

## Patterned Vowel Variation in Mandarin Loanword Adaptation: Evidence from a Dictionary Corpus\*

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This quantitative study examines vowel adaptation patterns in English-based Standard Mandarin (SM) loanwords drawn from a dictionary corpus. The findings are: (i) English non-central vowels are mostly matched in backness in SM, (ii) English high and low vowels have a strong tendency to be retained as high and low respectively in SM, whereas matches for English mid vowels mostly vary between mid and low in SM; (iii) the match between mid and low vowels and that between mid and high vowels are tolerated to various degrees, but a match between high and low monophthong vowels rarely occurs; (iv) a rounding mismatch rarely occurs for English unrounded vowels in the adaptation process, whereas non-high back rounded vowels, mid central vowels, and back diphthongs can be matched with an unrounded correspondent in SM. Possible explanations for and theoretical implications of these variation patterns are discussed.

### 1. Introduction

There is a high degree of variation in adapting English vowels into Standard Mandarin (SM) as it is common to match the same English vowel with several different vowels. English [eɪ] can be adapted to [ei] or the less faithful [i] and [ai], as shown in (1).

(1)	<i>Reagan</i>	[eɪ]	→	<i>lei.gen</i>	[lei.kən]
	<i>Reagan</i>	[eɪ]	→	<i>li.gen</i>	[li.kən]
	<i>Shoemaker</i>	[eɪ]	→	<i>xiu.mai.ke</i>	[ɕjou.mai.k <sup>h</sup> ʅ]

Deviation from faithful vowel adaptation can sometimes be attributed to individual users' or translators' preferences for particular characters based on semantic considerations or

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other factors (cf. Miao 2006). The question, however, is whether or not the seemingly chaotic variation in SM vowel adaptation is simply arbitrary and random or instead has general patterns and restrictions.

In my previous studies of vowel adaptation in SM loanwords (Lin 2007ab, to appear), I randomly collected more than 200 loanwords, with more than 410 vowel tokens, from publications such as newspapers, magazines and books, from radio and TA broadcasts, and from informal observation in daily life such as conversations and street signs. The findings are that (i) vowel backness is more faithfully replicated than height and rounding, (ii) 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, and (iii) central vowels behave as if they are unspecified for and/or ambiguous between front and back. Sample examples are given in (2). The data have been analyzed in Lin (to appear) in Optimality Theory with a set of loanword-specific faithfulness constraints called MIMIC that relates a loanword output to the identifiable foreign percept (Yip 2002, 2006).

(2) Sample examples

a. Examples for high vowels

<i>Grieg</i>	[i]	→	<i>ge.li.ge</i>	[kʎ.li.kʎ]	front high
<i>Grieg</i>	[i]	→	<i>ge.lei.ge</i>	[kʎ.lei.kʎ]	front mid
<i>Judy</i>	[u]	→	<i>zhu.di</i>	[tʂu.ti]	back high
<i>Judy</i>	[u]	→	<i>qiu.di</i>	[tʂ <sup>h</sup> ju.ti]	back mid

b. Examples for mid front vowels

<i>Reagan</i>	[eɪ]	→	<i>lei.gen</i>	[lei.kən]	front mid
<i>Reagan</i>	[eɪ]	→	<i>li.gen</i>	[li.kən]	front high
<i>Shoemaker</i>	[eɪ]	→	<i>xiu.mai.ke</i>	[çjou.mai.k <sup>h</sup> ʎ]	front low
<i>Blair</i>	[ɛ]	→	<i>bu.lei.er</i>	[pu.lei.ɛɪ]	front mid
<i>Blair</i>	[ɛ]	→	<i>bu.lai.er</i>	[pu.lai.ɛɪ]	front low
<i>Clements</i>	[ɛ]	→	<i>ke.li.men</i>	[k <sup>h</sup> ʎ.li.mən]	front mid

c. Examples for mid back rounded vowels

<i>Owen</i>	[oʊ]	→	<i>ou.wen</i>	[ou.wən]	back mid
<i>Dole</i>	[oʊ]	→	<i>du.er</i>	[tu.ɛɪ]	back high
<i>Gore</i>	[ɔ]	→	<i>guo.er</i>	[kwo.ɛɪ]	back mid
<i>Gore</i>	[ɔ]	→	<i>gao.er</i>	[kau.ɛɪ]	back low
<i>Ohio</i>	[oʊ]	→	<i>er.hai.er</i>	[ʎ.xai.ʎ]	back mid unrounded
<i>Oregon</i>	[ɔ]	→	<i>er.le.gang</i>	[ʎ.lʎ.kɑŋ]	back mid unrounded

d. Examples for low vowels

<i>Gallup</i>	[æ]	→	<i>gai.luo.pu</i>	[kai.lwo.p <sup>h</sup> u]	front low
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<i>Jackson</i>	[æ]	→	<i>jie.ke.sen</i>	[tɕjɛ.k <sup>h</sup> ʎ.sən]	front mid
<i>Harry</i>	[æ]	→	<i>ha.li</i>	[xa <sub>c</sub> .li]	central low
<i>Johnson</i>	[ɑ]	→	<i>qiang.sheng</i>	[tɕ <sup>h</sup> jaŋ.ʂəŋ]	back low
<i>Carter</i>	[ɑ]	→	<i>ka.te</i>	[k <sup>h</sup> a <sub>c</sub> .t <sup>h</sup> ʎ]	central low
e. Examples for mid central vowels					
<i>Kentucky</i>	[ə][ʌ]	→	<i>ken.de.ji</i>	[k <sup>h</sup> ən.tʎ.tɕi]	central/back mid
<i>Douglas</i>	[ʌ][ə]	→	<i>dao.ge.la.si</i>	[təu.kʎ.la <sub>c</sub> .sɿ]	back/central low
<i>Ferdinand</i>	[ə]	→	<i>fei.di.nan</i>	[fei.ti.nan]	front mid
<i>Jeremy</i>	[ə]	→	<i>jie.li.mi</i>	[tɕjɛ.li.mi]	front high
<i>Hillary</i>	[ə]	→	<i>xi.lai.li</i>	[ɕi.lai.li]	front low
<i>Bird</i>	[ə]	→	<i>bo.de</i>	[pwo.tʎ]	back mid rounded
<i>Curt</i>	[ə]	→	<i>ke.te</i>	[k <sup>h</sup> ʎ.t <sup>h</sup> ʎ]	back mid
<i>Curt</i>	[ə]	→	<i>kou.te</i>	[k <sup>h</sup> ou.t <sup>h</sup> ʎ]	back mid rounded
<i>Wordsworth</i>	[ə]	→	<i>wo.zi.hua.si</i>	[wu.tsɿ.xwa <sub>c</sub> .sɿ]	back high rounded/central low

In this study, I examine a larger corpus to provide quantitative evidence for patterned variation in SM vowel adaptation, and to uncover more details of the variation patterns to answer the following questions: (i) In terms of the front-back dimension, what vowels tend to have more faithful matches and what vowels tend to have more variable matches? (ii) In terms of the height dimension, what vowels tend to have more faithful matches and what vowels tend to have more variable matches? Is there further evidence that deviation in height is minimal? (iii) In terms of the rounding dimension, what vowels tend to tolerate a rounding mismatch and what vowels tend not to? (iv) Is there further evidence that central vowels are unspecified for and/or ambiguous between front and back? The next section presents the vowel adaptation patterns in a large dictionary corpus. Possible explanations for and theoretical implications of these variation patterns are then discussed in the final section.

## 2. The dictionary corpus and the variation patterns

The corpus consists of more than 4200 proper names for place and people with a total of 8974 vowel tokens taken from the appendixes of *Oxford Advanced English-English and English-Chinese Dictionary* (1978), which are transliterated by the five editors of the dictionary. For each English vowel token, the SM correspondent used is recorded and counted, and a database is created to list for each English vowel (i) the types of SM vowels or glide-vowel sequences used to match the vowel and (ii) the

number and percentage of the occurrence for each SM variant. For example, for English [i], 11 types of SM vowels/glide-vowel sequences are found to have been used to match [i] and the frequency of each SM variant is calculated: of the 536 tokens of English [i], 445 (83%) of them are matched with SM [i] and 50 (9%) of them with SM [ei]. Then for each English vowel, the SM variants are grouped into categories in terms of vowel quality: high, mid, low, front, central, back, rounded/unrounded, and the number and percentage for each group are calculated. My assumptions about the vowel qualities in Mandarin and English are given in (3).

- (3) Assumptions of vowel quality  
(cf. Lin 1989, 2007b, to appear, Duanmu 2000).

- a. SM phonemic vowels, with /ə/ and /a/ unspecified for backness

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

- b. SM surface vowels:

	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 <sub>c</sub>	ɑ	ɑu

- c. The glides, [j], [ɥ], and [w] are derived from the corresponding high vowels when followed by a non-high vowel: /ia/ → [ja], /uan/ → [wan].
- d. Allophonic rules for mid central /ə/  
 /ə/ → [ə] in a closed syllable: [ən], [əŋ]  
 /ə/ → [e] when adjacent to [i]/[j]: [ei], [je]  
 /ə/ → [o] when adjacent to [u]/[w]: [ou], [wo]  
 /ə/ → [ɤ] in a CV or V syllable: [kɤ]
- e. Allophonic rules for low /a/ (Lin to appear)  
 /a/ → front [a] before [i]/[n] or after [j]: [ai], [an], [ja].  
 /a/ → central [a<sub>c</sub>] in an open syllable in [wa<sub>c</sub>], [a<sub>c</sub>].  
 /a/ → back [ɑ] before [u] or [ŋ]: [ɑu], [ɑŋ]  
 /a/ → front raised [ɛ] between a high front glide and [n]: [jɛn], [ɥɛn].

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f. English vowels<sup>1</sup>

	front unrounded	central	back unrounded	back rounded
high	i ɪ			u ʊ
mid	eɪ ε	ə ʌ ə		oʊ ɔ ɔɪ
low	æ aɪ		ɑ	aʊ

Consider now Table I, in which the most frequently matches for each English vowel are tabulated. The subscripted number after each vowel is the number of tokens found in the data. The patterns exhibited in Table I are summarized in (4).

Table I The most frequently used SM correspondents to each English vowel from the dictionary corpus

English	SM	SM	English	SM	SM
[i] <sub>536</sub>	[i] <sub>445</sub> 83%	[ei] <sub>50</sub> 9%	[u] <sub>492</sub>	[u] <sub>405</sub> 82%	[ou] <sub>44</sub> /[wo] <sub>20</sub> 13%
[ɪ] <sub>1625</sub>	[i] <sub>1280</sub> 74%	[ei] <sub>144</sub> 9%	[ʊ] <sub>148</sub>	[u] <sub>109</sub> 74%	[ou] <sub>14</sub> /[wo] <sub>7</sub> 14%
[eɪ] <sub>339</sub>	[ei] <sub>120</sub> 35%	[ai] <sub>71</sub> 21%	[oʊ] <sub>469</sub>	[ou] <sub>30</sub> /[wo] <sub>235</sub> 57%	[u] <sub>59</sub> 13%
[ɛ] <sub>589</sub>	[ai] <sub>159</sub> /[a] <sub>30</sub> 32%	[ei] <sub>110</sub> 19%	[ɔ] <sub>600</sub>	[wo] <sub>210</sub> /[ou] <sub>5</sub> 36%	[aʊ] <sub>137</sub> 23%
[æ] <sub>847</sub>	[a] <sub>304</sub> /[ai] <sub>47</sub> /[ja] <sub>79</sub> 51%	[a_c] <sub>329</sub> 39%	[ɑ] <sub>605</sub>	[a_c] <sub>385</sub> 62%	[ɑ] <sub>100</sub> 17%
[ə] <sub>2106</sub>	[a_c] <sub>603</sub> 29%	[ə] <sub>322</sub> 15%	[ə] <sub>152</sub>	[wo] <sub>40</sub> 26%	[ɻ] <sub>28</sub> 18%
			[ʌ] <sub>155</sub>	[a_c] <sub>29</sub> 19%	[ə] <sub>29</sub> 19%
[aɪ] <sub>230</sub>	[ai] <sub>146</sub> /[a] <sub>14</sub> 70%	[ei] <sub>23</sub> 10%	[aʊ] <sub>58</sub>	[aʊ] <sub>34</sub> [ɑ] <sub>8</sub> 72%	[wo] <sub>5</sub> 9%
			[ɔɪ] <sub>23</sub>	[wo.ji] <sub>6</sub> 26%	[wo] <sub>3</sub> 13%

<sup>1</sup> Following the dictionary editors' English transcriptions, the low back rounded vowel [ɒ] in British English is grouped together with [ɔ].

- (4) Patterns exhibited in Table I
- a. The general patterns of (i) backness matching, (ii) possible deviation in height/rounding, and (iii) ambiguity in backness for central vowels are all evident.
  - b. The most frequently used SM correspondents to the high/mid front and back vowels in English are all front and back respectively, and at least one of the SM correspondents in each case deviates in height.
  - c. The low vowels are matched with low vowels with the same backness or with the central low vowel. It is interesting to note that the central low vowel in SM seem to be the preferred match for the English back low vowel (62%).
  - d. For mid central vowels, the most common matches are central or back vowels although the total percentage of the most frequent matches for each vowel is lower than 45%, indicating a greater degree of matching variability.
  - e. For the diphthongs, backness is faithfully matched with possible deviation of height for low diphthongs.
  - f. Rounding mismatch occurs for [ə] (→ [wə]) and [aʊ] (→ [ɑ]).

There are clearly different degrees of variable adaptation for different vowels: Adaptation of mid vowels varies most, and adaptation of low vowels is more variable than that of high vowels but less so than that of mid vowels. We can see that English high vowels are matched with SM high vowels in the majority of the cases, ranging from 74% to 83%. Adaptation of mid vowels are much more variable in height matching, ranging from 15% to 57%. Adaptation of mid central vowels are especially variable: there are 15 SM variants for [ʌ], 17 for [ə] and 29 for [ɐ], and the combined percentage of the two most frequently used variants for each mid central vowel is less than 45%.

Consider now Table II, in which the matches for each English vowel are classified in terms of vowel quality. Again, the subscripted number after each vowel is the number of tokens found in the data. A rounding mismatch occurs when an English rounded vowel is matched with an unrounded correspondent in SM, and when an English unrounded vowel is matched in SM with a rounded vowel. The last column in Table II indicates the percentage of the SM matches that differ from the English vowel in rounding. The patterns exhibited in Table II are summarized in (5).

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Table II SM variants used for each English vowel in terms of vowel quality

English	SM front	SM central	SM back	SM high	SM mid	SM low	rounding mismatch
[i] <sub>536</sub>	96%	2%	2%	84%	14%	2%	2%
[ɪ] <sub>1625</sub>	93%	4%	3%	80%	17%	3%	2%
[eɪ] <sub>339</sub>	76%	18%	6%	6%	50%	44%	3%
[ɛ] <sub>589</sub>	70%	13%	17%	11%	52%	37%	7%
[u] <sub>492</sub>	1%	1%	98%	83%	16%	1%	3%
[ʊ] <sub>148</sub>	0%	3%	97%	74%	22%	4%	4%
[oʊ] <sub>469</sub>	1%	4%	95%	13%	74%	13%	17%
[ɔ] <sub>600</sub>	3%	19%	78%	6%	52%	42%	38%
[æ] <sub>847</sub>	52%	41%	7%	0%	7%	93%	1%
[ɑ] <sub>605</sub>	11%	65%	24%	1%	7%	92%	4%
[ə] <sub>2106</sub>	29%	44%	27%	6%	40%	54%	14%
[ɚ] <sub>152</sub>	20%	10%	70%	5%	74%	21%	53%
[ʌ] <sub>155</sub>	12%	38%	50%	15%	44%	41%	42%
[aɪ] <sub>230</sub>	95%	3%	2%	15%	13%	72%	2%
[aʊ] <sub>58</sub>	2%	7%	91%	5%	19%	76%	22%
[ɔɪ] <sub>23</sub>	9%	4%	87%	9%	69%	22%	22%

(5) Patterns exhibited in Table II

The front-back dimension

- a. English high/mid front and back vowels and diphthongs are mostly adapted with the same backness specification in SM, ranging from 70% for [ɛ] to 98% for [u].
- b. English [æ] is likely to be adapted as either a front (52%) or central vowel (41%) in SM, whereas English [ɑ] is more likely to be adapted as a central vowel in SM (65%) and is matched with a back vowel at 24%.
- c. English mid central schwa tends to be matched with a central vowel (44%), but this tendency is not as strong as the front and back matches in the high/mid vowels and diphthongs since the combined front and back vowel matches for schwa reaches 56% (29% for front plus 27% for back), which indicates much variation in the adaptation of schwa.
- d. The other two English mid central vowels tend to be matched with a back vowel in SM: 50% for [ʌ] and a strong 70% for [ɚ].

The height dimension

- e. High and low vowels have a strong tendency to remain high and low respectively in SM, ranging from 74% for [ʊ] to 93% for [æ].
- f. With the exception of [oʊ] and [ə], which tend to stay as mid (74%), English mid vowels tend to be matched with either a mid or low vowel in SM, with a mid vowel match hovering around 40-52%.

Rounding mismatch

- g. A rounding mismatch very rarely occurs for English unrounded front vowels, high back rounded vowels, and low vowels.
- h. Back rounded mid vowels and diphthongs, i.e. [oʊ], [ɔ], [aʊ], and [ɔɪ], and the schwa are sometimes matched with an unrounded one (14% to 22%).
- i. A rounding mismatch occurs most frequently for [ə] (53%), [ʌ] (42%), and [ɔ] (38%).

Based on these exhibited patterns, the following generalizations obtain:

(6) Generalizations

- a. In terms of the front-back dimension, English non-central high/mid vowels and diphthongs are mostly matched in backness in SM, whereas the SM matches for English central vowels and low vowels vary to a larger extent.
- b. In terms of the height dimension, English high and low vowels tend to be retained as high and low respectively in SM, whereas matches for English mid vowels mostly vary between mid and low in SM.
- c. The match between mid and low vowels and that between mid and high vowels are tolerated to various degrees, but a match between high and low vowels rarely occurs, ranging from 0% for [æ] to 5% for [aʊ], although with a slightly higher 15% high-vowel match for [aɪ].
- d. A rounding mismatch rarely occurs for English unrounded front and low vowels in the adaptation process, whereas mid back rounded vowels, mid central vowels, and back diphthongs can be matched with an unrounded correspondent in SM.

What can we then conclude from the variation patterns in the dictionary corpus? The general patterns identified in the previous studies are supported; that is, (i) vowel backness is more faithfully replicated than height and rounding; (ii) deviation in height is tolerated but minimal; (iii) central vowels behave as if they are unspecified for and/or ambiguous between front and back. However, this dictionary corpus study reveals some interesting detailed variation patterns in which some vowels are much more faithfully



replicated while some others are more likely to deviate in backness, height, and/or rounding. Specifically, the answers to the questions raised in §1 are given in (7)-(10).

- (7) In terms of the front-back dimension, what vowels tend to have more faithful matches and what vowels tend to have more variable matches?  
 Low vowels and mid central vowels have more variable matches than high/mid non-central vowels.
- (8) In terms of the height dimension, what vowels tend to have more faithful matches and what vowels tend to have more variable matches? Is there further evidence that deviation in height is minimal?
  - a. High and low vowels are mostly faithfully matched in height, whereas mid vowels have more variable matches, with preferences for mid and low matches.
  - b. A high to low match and vice versa are indeed rare, supporting the minimal deviation restriction on height mismatches.
- (9) In terms of the rounding dimension, what vowels tend to tolerate a rounding mismatch and what vowels tend not to?
  - a. Rounding mismatches occur less frequently than height deviation in general, and there exhibits an asymmetry between unrounded and rounded vowels, between central and non-central vowels, and between high/low and mid vowels.
  - b. Rounding mismatches are restricted to mid back rounded and mid central unrounded vowels, and the back low rounded diphthong.
  - c. Non-central unrounded vowels and high/low monophthong vowels are rarely matched with a rounded vowel.
- (10) Is there further evidence that central vowels are unspecified for and/or ambiguous between front and back?
  - a. Mid central vowels exhibit highest degrees of variation in matches of front, central and back vowels, suggesting that they are not specified for backness or their backness quality is not salient.
  - b. The SM low central vowel is a common match for either a front or back low vowel in English, showing its ambiguous status in backness grouping and categorization.

In sum, we have seen quantitative details in the vowel adaptation patterns in SM loanwords based on the dictionary corpus. Although the general variation patterns identified in the previous studies are supported, this study has uncovered the interesting fact that not all non-central vowels have the same variation patterns, and some types of

vowels tend to be more variably matched in terms of certain vowel quality while some others tend not to.

### 3. Discussion and concluding remarks

One question raised by the patterns found in the dictionary corpus is this: Why are there asymmetrical variation patterns among different types of vowels? The data show that the more peripheral the English vowel is, the less deviation and variation there is in the SM matches: (i) Tense high/mid vowels show less backness variation in SM matches than the corresponding lax ones, and the high vowels show less such variation than mid vowels; e.g., [i] is mostly faithfully matched, [ɪ] is slightly less so, [eɪ] is more variable, and [ɛ] is even more variable; (ii) high and low vowels show much less deviation in height than mid vowels; (iii) mid central vowels have most variable matches in height, backness, and/or rounding. The fact that vowels with better perceptual contrasts and saliency (e.g. peripheral vowels, tense vowels) are adapted more faithfully while vowels with relatively poor perceptual contrasts and saliency (e.g. mid central vowels, mid vowels, lax vowels) have more variable matches seems to suggest that perceptual factors play a crucial role in the variation patterns of SM loanword vowel adaptation.

There have been heated debates regarding how loanwords are adapted and processed. The phonetics approach (Peperkamp and Dupoux 2003, Peperkamp 2005) argues that adaptation results from misperception and is processed at the phonetic level. In the phonology approach (Paradis & LaCharité 1997, LaCharité and Paradis 2005), the input to the adaptation process is based on the phonology of the source language, and loanword adaptation follows category preservation/proximity principles where segment matching is based on phonological categories. In the combined perception-phonology approach (e.g. Silverman 1992, Yip 1993, 2002, 2006, Steriade 2001, Kenstowicz 2003, Kang 2003), the input to the adaptation process is based on how the borrowers perceive the acoustic signals of the source language, and the perception-based input is modified/adapted by the borrowing language's phonological grammar.

The implications of this study, together with the previous ones, for theories of loanword phonology are: (i) The variability of vowel adaptation in SM loanwords casts doubt on the strict form of phonological category preservation/proximity principles (LaCharité and Paradis 2005) and argues against a purely perceptual misperception account (Peperkamp and Dupoux 2003, Peperkamp 2005); (ii) the fact that non-peripheral vowels, such as mid and central vowels, exhibit more variation in matches and/or ambiguity for categorization while peripheral vowels are more faithfully replicated suggests that the input to the adaptation process is more likely to be based on auditory perception; (iii) the inviolability of SM phonotactics and allophonic distributions reflects the dominant phonological force and supports theories of loanword adaptation that incorporate phonological grammar (Paradis and LaCharité 1997, LaCharité and Paradis 2005, Yip 2006, Smith 2006ab, among others); (iv) the variation in vowel adaptation and

the prioritized matching in favor of some aspects of foreign inputs support a ranked set of loanword-specific constraints (Yip 2002, 2006, Smith 2006ab, Lin to appear.)

There are still larger issues in loanword phonology that remain to be determined. First, what is the nature of the input to loanword adaptation and processing? Is the input phonetic in nature or phonological or a combination of both? Although this study seems to suggest that the input is more likely to be based on auditory perception, an analysis in which the input combines phonetic and phonological properties could also work. Second, how do we formally model variation patterns in loanword adaptation and processing? Some recent work on modeling variation and frequency-based data/patterns (e.g. Coetzee 2006 and references therein) may help lead to a more refined formal analysis of the SM vowel adaptation data.

This study may also have broader implications for feature theory. That some features are more important than others in the adaptation process and minimal deviation in the less important features is tolerated suggests that not all vowel features are equally salient perceptually or of the same weight phonologically. The variable matching for a mid central vowel and the less stringent matching in height and rounding could point to a feature theory in which the front-back dimension is primary for vowel quality and the height and rounding dimensions are secondary, and a central vowel is unspecified for or ambiguous between front and back. Studies in other domains, such as imperfect puns and perceptual errors, also seem to indicate that some vowel features are less faithfully retained than others (Miao 2006, 154). For example, Zwicky and Zwicky (1986) observes that imperfect puns in English more frequently tolerate deviation in height and tenseness, which, like this study, may suggest that certain vocalic features are perceptually less salient and/or phonologically secondary. However, the prediction that vowel height could be phonological secondary seems to run counter to the typological patterns in which all languages have height contrasts but some lack backness contrasts, and languages tend to have more levels of contrasts in vowel height than backness (see Lin to appear). It could be that some combinations of the phonetics and phonology of the individual languages and some universal aspects of vowel features play a role in the asymmetrical behavior of vowel features, and I leave it open for future research.

Several larger questions with regard to the nature/properties of vowel features and feature theory then remain to be answered. First, why is that vowel height or vowel rounding is less salient or less important than vowel backness in the SM loanword adaptation process? This is in contrast to the fact that for consonants, manner features are more faithfully retained than place and voicing features (Steriade 2001, Miao 2006). Second, what phonetic and/or phonological factors influence the asymmetrical behavior of vowel features in different languages and/or universally. Third, what phonetic and/or psycholinguistic experiments can be conducted to test any asymmetrical behavior of features and gain a better understanding of the underlying causes?

As far as SM loanword phonology is concerned, future studies need to (i) examine a wider range of corpora to neutralize personal idiosyncrasies in transliteration; (ii)

investigate what factors can potentially affect patterns of vowel quality matching and to what extent, (iii) consider factors such as actual acoustic similarity, competing choices between consonant and vowel faithfulness, restrictions on syllable types and written characters, and possible influence by orthography, (iv) determine between which type of English (American, British, English spoken by Chinese) and which variety of SM (in China, Taiwan, or overseas communities) acoustic values/vowel quality should be compared, (v) conduct statistics analysis and provide a formal model that better reflects the quantitative distribution, and (vi) examine prosodic adaptation, e.g., how stress is adapted into tone.

In conclusion, this quantitative study of a dictionary corpus confirms the general vowel adaptation patterns found in the previous studies but provides more details on what types of vowels are more faithfully adapted than other ones. The above discussion also demonstrates the areas in which such studies can made contributions to and how future studies may provide insights into SM loanword phonology in particular and phonological theory in general.

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