Speaker 1	Ø.Ø / Ø.t / Ø.t	Speaker 5	Ø.Ø / Ø.t / Ø.p
Speaker 2	Ø.Ø / Ø.t / Ø.Ø	Speaker 3	Ø.Ø / Ø.t / Ø.t
Speaker 6	Ø.Ø / Ø.Ø / Ø.t	Speaker 7	Ø.Ø / Ø.p / Ø.p?
Speaker 4	Ø.Ø / Ø.p / Ø.p	Speaker 8	Ø.Ø / Ø.t / Ø.t

[oʊ]

___m]$_\sigma$	nos. 2(-berg), 9(-ton), 28(-ville)		
Speaker 1	n.m / n.p / n.Ø	Speaker 5	n.Ø / Ø.m / Ø.m
Speaker 2	Ø.Ø / Ø.m / n.m	Speaker 3	n.Ø / n.m / Ø.m
Speaker 6	n.Ø / n.Ø / n.Ø	Speaker 7	n.Ø / n.m / n.m
Speaker 4	n.Ø / n.p / n.m	Speaker 8	n.Ø / n.Ø / n.Ø
___l]σ	nos. 5(-ville), 36(-berg), 45(-ton)		
Speaker 1	w.Ø / w.Ø / w.Ø	Speaker 5	Ø.Ø / Ø.Ø / Ø.Ø
Speaker 2	Ø.Ø / Ø.Ø / Ø.r	Speaker 3	Ø.Ø / Ø.Ø / Ø.r
Speaker 6	Ø.Ø / Ø.Ø / Ø.Ø	Speaker 7	Ø.Ø / Ø.Ø / Ø.Ø
Speaker 4	n.Ø / n.Ø / Ø.r	Speaker 8	Ø.Ø / Ø.Ø / Ø.Ø
___p]$_\sigma$	nos. 13(-ville), 21(-ton), 49(-berg)		
Speaker 1	Ø.p / Ø.p / Ø.p	Speaker 5	Ø.p / Ø.p / Ø.p
Speaker 2	Ø.Ø / Ø.Ø / Ø.Ø	Speaker 3	Ø.p / Ø.p / Ø.t
Speaker 6	Ø.Ø / Ø.Ø / n.Ø	Speaker 7	Ø.k / Ø.p / Ø.Ø
Speaker 4	Ø.p / Ø.p / Ø.t	Speaker 8	Ø.k / Ø.k / Ø.t
___t]$_\sigma$	nos. 20(-ville), 31(-berg), 43(-ton)		
Speaker 1	Ø.t / Ø.t / Ø.Ø	Speaker 5	Ø.t / Ø.t / Ø.Ø
Speaker 2	Ø.t / Ø.Ø / Ø.Ø	Speaker 3	Ø.t / Ø.t / Ø.Ø
Speaker 6	Ø.Ø / Ø.Ø / Ø.Ø	Speaker 7	Ø.t / Ø.Ø / Ø.Ø
Speaker 4	Ø.t / Ø.t / Ø.Ø	Speaker 8	Ø.k / Ø.Ø/ Ø.Ø

Percentage of word length per speaker

Speaker 1	
2 syllables	10/50 (20%)
3 syllables	15/50 (30%)
4 syllables	22/50 (44%)
5 syllables	3/50 (6%)
Speaker 2	
2 syllables	8/50 (16%)
3 syllables	35/50 (70%)
4 syllables	7/50 (14%)
Speaker 3	
2 syllables	7/50 (14%)
3 syllables	21/50 (42%)
4 syllables	22/50 (44%)
Speaker 4	
2 syllables	7/50 (14%)
3 syllables	25/50 (50%)
4 syllables	18/50 (36%)
Speaker 5	
2 syllables	15/50 (30%)
3 syllables	22/50 (44%)
4 syllables	13/50 (26%)
Speaker 6	
2 syllables	14/50 (28%)
3 syllables	35/50 (70%)
4 syllables	1/50 (2%)

Speaker 7		
2 syllables	10/48	(20.8%)
3 syllables	30/48	(62.5%)
4 syllables	8/48	(16.7%)
Speaker 8		
2 syllables	14/50	(28%)
3 syllables	21/50	(42%)
4 syllables	14/50	(28%)
5 syllables	1/50	(2%)