Concentric: Studies in Linguistics
39.2 (November 2013): 1-31

Modeling Salience and Prosody in Loanword Adaptation: Cases of English [ɹ] in Mandarin*

Mingchang Lu
National Chengchi University

This paper probes the effects of phonetic salience and prosody on patterned lexical variation in word-loaning processes. The case is the retention/deletion of [ɹ] from English input to the corresponding underlying representations perceived by Mandarin speakers. Based on a sizable corpus, while the retention/deletion of English [ɹ] is variable on a word-by-word basis, the percentage distribution is observed to be conditioned by a handful of factors of phonetic salience, specifically position, sonority and similarity/dissimilarity, and prosodic preference for binary feet in Mandarin. The patterned distribution in loanword adaptation is appropriately modeled in stochastic evaluations (Boersma 1997, 1998, Boersma & Hayes 2001), which better capture this insight through the key notions of seeing constraints as ranges of value on a linear scale of strictness, and, insofar as the ranking values of two mutually contradictory constraints are close enough, overlapping is inevitable, i.e. the area where dominance between them may be reversed and which results in variation.

Key words: loanword adaptation, lexical variation, phonetic salience, position, sonority, similarity, binary foot, Stochastic-OT

1. Introduction

Due to the key notions of violable constraints that suitably model the oftentimes conflicting forces of preservation of input information and obedience to the sound system of the output language, Optimality Theory (OT, Prince and Smolensky 1993/2004) has served as a mainstream framework to model loanword adaptation (Yip 1993, 2002, 2006, Paradis 1995, 1996, Kenstowicz 2003a, 2003b, Shinohara 2001, 2004, Labrune 2002, Kang 2003, Shih 2004, Miao 2005, Lu 2006, Lin 2007a, 2008a, 2008b, among many others). However, inevitable **lexical variation**[1] (Zuraw 2010) between retention (through vowel insertion) and deletion of an excess consonant from

* My primary thanks go to Yuchau E. Hsiao, who inspired me to pursue work on loanword phonology very early in my graduate career. This paper would not have been possible without his guidance and encouragement throughout the duration. I am also indebted to Feng-fan Hsieh for his valuable input in the preparation of this work. Thanks also go to the audience at TPC-4, where an earlier version was presented, for their useful comments. Finally, I am grateful to three anonymous reviewers, whose criticisms have led to many revisions of this paper.

1 Lexical variation in loanwords refers to the situation where an element, e.g. segment, in foreign input may undergo a certain phonological process (say, deletion) to conform to native phonotactics, while the element in another foreign input in the same or similar phonetic context may undergo a different phonological process (say, vowel insertion). For example, the [ɹ] in English *Norman* is deleted as [.nwo53.man53.] in Mandarin, while the [ɹ] in *Hormone* is retained via schwa insertion as [.xɤ53.əɹ21.moŋ35.]. In **free variation**, on the other hand, a single foreign word has two or more adapted forms in the recipient language. For example, the English name *Truman* is adapted as [.tu53.lu21.mən35.] to refer to the American president, whereas it is adjusted as [.tʂu21.mən35.] in the Mandarin name of the Hollywood film *Truman Show*.

the source language (L_S) that is beyond the syllabic scope of the recipient language (L_R) is either left unanswered or deemed as mutually exceptional, as confined by the idea of fixed ranking in standard OT. In response, this paper claims that the distribution of "normalities" and "exceptions" are in effect patterned by phonetic salience and prosody, and offers a resolution to the above theoretical inadequacy by employing Stochastic OT (Boersma 1997, 1998, Boersma & Hayes 2001). In this revised version of OT, universal constraints are viewed as ranges of value along a linear scale, and variation in input-output mapping is meant to happen insofar as the ranking values of two contradictory constraints are close enough to incur an overlapping area. The dominance between the two constraints may alternate in this area, and hence variation happens. The probability of variation rests on the precise distance between the respective ranking values of the two constraints. The theoretical background will be elaborated upon in Subsection 6.1.

Word-loaning processes involve nativization of a foreign input that originally may or may not be compatible with the native phonology segmentally or/and suprasegmentally. This is sketched in Figure 1.

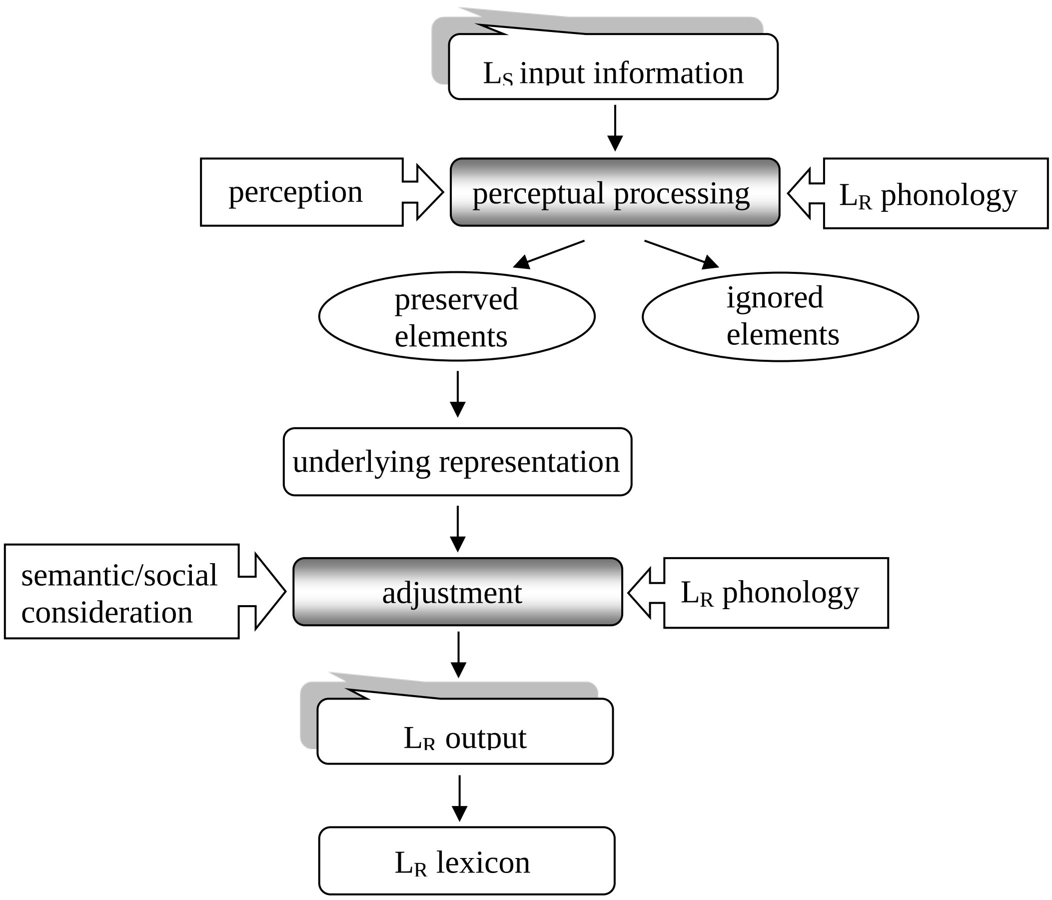


Figure 1. A perception-production model for loanword adaptation

In general, we adopt the scenario that perception and production play equal roles in the word-loaning process (Silverman 1992, Yip 1993, Kenstowicz 2003b, Broselow 2005), where L_R phonology works at both levels—processing the acoustic information in perception and adjusting the underlying representation (henceforth UR, the output of perceptual processing) in production. In particular, we highlight the stage of perceptual processing, i.e. how perception and L_R phonology determine the preservation and ignorance of a given element both individually and interactively.

This paper concerns factors of phonetic salience, i.e., position, sonority, and similarity/dissimilarity, as well as prosody, specifically regarding the preferred disyllabic feet in Mandarin, that may govern the retention/deletion of an input segment in the output form. The data are Mandarin (L_R) adaptations of English (L_S) loanwords and transliterations (loanwords throughout), as little has been said in phonological literature on Mandarin loanwords in this regard (Miao 2005, Lin 2007a, 2008a, 2008b). Among the L_S segments that are adapted by Mandarin speakers, the retention/deletion of the retroflex [ɹ] serves as an appropriate target of investigation on phonetic salience due to its sonorancy and articulatory closeness to [+back] vowels. This will be discussed in the third section.

The loanwords in question are based on a collection of 1,563 English-based loanwords and transliterations of proper nouns in Mandarin, among which 330 are monosyllabic and 1,233 polysyllabic. Sources containing [ɹ] in any position are observed and the retention/deletion of it in the Mandarin adaptation is recorded. To lay the focus on phonetic correlates to the retention/deletion of [ɹ], the patterns are based solely on the observation of polysyllabic source words since the obligatory realization of L_S vowels (hence syllables) renders the prosodic preference for disyllabic feet in Mandarin invisible. By analogy, with a view to clarifying the extent of prosodic influence on adaptation, we simply consider monosyllabic source words instead since, realistically, the speaker may have to decide on yielding to either weak phonetic salience (deletion of a segment) or preference for disyllabic output (retention of a segment by epenthesis) when faced with input of this sort.

The discussion proceeds as follows. Section 2 gives a brief introduction to the phonotactic basics of the two languages in question, followed by Section 3, in which the data are presented to show various effects of phonetic salience, in the order of position, sonority, and similarity/dissimilarity. Section 4 gives the monosyllabic data to manifest the effect of similarity-prosody interaction. A conventional OT-based analysis is provided in Section 5, where variable constraint rankings are initially proposed to indicate the paradoxical problems. In Section 6, data with lexical variation are submitted to a stochastic evaluation. Finally, Section 7 gives concluding remarks.

2. Phonotactic basics

The languages involved are English (L_S) and Mandarin (L_R). English has 24 consonants and allows maximally three consonants in onset, as in "[.splæʃ.] *splash*" and four consonants in coda, as in "[.tʰɛksts.] *texts*". Mandarin has 21 consonants, and the maximal syllable structure is, in the standard view, in the form of CGVX (C: consonant, G: glide, V: vowel, X: C or V, Cheng 1973). Except for [ŋ], all consonants can be the onset, whereas only the alveolar nasal [n] and the velar nasal [ŋ] can be the coda consonants, as in "[.min35.] 民" ('people') and "[.miŋ35.] 明" ('bright'). An exception is [ɹ] in a limited context, with the only possible nucleus being schwa [ə], as in "[.əɹ35.] 兒" ('son'), "[.əɹ21.] 耳" ('ear'), "[.əɹ53.] 二" ('two'). No consonant is allowed in the onset of the structure [əɹ].

Liquids, if any, are obligatorily adjacent to the nuclear vowel, either prevocalic or postvocalic, under the government of SSP. In English, [ɹ] appears as a simplex onset ([.ɹe.] *ray*), the second ([.pʰɹe.] *pray*) or third onset ([.spɹe.] *spray*) following an obstruent in a complex onset, the simplex coda ([.ɑɹ.] *are*), or the first consonant in a complex coda ([.ɑɹt.] *art*). In Mandarin, however, the only position for [ɹ] is the onset, either as a simplex one ([.ɹan21.] 染, 'dye') or followed by a labial glide ([.ɹwan21.] 軟, 'soft') except for, as mentioned above, the simplex coda after a schwa. Thus, while L_S [əɹ] may stay intact in L_R, e.g. "[.əɹg.] *Erg* → [.əɹ21.gɤ35.] 爾格", any [ɹ]-coda that is not preceded by a schwa in L_S is bound to be systematically adjusted in L_R.

3. Phonetic salience

In this section, the patterns regarding retention/deletion of [ɹ] are claimed to be patterned by a handful of phonetic effects on salience, in the order of position, sonority, and similarity/dissimilarity. This leads us to currently exclude loanwords with monosyllabic sources to prevent prosodic factors from obscuring the patterns. Effects of prosody will be discussed in Section 4.

3.1 Position

As noted, [ɹ] appears as the onset, second/third onset, or coda in an L_S syllable. The patterns of retention/deletion in L_R are laid out in terms of this positional difference in (1). Being irrelevant to the current issue, English stress and Mandarin tones are left out henceforth to avoid distraction and save space.

(1) Position-driven patterns[2]

a. Onset

L_S input	L_R UR	Process	Percentage
[.ɹæm.bo.] *Rambo*	/.lan.p^{h}wo./[3]	Retention	100% (187/187)

b. Second/Third onset

L_S input	L_R UR	Process	Percentage
[.o.p^{h}ɹɑ.] *Oprah*	/.ou.p^{h}u.la./	Retention	87.84% (65/74)
[.laɪ.k^{h}ɹə.] *Lycra*	/.laɪ.k^{h}a./	Deletion	12.16% (9/74)[4]

c. Coda

L_S input	L_R UR	Process	Percentage
[.hɔɹ.mon.] *Hormone*	/.xɤ.əɹ.moŋ./	Retention	8.61% (39/453)
[.nɔɹ.mən.] *Norman*	/.nwo.man./	Deletion	91.39% (414/453)

In (1a), a simplex onset [ɹ] in L_S is retained in L_R underlying representations without exception, either as /l/ or /ɹ/ (see Footnote 3). Alternations are found in the other two categories. In (1b), with [ɹ] as the second/third onset, retention remains the main strategy, accounting for 87.84%. In 12.16%, however, [ɹ] is deleted. In (1c), contrary to onsets, 91.39% of [ɹ]-codas are deleted, with only 8.61% retained.

Syllable onsets, as word-initial materials, enjoy more perceptual privileges compared to syllable codas (Beckman 1997, Steriade 2001b). Conceptually positional prominence corresponds well to word-loaning “gradiently”: simplex onsets are the most prominent such that retention is the only strategy, codas are the least prominent and therefore over 90% are deleted[5], and second or third onsets are in an intermediate position, with retention being 87.84%, lower than the simplex onsets’ 100%, and deletion being 12.16%, lower than the codas’ 91.39%. Following Steriade’s (2001b) formula, if a speaker’s judgment of phonological similarity is deduced from

[2] English input is presented in brackets since it is a true phonetic realization of the source, while the corresponding underlying forms in Mandarin are enclosed in slashes since they are the mental representations in the L_R speaker’s short-term memory. Note that the phonetic transcription of an L_R UR may not necessarily be the authentic underlying form, which awaits further adjustment in production grammar that involves semantic and social factors. For convenience’s sake, however, the L_R output form is adopted as L_R UR, which should be harmless for a paper that simply deals with the issue of whether [ɹ] is retained or not, as determined early in perceptual processing.

[3] Both English liquids [ɹ] and [l] in onset are predominantly adapted into [ℓ], even though the former phonetically corresponds more closely to the identical [ɹ] (or at least the closer [z̩]), also a permissible onset in Mandarin. Miao (2005) attributes it to the unmarkedness of [l]-initial syllables in Mandarin. Such an issue belongs to the production level and is thus beyond this paper’s scope.

[4] Significantly more examples (5 out of 9) of deletion are observed in [k^{h}ɹ], [kɹ] and [ɡɹ] sequences, e.g. “/.maɪ.k^{h}ɹo.fon./ *microphone* → [.mai.k^{h}ɤ.foŋ.]”. An explanation is that velar stops and the retroflex [ɹ] are both dorsal in place of articulation, leading to the weaker perceptual salience of the latter.

[5] The retention/deletion of [ɹ]-codas should be further determined by the backness of the preceding vowel, as we will see in 3.3 and later discussions.

observations of confusion, the salience hierarchy of [ɹ] in different positional contexts can be sketched in (2), denoting that the perceptual distinctiveness between [ɹ] and silence in the simplex onset position is greater than that in the second or third onset position, which in turn is greater than that in the coda position.

(2) Salience hierarchy by position (➢ = less confusable, more distinctive than)
[ɹ] vs. Ø /._V ➢ [ɹ] vs. Ø /.C(C)_V ➢ [ɹ] vs. Ø /V_

It is noteworthy that a certain number of variable realizations of the second/third onset, specifically in the sequences of [tɹ], [t^hɹ] or [dɹ], are excluded from the statistics for the reasons elaborated below.

When the onset cluster is [tɹ], [t^hɹ] or [dɹ] and is followed by a front vowel in the source, two other alternatives are discovered. First, with 14 instances, the first alveolar stop is mapped to alveolar affricate [ts^h], and the second or third [ɹ] is glided to [w], surfacing altogether as "[.ts^hwei.] 崔" in L_R. Examples of such are "[.**t^hɹɛ**.vəɹ.] *Trevor* → [.**ts^hwei**.fo.] 崔佛" and "[.**dɹæ**ks.ləɹ.] *Drexler* → [.**ts^hwei**.sɨ.lɤ.] 崔斯勒". Though [ɹ]-gliding (with the feature [+round] is retained) is widely attested in works on first language acquisition and speech errors, which may indeed influence the mapping. Another explanation is that the L_R morpheme "[.ts^hwei.] 崔" is a renowned family name among Chinese people, and thus transliteration from sources referring to people's names to this morpheme is plausible. An example to illustrate this is the comparison between "[.dʌŋ.k^hən.] *Duncan*" and "[.dʌn.lɑp.] *Dunlop*". With a similar first syllable, the former, an English family name, is transliterated as "[.**təŋ**.k^hən.] **鄧**肯", the first morpheme of which is also a well-known family name among Chinese. However, the latter, the brand name of a tire company, was transliterated as "[.**təŋ**.lu.p^hu.] **登**錄普", the first morpheme of which is a common morpheme, not a family name, though the syllable structure is identical to that of "鄧". We intentionally leave out entries of this type since semantic/social factors are involved.

Second, with 7 instances, the same sequences are "fused" into a single retroflex L_R phoneme [$tʂ^h$] or [tʂ], as in "[.k^hæs.**tɹ**o.] *Castro* → [.k^ha.sɨ.**$tʂ^h$**u.] 卡斯楚" and "[.ɑɹm.s**tr**ɑŋ.] *Armstrong* → [.a.mu.sɨ.**tʂ**waŋ.] 阿姆斯壯". A perceptual account of the fusion is presumed to be the feature [+coronal] that the two consecutive consonants [t] and [ɹ] share in common, which endows the sequence with a greater tightness in perception. Cases like this are excluded too for the unclear retention of [ɹ].

3.2 Sonority

The sonority of a sound refers to its loudness relative to that of other sounds with the same length, stress and pitch (Ladefoged 2001). The sonority scale that is widely approved of by most phonologists is shown in (3).

(3) Sonority scale of speech sounds

vowels
glides
liquids — sonority
nasals
obstruents

It is thus assumed that in isolation, vowels are most perceptible while obstruents are the least, with the other sounds placed in between, as scaled in (4).

(4) Salience hierarchy by sonority

V vs. Ø ➢ G vs. Ø ➢ L vs. Ø ➢ N vs. Ø ➢ O vs. Ø

However, when a segment appears next to a vowel, namely in the context of either "_V" or "V_", it is contended that the ranking of salience concerning the sonority scale is reversed, since in that position, the more sonorant the segment is, the more similar it is to the adjacent vowel, contributing to less contrast between the vowel and the segment. This results in (5), indicating that the perceptual distinctiveness between an obstruent and silence when adjacent to a vowel is the greatest, while that between a vowel and another vowel is the weakest, in the opposite order to (4).

(5) Salience hierarchy in the context of "_V" or "V_" by sonority

O vs. Ø /_V or V_ ➢ N vs. Ø /_V or V_ ➢ L vs. Ø /_V or V_ ➢ G vs. Ø /_V or V_ ➢ V vs. Ø /_V or V_

The effect is shown in the loanword data. Compare the different patterns in [ɹ] (low salience) and stops (high salience) in (6).

(6) Comparison between /ɹ/ and stops in retention

a. Onset

[ɹ] (high sonority): 100% ([.**ɹ**ɑ.bɪ.] *Robby* → [.**l**wo.pi.] 羅比）

Stops (low sonority): 100% ([.**b**ɑ.bɪ.] *Bobby* → [.**p**a.pi.] 巴比)

b. 2nd/3rd onset

[ɹ] (high sonority): 87.84% ([.f**ɹ**æn.k^{h}i.] *Frankie* → [.fa.**l**an.tɕi.] 法蘭基)

Stops (low sonority): 100% ([.s**t**æn.fəɹd.] *Stanford* → [.ʂɨ.**t**an.fo.] 史丹佛)

c. Coda

[ɹ] (high sonority): 8.61% ([.dɑ**ɹ**.wɪn.] *Darwin* → [.ta.**əɹ**.wən.] 達爾文)

Stops (low sonority): 62.83% ([.ɛ**d**.wɪn.] *Edwin* → [.ai.**tɤ**.ən.] 愛德恩)

The comparison between [ɹ] and stops is made in terms of the same position in the syllable. The positional prominence of simplex onsets overrides any other effects, and hence in (a), both [ɹ] and stops are 100% preserved in L_R without exception. Being the second or third onset, however, part of the [ɹ]'s undergo deletion ([.maɪ.k^h**ɹ**ə.fon.] *microphone* → [.mai.k^{h}ɤ.foŋ.] 麥克風), with 87.84% of them still retained. Comparatively, second onset stops are 100% retained in L_R. The most significant contrast is revealed in the coda position, where [ɹ] is usually deleted ([.hɑ**ɹ**.vəɹd.] *Harvard* → [.xa.fo.] 哈佛), and only less than 10 percent of them remain. In comparison, over 60% of stops are preserved in L_R even as coda, with the rest deleted ([.lɑ.dʒɪ**k**.] *logic* → [.lwo.tɕi.] 邏輯).

English loanwords in Cantonese reveal a similar effect of sonority on adaptation patterns and serve as a proper cross-linguistically comparable case. Consider (7), where the data are cited and slightly modified in transcription from Silverman (1992), Yip (1993, 2006).

(7) Evidence from English-based loanwords in Cantonese

a. [ɹ] in monosyllabic loanwords

(i) Retention		(ii) Deletion	
<u>English</u>	<u>Cantonese</u>	<u>English</u>	<u>Cantonese</u>
b**r**eak	[.pik.**l**ik.]	p**r**ice	[.p^{h}aj.si.]
p**r**int	[.p^{h}i.**l**in.]	f**r**iend	[.fɛn.]
c**r**eam	[.key.**l**im.]	p**r**om	[.p^{h}ɒŋ.]
b**r**ake	[.pik.**l**ik.]	sp**r**ing	[.si.pɛŋ.]
		c**r**eep	[.kip.]

b. [ɹ] in polysyllabic loanwords

Deletion

<u>English</u>	<u>Cantonese</u>
p**r**inter	[.p^{h}ɛn.t^{h}a.]
b**r**oker	[.puk.k^{h}a.]
f**r**eezer	[.fi.sa.]
p**r**ofessor	[.p^{h}ow.fa.sa.]

p**r**oton	[.pow.tʰan.]
st**r**awberry	[.si.tɔ.pɛ.lej.]

c. Stops in monosyllabic and polysyllabic loanwords

Retention

English	Cantonese
s**t**ick	[.si.**t**ik.]
s**t**amp	[.si.**t**am.]
s**t**ore	[.si.**t**ɔ.]
S**p**ielberg	[.si.**pʰ**i.wo.]
s**p**anner	[.si.**p**a.la.]
s**t**rawberry	[.si.**t**ɔ.pɛ.lej.]

Cantonese does not allow [ɹ] in any position (Bauer & Benedict 1997). As the second or third onset in (7a, b), retention of [ɹ] can only be found in (7a)(i), where the English input is all monosyllabic, since [ɹ] is occasionally salvaged to ensure a minimally disyllabic output by Cantonese speakers, like most other quantity-sensitive Chinese languages, though such a prosodic preference may in other cases be overridden, as exemplified in (7a)(ii). In (7b), however, no retention appears when the English source has more than two syllables. In contrast, stops are always retained regardless of the syllable number of the source, as shown in (7c). Likewise, the sonority effect plays a crucial role in Cantonese data.

3.3 Similarity/Dissimilarity

As discussed, coda is the perceptually weakest position and thereby a postvocalic [ɹ] is subject to deletion when borrowed into L_R. Closer investigation, however, reveals that backness of the preceding vowel is highly influential. Refer to (8).

(8) Similarity-driven patterns

a. V[-back] + [ɹ]

L_S input	L_R UR	Process	Percentage
[.kʰæʃ.mɪ**ɹ**.] *Kashmir*	/.kʰɤ.ʂɨ.mi.**əɹ**./	Retention	65.22% (15/23)
[.æm.pʰɪ**ɹ**.] *ampere*	/.an.pʰei./	Deletion	34.78% (8/23)

b. V[+back] + [ɹ]

L_S input	L_R UR	Process	Percentage
[.dɑ**ɹ**.wɪn.] *Darwin*	/.ta.**əɹ**.wən./	Retention	5.58% (24/430)
[.kʰɑ**ɹ**.mən.] *Carmen*	/.kʰa.mən./	Deletion	94.42% (406/430)

Contrary to the general strategy of deletion for [ɹ]-codas, in context (a), where the nuclear vowel is [-back], 65.22% of the [ɹ]'s are retained through schwa insertion, and the rest, 34.78%, are deleted. In context (b), in which [ɹ] is preceded by a [+back] vowel, 94.42% [6] of them are deleted, with only 5.58% being retained. The distributions of the two categories seem asymmetric in that the contrast in the latter is significantly more drastic than that in the former.

What critically conditions the distributions above is the context, specifically the backness of the preceding vowel. Simply put, similarity between a pair of neighboring segments contributes to the extent of their confusability. In producing a retroflex approximant, the tongue tip is curled back toward the hard palate, whether or not it actually makes contact there (Bickford & Floyd 2006). To produce a [+back] vowel, likewise, the tongue is close to the back surface of the vocal tract. A retroflex thus bears a certain similarity to a [+back] vowel in that the articulation of both involves the back part of the oral cavity or the backward movement of the tongue. Under this rationale, in the sequence of "V[+back] + [ɹ]", the retroflex may in a sense "blend" with the precedent vowel, weakening the distinctiveness of the latter. By analogy, the ease of perception of [ɹ] when following a [-back] vowel, the production of which relies on the tongue root being rather forward, is therefore comprehensible.

In acoustic terms, the backness of vowels is primarily reflected in their second formant frequencies: front vowels have a high F2 and back vowels have a low F2. The F2 of [ɹ] is rather low, behaving like a [+back] vowel. Refer to (10).

(9) F2 of [-back] vowels, [+back] vowels, and liquids (based on Ladefoged 2001)

	[-back] vowels	[+back] vowels	Liquids
F2	1660-2250Hz	870-1100Hz	1000-1200Hz

In the sequence of "V[-back] + [ɹ]", the F2 transition undergoes a sharp fall, i.e. from 1660-2250Hz to 1000-1200Hz, whereas that in the "V[+back] + [ɹ]" sequence it is relatively flat, i.e. from 870-1100Hz to 1000-1200Hz, in a way that F2 does not change but simply lasts a bit longer. The "sharp" fall in the sequence of [-back] vowel plus [ɹ] endows [ɹ] with more robustness, yet the "flat" F2 transition in the sequence of [+back] vowel plus [ɹ] contributes to higher confusability of the latter (see also Epsy-Wilson 1992 for further details on the acoustic properties of semivowels). On this ground, the higher rate of retention of [ɹ] in a "V[-back] + [ɹ]" sequence than in "V[+back] + [ɹ]" is plausibly attributed to the salience hierarchy below, saying that

[6] The asymmetry between the "lower" 65.22% of retention in the salient context of (8a) and the "higher" 94.42% of deletion in the unsalient context of (8b) should be attributed to the markedness of /ɹ/ as the coda in Mandarin. For this I thank an anonymous reviewer.

the perceptual distinctiveness between [ɹ] and silence before a [-back] vowel is greater than that before a [+back] vowel.

(10) Salience hierarchy by similarity/dissimilarity

[ɹ] vs. Ø /V[-back]_ ➢ [ɹ] vs. Ø /V[+back]_

4. When phonetic salience encounters prosody

In 3.2, the prosodic preference for disyllabicity in Chinese languages is briefly discussed to explain the Cantonese data. In this section, we turn our attention back to Mandarin and see how phonetic salience interacts with prosody in loanword adaptation. Meanwhile, with a view to gaining a clearer picture that shows both effects we confine the data to monosyllabic source words with [ɹ]-codas[7], since the disyllabic tendency in Mandarin may be rendered invisible if the source word has more than two syllables already (the vowels are bound to be realized, and hence a polysyllabic underlying form is obligatory), as shown in (11).

(11) Patterns by similarity-prosody interaction

a. V[-back] + [ɹ]

Context	L_S input	L_R UR	Process	Percentage
(C)VR	[.k^{h}wiɹ.] *queer*	/.k^{h}u.əɹ./	Retention	100% (1/1)
with a cluster	[.p^{h}iɹs.] *Pierce*	/.p^{h}i.əɹ□sɨ./	Retention	100% (4/4)

b. V[+back] + [ɹ]

Context	L_S input	L_R UR	Process	Percentage
(C)VR	[.θoɹ.] *Thor*	/.swo.əɹ./	Retention	100% (2/2)
with a cluster	[.mɑɹk.] *Mark*	/.ma.k^{h}ɤ./	Deletion	100% (33/33)

Also discussed in 3.3, the backness of the preceding vowel plays a crucial role in the confusability of the [ɹ]-coda, and hence we classify the data into [ɹ]-codas with a [-back] preceding vowel and those with a [+back] preceding vowel. In each category the contexts are further divided in terms of contexts: one with [ɹ] as the simplex coda, and the onset, if any, is also a single consonant; the other with [ɹ] embedded in a complex coda, or with [ɹ] as the simplex coda but the onset is complex. The demarcation of whether or not there exists a consonant cluster either as the onset or as

[7] An analysis on monosyllabic loanwords is inevitable if we are to investigate the possible militating forces between phonetic salience and prosody, even though the number of monosyllabic tokens with /ɹ/-codas is relatively small. Like most Chinese languages, Mandarin has been claimed to be quantity-sensitive and is strongly constrained by the requirement of minimally binary feet, as supporting studies on loanword adaptation have been found in the literature (Silverman 1992, Yip 1993, Miao 2005, Lu 2006).

the coda in the source is to manifest the contrast. Without a cluster in the L_S syllable, disyllabicity will force the [ɹ]-coda to be realized as the second syllable in L_R underlying form. If there is a cluster, however, the consonant(s) excluding [ɹ] suffices for the second syllable without the need to realize the postvocalic [ɹ], and hence the sole factor of retention/deletion of it is its phonetic salience.

Unlike other categories discussed so far, no "exceptions" are spotted in the data driven by similarity-prosody interaction[8]. When the preceding vowel is [-back], in (11a), [ɹ] is always retained, whether or not there is a cluster in the L_S input. In (11b), however, when the vowel is [+back], the two contexts show variable results: in the context without a cluster, namely "(C)VR", [ɹ] is retained in both instances, but in the context with a cluster, [ɹ] is deleted in all the 33 cases.

The interaction between phonetic salience and prosody is obvious here. Preceded by a [-back] vowel, [ɹ] is so salient that it is always realized even if there is a cluster within the monosyllabic word, let alone the single instance where there is no cluster. Following a [+back] vowel, more interestingly, [ɹ] bears a great similarity to the vowel, and hence tends to be ignored when it is embedded in a complex coda or when the onset is complex, since "(C)VR" context, only the postvocalic [ɹ] can be realized as the second syllable, and accordingly its low phonetic salience has to yield to the obligatory foot binarity of L_R, resulting in its retention.

5. An OT analysis[9]

This section provides a standard OT-based analysis for the retention/deletion of English [ɹ]'s in the Mandarin speakers' mental representations, as discussed in the above two sections. As we will see, conventional OT may find it infeasible to capture the insight of the "patterned" lexical variation between retention and deletion of [ɹ] when the data reveal inconsistency, though it still successfully offers a sound resolution to the "absolute" patterns found in simplex onsets and those from monosyllabic source words.

[8] Possible exceptions are English *bar*, *beer*, *car*, *tsar*, and even *tart*, with a cluster, all of which surface as monosyllabic but are attached to"[.pa.] 吧" in "[.tɕjou.pa.] 酒吧" ('wine bar') and "[.ʂa.la.pa.] 沙拉吧" ('salad bar'), "[.pʰi.] 啤" in "[.pʰi.tɕjou.] 啤酒" ('beer wine'), "[.kʰa.] 卡" in "[.kʰa.tʂɤ.] 卡車" ('car vehicle'), "[.ʂa.] 沙" in "[.ʂa.xwaŋ.] 沙皇" ('tsar emperor'), and "[.tʰa.], 塔" in "[.tan.tʰa.] 蛋塔" ('egg tart'). They are excluded since their lexicalization relies on another morpheme that explicates its category in semantics, and the surface form turns out to be a polysyllabic word in L_R, which still respects the MINIMALWORD constraint in most Chinese languages. The chance to hear L_R speakers say these monosyllabic words in isolation is slim.

[9] For the detailed mechanism of OT, refer to Prince & Smolensky (2004) for the original work and McCarthy & Prince (1995) for their further development of Correspondence Theory.

5.1 Position-driven patterns

5.1.1 Simplex onset

As elaborated in 3.1, [ɹ] as the simplex onset enjoys perceptual privilege and is always retained in L_R UR, either as [l] or [ɹ]. The tableau in (12) gives a standard Optimality-Theoretic account for this.

(12) Max-R(._V), Ident-[liquid] (Retention: 100%)

[.ɹæm.bo.]	Max-R(._V)	Ident-[liquid]
a. ☞.**l**an.pʰwo.		
b. .an.pʰwo.	*W	
c. .**t**an.pʰwo.		*W

Max-R(._V) forbids deletion of simplex onset [ɹ] and Ident-[liquid] requires liquid-to-liquid mapping, with no crucial ranking in between. Compared to the winner, Candidate (b) is disfavored by Max-R(._V) for its deletion of [ɹ]. Ident-[liquid] favors the winner over Candidate (c) since [ɹ] is mapped to a stop. A potential winner is /.**ɹ**an.pʰwo./, but as elaborated in Footnote 3, the preference for [l] in L_R output should be attributed to the wider distribution of [l]-initial syllables in the L_R lexicon, i.e. constrained by the production grammar, and is out of our focus. For consistency, we adopt the intact L_R output form as the L_R UR (see Footnote 2 for details).

5.1.2 Second/third onset

When [ɹ] is embedded as the second/third consonant within a complex onset, the probability of retention is rather high at 87.84%, though it is lower than the perfect retention rate of simplex [ɹ]-onsets. Moreover, the process of deletion emerges in this category, accounting for 12.16%. In OT, it is thus a typical conflict between Max and Dep, and two variable rankings are needed.

On the one hand, 87.84% of the second/third onset [ɹ] is retained. Confined by the L_R syllable structure, the first onset (mostly a stop, e.g. [.o.**pʰ**ɹɑ.] *Oprah*, or [f], e.g. [.**f**ɹo.do.] *Frodo*) or both the first and second onset (mostly a fricative-stop sequence, e.g. /.**st**ɹæs.bəɹg./, *Strasberg*) in the source has to be retained in L_R via vowel insertion, since the onset of the target syllable in L_R is already “possessed” by the adjacent [l] (e.g. “[.ou.**pʰu**.la.] 歐普拉”, “[.**fo**.lwo.two.] 佛羅多” and “[.**ʂɨ.tʰɤ**.la.sɨ.pau.] 史特拉斯堡”, from *Oprah*, *Frodo* and *Strasberg* respectively). Under this rationale, the ranking along with an exemplifying tableau is given in (13) to account for this type.

Mandarin allows no complex margin in any position, so the structural constraint *CC ranks at the top. Max-R(.C(C)_V), prohibiting deletion of the second/third onset [ɹ], ranks at the middle with Ident-[liquid]. Dep-V is ranked at the bottom, owing to the inevitable vowel epenthesis for the retention of the first (or both the first and second) onset obstruent. With this ranking, Candidate (b) is disfavored by the undominated *CC and was ruled out. Ident-[liquid] favors the winner over Candidate (c) in that [ɹ] is realized as a stop. Max-R(.C(C)_V) favors the winner over Candidate (d) since the latter deletes the second onset [ɹ] from the input. Candidate (a) wins the evaluation though Dep-V at the bottom favors all losers.

(13) *CC >> Ident-[liquid], Max-R(.C(C)_V) >> Dep-V (Retention: 87.84%)

[.o.p^{h}**ɹ**ɑ.]	*CC	Ident-[liquid]	Max-R(.C(C)_V)	Dep-V
a. ☞.ou.p^{h}u.**l**a.				*
b. .ou.p^{h}**ɹ**a.	*W			L
c. .ou.p^{h}u.**t**a.		*W		L
d. .ou.p^{h}a.			*W	L

To account for the remaining 12.16% that undergo deletion, Dep-V is promoted to the middle with Ident-[liquid] and Max-R(.C(C)_V) is demoted to the bottom, See (14).

(14) *CC >> Ident-[liquid], Dep-V >> Max-R([C(C)_V] (Deletion: 12.16%)

[.laɪ.k^{h}**ɹ**ə.]	*CC	Ident-[liquid]	Dep-V	Max-R(.C(C)_V)
a. ☞.lai.k^{h}a.				*
b. .lai.k^{h}**ɹ**a.	*W			L
c. .lai.k^{h}a. **t**a.		*W	*W	L
d. .lai.k^{h}a. **l**a.			*W	L

Candidate (b), with a complex onset, is disfavored by the highest *CC. Candidates (c) and (d) are penalized by Dep-V for the epenthetic /a/ in /k^{h}a/, though they are both favored by the loser-favoring Max-R(.C(C)_V). The winning Candidate (a) is favored by all constraints except for the bottomed Max-R(.C(C)_V).

The percentage of 12.16% is too significant to be deemed exceptional. The only way out in standard OT is to re-rank the constraints, which not only vacuously leads to multiple grammars, but also fails to capture the effects of phonetic salience that influence the distribution. We will see more such cases as we move on.

5.1.3 Coda

Adaptation of [ɹ]-codas reflects a mirror image to that of [ɹ]-onsets, in which deletion is the major process (91.39%) and retention is found in significantly fewer cases (8.61%). The two variable outcomes, likewise, demand two independent ranking arguments, as illustrated in (15) and (16).

The structural constraint CodaCon acts as a package that assigns a violation mark to any single segment that does not conform to the requirement for a well-formed coda (a single [n], [ŋ], or [ɹ] in the [əɹ] syllable, see Section 2 for details) in Mandarin. Like *CC, which regulates the onset structure, CodaCon should be undominated too. In (15) and (16), CodaCon disfavors both candidate (b)'s, since, as noted in Section 2, [ɹ] is an illicit coda except for the syllable [əɹ]. In (15), Dep-V ranks higher than Max-R(V_), so deletion results, while in (16), Max-R(V_) dominates Dep-V and therefore the candidate in which the [ɹ] is retained via vowel insertion wins.

(15) CodaCon >> Dep-V >> Max-R(V_) (Deletion: 91.39%)

[.nɔɹ.mən.]	CodaCon	Dep-V	Max-R(V_)
a. ☞.nwo.man.			*
b. .no**ɹ**.man.	*W		L
c. .nwo.**əɹ**.man.		*W	L

(16) CodaCon >> Max-R(V_) >> Dep-V (Retention: 8.61%)

[.hɔɹ.mon.]	CodaCon	Max-R(V_)	Dep-V
a. ☞.xɤ.**əɹ**.moŋ.			*
b. .xɤ**ɹ**.moŋ.	*W		L
c. .xɤ.moŋ.		*W	L

5.2 Sonority-driven patterns

Subsection 3.2 gives the rationale that adjacency to a vowel induces a reversed phonetic salience hierarchy when compared to the standard sonority scale; that is, the more sonorant a segment is, the less salient it is in "_V" and "V_" contexts, and vice versa. This assumption is later illustrated by the comparison between adaptations of [ɹ] and stops, repeated here: 1) as the simplex onset, both consonants are 100% retained, 2) as the second or third onset, [ɹ] is retained 87.84% of the time, and retention of stops is found in 100% of the data, and 3) as the coda, [ɹ] is retained in only 8.61% of cases, while for stops retention occurs in 62.83% of cases. Within OT, likewise, a fixed single ranking suffices to cope with an absolute pattern with no variation involved, but constraint re-ranking becomes inevitable in tackling optionality. To pinpoint the discrepancy between [ɹ] and stops in phonetic salience, we give an analysis of codas, i.e. the position where the most noticeable difference in phonetic salience between them can be observed. Since [ɹ]-codas are discussed in 5.1.3, now consider the stop codas in (17) and (18).

Like [ɹ]-codas, retention or deletion of a stop coda relies on the mutual ranking between Max and Dep; that is, provided that Max-T(V_.) ranks over Dep-V, retention happens, but when Dep-V outranks Max-T(V_.), deletion results. Both constraint rankings are thus required to account for loanwords like (17) and (18). Contrary to [ɹ]-codas, as exemplified in (15) and (16), the main adaptation for stop codas is retention, with deletion the secondary tendency.

(17) CodaCon >> Max-T(V_.) >> Dep-V (Retention: 62.83%)

[.gɑɹ.nɪ**t**.]	CodaCon	Max-T(V_.)	Dep-V
a. ☞.tɕja.nai.**tʰɤ**.			*
b. .tɕja.nai**t**.	*W		L
c. .tɕja.nai.		*W	L

(18) CodaCon >> Dep-V >> Max-T(V_.) (Deletion: 37.17%)

[.dʒæ.nɪ**t**.]	CodaCon	Dep-V	Max-T(V_.)
a. ☞.tʂən.ni.			*
b. .tʂən.ni**t**.	*W		L
c. .tʂən.ni.**tʰɤ**.		*W	L

5.3 Similarity/Dissimilarity-driven patterns

As discussed in 3.3, the retention/deletion of an [ɹ]-coda is highly conditioned by the backness of the preceding vowel; i.e. retention occurs more often (65.21%) when the vowel is [-back], whereas deletion takes place in overwhelmingly more cases (94.41%) when the vowel is [+back]. The asymmetric distributions in the two contexts are assumed to be patterned by the similarity/dissimilarity between the two adjacent sounds: [ɹ] is less similar to a [-back] vowel, i.e. more distinctive, so it tends to be retained in the context of "V[-back] + [ɹ]", while it is more similar to a [+back] vowel, i.e. more confusable, and thus subject to deletion in the "V[+back] + [ɹ]" context. The two seemingly separate contexts can be considered within a constraint set if Max-R(V_) breaks down into Max-R(V[-back]_) and Max-R(V[+back]_).

In (19a), where the nuclear vowel is [-back], the candidate where [ɹ] is retained by inserting a schwa wins out since Max-R(V[-back]_) ranks over Dep-V. On the contrary, in (19b), where [ɹ] is preceded by a [+back] vowel, deletion results due to the dominance of Dep-V over Max-R(V[+back]_). Reverse ranking, however, leads to the opposite outcomes, as shown in (20).

(19) CodaCon >> Max-R(V[-back]_) >> Dep-V >> Max-R(V[+back]_)

a. V[-back] + [ɹ] (retention: 65.22%)

[k.ʰæʃ.mɪɹ.]	CodaCon	Max-R(V[-bk]_)	Dep-V	Max-R(V[+bk]_)
a. ☞.kʰɤ.ʂɨ.mi.**əɹ**.			*	
b. .kʰɤ.ʂɨ.mi**ɹ**.	*W		L	
c. .kʰɤ.ʂɨ.mi.		*W	L	

b. V[+back] + [ɹ]: (deletion: 94.42%)

[.kʰɑɹ.mən.]	CodaCon	Max-R(V[-bk]_)	Dep-V	Max-R(V[+bk]_)
a. ☞.kʰa.mən.				*
b. .kʰa**ɹ**.mən.	*W			L
c. .kʰa.**əɹ**.mən.			*W	L

(20) CodaCon >> Max-R(V[+back]_) >> Dep-V >> Max-R(V[-back]_)

a. V[-back] + [ɹ] (Deletion: 34.78%)

[.æm.pʰɪɹ.]	CodaCon	Max-R(V[+bk]_)	Dep-V	Max-R(V[-bk]_)
a. ☞.an.pʰei.				*
b. .an.pʰei**ɹ**.	*W			L
c. .an.pʰei.**əɹ**.			*W	L

b. V[+back] + [ɹ] (Retention: 5.58%)

[.daɹ.wɪn.]	CodaCon	Max-R(V[+bk]_)	Dep-V	Max-R(V[-bk]_)
a. ☞.ta.**əɹ**.wən.			*	
b. .ta**ɹ**.wən.	*W		L	
c. .ta.wən.		*W	L	

With Max-R(V[+back]_) outranking Dep-V, an [ɹ] following a [+back] vowel is retained by way of vowel epenthesis, yet an [ɹ] after a [-back] vowel is deleted, a result that is contrary to (20) and is found in fewer cases.

5.4 Patterns by similarity-prosody interaction

In this category, we intend to see what happens when an L_R speaker has to make a choice between phonetic salience and prosodic preference if meeting one requirement inevitably goes against the other. Noted in Section 4, the data are confined to monosyllabic L_S words such that the prosodic effect may emerge. Unlike most patterns that show lexical variations, all the tendencies are absolute (i.e. no exceptions are found) and can be analyzed through a single categorical constraint ranking. The tableaux in (21) show the constraint ranking in action.

(21) CodaCon, MinimalWord >> Max-R(V[-back]_) >> Dep-V >> Max-R(V[+back]_)

a. V[-back] + [ɹ]: (C)VR (Retention: 100%)

[.kʰwiɹ.]	CodaCon	MinWd	Max-R(V[-bk]_)	Dep-V	Max-R(V[+bk]_)
a. ☞.kʰu.**əɹ**.				*	
b. .kʰu**ɹ**.	*W	*W		L	
c. .kʰu.		*W	*W	L	

b. V[-back] + /ɹ/: with a cluster (Retention: 100%)

[.pʰiɹs.]	CodaCon	MinWd	Max-R(V[-bk]_)	Dep-V	Max-R(V[+bk]_)
a. ☞.pʰi.**əɹ**.sɨ.				**	
b. .pʰi**ɹ**.sɨ.	*W			*L	
c. .pʰi.sɨ.			*W	*L	

c. V[+back] + /ɹ/: (C)VR (Retention: 100%)

[.θoɹ.]	CodaCon	MinWd	Max-R(V[-bk]_)	Dep-V	Max-R(V[+bk]_)
a. ☞.swo.**əɹ**.				*	
b. .swo**ɹ**.	*W	*W		L	
c. .swo.		*W		L	*W

d. V[+back] + /ɹ/: with a cluster (Deletion: 100%)

[.mɑɹk.]	CodaCon	MinWd	Max-R(V[-bk]_)	Dep-V	Max-R(V[+bk]_)
a. ☞.ma.kʰɤ.				*	*
b. .ma**ɹ**.kʰɤ.	*W			*	L
c. .ma.**əɹ**.kʰɤ.				**W	L

That obedience to prosody takes precedence over phonetic salience is obvious here. MinimalWord, prohibiting the output from having less than two syllables, is added to the ranking at the top[10] with CodaCon, as it is never violated in the data. Retention is the strategy in both (21a) and (21b), showing that [ɹ] is retained insofar as the preceding vowel is [-back], whether or not there is a cluster in the input. This indicates that [ɹ] after a [-back] vowel is so salient that it is still realized even if the speaker has other consonant(s) to choose from as the second syllable in the adapted form. However, when the preceding vowel is [+back], it becomes less distinctive: in (21c), it survives in the "(C)VR" context since [ɹ] is the only consonant to be realized as the second syllable in L_R, but it is easily ignored when the speaker has another consonant that is perceptually more prominent, i.e. an obstruent, to retain as the

[10] Readers may argue that MinimalWord may not always rank as highest throughout Mandarin loanword phonology, with evidence found in "[.dɑn.] *Don* → [.tʰaŋ.] 唐", "[.jɑŋ.] *Young* → [.jaŋ.] 楊", "[.pʰaʊnd.] *pound* → [.paŋ.] 磅", "[.tʰʌn.] *ton* → [.tun.] 噸", and the like, most of which, however, are terms of family names or units of measurement. We plausibly assume that extragrammatical (social/semantic) factors may be influential. If this assumption is true, such monosyllabic output must pertain to production, rather than perception.

second syllable.

5.5 Summary

As observed thus far, pure phonetic factors that contribute considerably to the extent of salience (i.e. position, sonority, and similarity/dissimilarity) are mapped to the speaker's perception grammar yet must yield to the structural constraints that originate from the native phonology. In general, markedness constraints that regulate the L_R structure both segmentally and suprasegmentally are undominated (*CC, CodaCon, and MinimalWord). What follows is the faithfulness constraints (Max, Dep, and Ident family), within which the ranking between Max-R and Dep-V reflects the salience of [ɹ] endowed by either the external contexts (position and the preceding vowel) or the internal acoustic intensity (sonority). What constitutes a theoretical problem to a standard OT-based analysis, as given in this section, is the paradoxical ranking arguments proposed to deal with variations. It is thus claimed that adopting a stochastic view toward data with systematic optionality may provide a parsimonious account with a single grammar. Moreover, it makes reference to the precise probability via the numerical position of a constraint relative to the others on the linear scale.

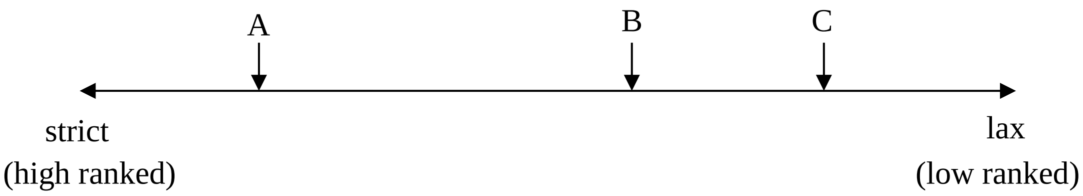
6. A Stochastic-OT analysis

In this section, we first give a brief introduction to the key ingredients of Stochastic OT, and reexamine the data that involve variations with probabilities as discussed in the previous section. As we will see, with its crucial notions of viewing constraints as ranges of value on a continuous scale, rather than points, and the inevitable overlapping area, i.e. where free rankings occur, that is incurred by the closeness of two neighboring constraints, Stochastic OT serves as a tenable model to encode the lexical variations in loanword adaptation.

6.1 A brief introduction to stochastic evaluation

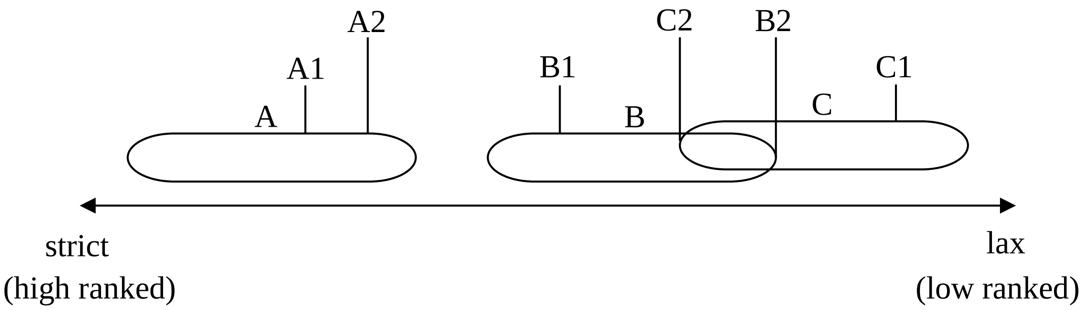
Stochastic candidate evaluation originally appears in the development of Boersma's (1997, 1998) Gradual Learning Algorithm (GLA) and Boersma & Hayes's (2001) empirical application of GLA, an error-driven algorithm that simulates the phonological learning of a (fragment of a) constraint-based grammar. What is unique to the algorithm is the type of Optimality-theoretic grammar it advocates. Rather than a set of ranked constraints that are essentially discrete from one another, it features a continuum of constraint strictness on which each constraint is assigned a certain value. Higher values correspond to higher-ranked, less violable constraints, and vice versa. The schema in (22) presents a categorical ranking, where Constraint A >> Constraint B >> Constraint C, though it might be said that Constraint A outranks Constraint B more than Constraint B outranks Constraint C.

(22) A continuous ranking scale (categorical)



Under no circumstances will the ranking alter provided each constraint falls on a **point** of the scale. The continuous scale, however, is of more theoretical significance if each constraint is equally assigned a **range** of value, rather than a single point on the scale. The assumption is realistically grounded in that at *evaluation time*, i.e. the moment of speaking, a random positive or negative value of noise is added to the *ranking value* (the permanent central point on a constraint range), and the resultant value used at actual evaluation time is termed the *selection point*. In this scenario, the dominance between two constraints may be less fixed if their ranking values are close enough to cause an overlapping area, where the ranking between them is unspecified, depending on which selection points are chosen as the real values. This is shown below:

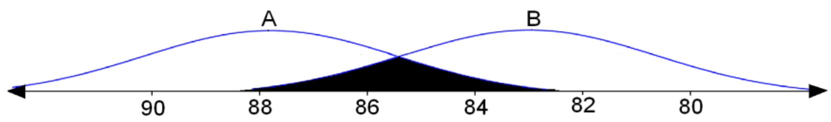
(23) A continuous ranking scale with ranges



As depicted in (23), Constraint A is too far from the other constraints to overlap, and hence it is ranked highest in both evaluations. In the first evaluation time (Selection Point 1), B1 is higher than C1, a ranking that takes place in most cases for the higher ranking value of Constraint B. In the second evaluation, however, C2 outranks B2, because it happens that the speaker chooses the bottom value of Constraint B and the top value of Constraint C. Such a ranking, though possible, will still be rarer since it may only occur in the comparatively small overlapping area.

A noteworthy concept along these lines is that the random noise perturbation, namely the constraint range in this realm, that takes place in the real world can be properly portrayed as bell-curved *normal* (/*Gaussian*) *distribution*, where 68.27% of the selection points reside within one standard deviation (σ) from the mean (μ) on both sides, 95.45% within two σ's, and 99.73% within three. Any probability falling beyond μ ± 3σ becomes vanishingly low. The event of overlapping ranking distributions is illustrated below (Boersma & Hayes 2001):

(24) Overlapping ranking distributions



Stochastic evaluation is in nature applied to simulated learning algorithms in which relative constraint positions that are in conflict with the current ranking hypothesis may shift on the ranking scale as the algorithm is "fed" with more correct linguistic input. In our study, this mechanism is found to be highly workable on the lexical variations with optionality in loanword adaptation. The difference, however, is that the adult speaker's grammar in dealing with loanwords should be fixed (though the selected values within the overlapping area are variable), unlike the moveable ranking values of constraints as those working in GLA. Another discrepancy lies in the claim that the "fixed" loanword phonology is hardly acquired or learned, at least in the phase of determination of retention/deletion of an input element, but instead judged by both phonetic cues and native phonology.

6.2 Probabilistic variations by position

In 5.1, we related different positions in a syllable to the phonetic salience of [ɹ]. In this subsection, we give a Stochastic-OT resolution to the patterned variation in respect of syllable position, which is found in second/third onsets and codas.

6.2.1 Second/third onset

In 5.1.2, we had to propose two variable ranking arguments within OT to account for the alternation between retention and deletion of [ɹ] as the second/third onset in the input. The rankings, along with their percentages of occurrence, are given in (25).

(25) Variable rankings for second/third onsets

Strategy	Constraint ranking	Percentage
Retention	*CC >> Ident-[liquid], Max-R(.C(C)_V) >> Dep-V	87.84%
Deletion	*CC >> Ident-[liquid], Dep-V >> Max-R(.C(C)_V)	12.16%

From a stochastic viewpoint, the ranking values of Max-R(.C(C)_V) and Dep-V have to be close enough to incur an overlapping area, the overlapping "degree" of which, however, is judged by the involved probability of each ranking. Following the convention of most Stochastic-OT works, we adopt an arbitrary value of 2.0 as the evaluation noise (σ), and thus the range should cover 12 units (nearly 100% fall in 3 σ's on both sides). The initial state of constraints is given the arbitrary value of 100. Though there should be no "starting point" (in Boersma's original works) in the current fixed adult grammar, we place the constraints in this neighborhood for the sake of consistency. Through mathematical calculation, the ranking values are obtained and listed in (26).

(26) Ranking for second or third onsets

Constraint	Ranking value
*CC	135.56
Ident-[liquid]	102.63
Max-R(.C(C)_V)	102.63
Dep-V	93.55

*CC is arbitrarily assigned the ranking value 135.56 so it is sufficiently high to avoid overlapping with the other constraint ranges. The ranking value 102.63 for both Ident-[liquid] and Max-R(.C(C)_V), and 93.55 for Dep-V, however, incur an overlapping area of 24.32% of each, indicating that the lower Dep-V may still 12.16% (half of 24.32%) possibly outrank Ident-[liquid] and Max-R(.C(C)_V). In (27), we apply the ranking values to genuine loanword data with hypothetical selection points.

A common selection results in retention of [ɹ] through Max-R([C(C)_V) >> Dep-V, while a rare yet possible choice is deletion of [ɹ] via the reversed ranking.

(27) Hypothetical selection points and results 1 (CSP: common selection points, RSP: rare selection points)

	Max-R(.C(C)_V)	Dep-V	Result	Example
CSP	103.92	98.87	Retention	[.o.pʰɹɑ.] → /.ou.pʰu.la./
RSP	97.38	99.23	Deletion	[.laɪ.kʰɹə.] → /.lai.kʰa./

6.2.2 Coda

Subsection 3.1 discusses how codas, as opposed to onsets, bear the least phonetic prominence within a syllable. In 5.1.3, Max-R(V_) and Dep-V are ranked variably but in a reversed manner with regard to their distribution as compared to (27), as repeated in (28).

(28) Variable rankings for codas

Strategy	Constraint ranking	Percentage
Deletion	CodaCon >> Dep-V >> Max-R(V_)	91.39%
Retention	CodaCon >> Max-R(V_) >> Dep-V	8.61%

Based on the distribution, as done in 6.2.1, we provide a stochastic approach to the otherwise paradoxical problem:

(29) Ranking for codas (Ver. 1)

Constraint	Ranking value
CodaCon	135.56
Dep-V	93.55
Max-R(V_)	83.62

CodaCon is ranked at the same height as *CC for inviolability. Max-R(V_) is assigned a value that is generally lower than Dep-V but overlapping is still inevitable. With the ranking values assigned to Dep-V and Max-R(V_), the overlapping area will be 17.22% of each, so the odds that Max-R(V_) outranks Dep-V is 8.61%. In (30), likewise, we illustrate both the common and rare results. In 6.4, we will revisit this category by taking the backness of the preceding vowel into consideration.

(30) Hypothetical selection points and results 2

	Dep-V	Max-R(V_)	Result	Example
CSP	97.1	86.45	Deletion	[.nɔɹ.mən.] → /.nwo.man./
RSP	88.78	89.35	Retention	[.hɔɹ.mon.] → /.xɤ.əɹ.moŋ./

6.3 Probabilistic variation by sonority

As discussed in Subsection 3.2, despite a lower sonority than liquids, stops are nonetheless presumably more phonetically distinctive when adjacent to a vowel. The effect is observable in the coda position. Subsection 5.2 provides the responsible rankings, reconstructed in (31):

(31) Variable rankings for stop codas

Strategy	Constraint ranking	Percentage
Retention	CodaCon >> Max-T(V_.) >> Dep-V	62.83%
Deletion	CodaCon >> Dep-V >> Max-T(V_.)	37.17%

Stochastically, (32) lists the ranking values arrived at by calculation.

(32) Ranking for stop codas

Constraint	Ranking value
CodaCon	135.56
Max-T(V_.)	96.63
Dep-V	93.55

The close ranking values of Max-T(V_.) and Dep-V induce a large overlapping area of 74.34% of each, and the probability that the selection point of the generally lower Dep-V is higher than Max-T(V_.) is then 37.17%. See (33) for examples.

(33) Hypothetical selection points and results 3

	Max-T(V_)	Dep-V	Result	Example
CSP	100.58	92.7	Retention	[.gɑɹ.nɪ**t**.] → /.tɕja.nai.**tʰɤ**./
RSP	93.2	97.66	Deletion	[.dʒæ.nɪ**t**.] → /.tʂən.ni./

Comparing (27) with (33), despite retention being the major strategy due to the generally higher covered range of Max-R constraints over Dep-V on the scale, the overlapping extent of Max-T(V_.) and Dep-V is greater than that of Max-R(.C(C)_V) and Dep-V. This reveals that probabilities of retention/deletion in the former are "more even" than those in the latter (notionally two completely overlapping constraints incur a fifty-fifty probabilistic distribution of one dominating the other).

6.4 Probabilistic variation by similarity/dissimilarity

Subsection 5.3 formulates the asymmetric patterns of [ɹ]-codas induced by the backness of the preceding vowel, and the distribution reveals a remarkable contrast due to the effects of similarity/dissimilarity. Refer to (34).

(34) a. Constraint ranking 1: CodaCon >> Max-R(V[-back]_) >> Dep-V >> Max-R(V[+back]_)

Context	Strategy	Percentage	Example
V[-back]+[ɹ]	Retention	65.22%	[.kʰæʃ.m**ɪɹ**.] → /.kʰɤ.ʂɨ.mi.**əɹ**./
V[+back]+[ɹ]	Deletion	94.42%	[.kʰ**ɑɹ**.mən.] → /.kʰa.mən./

b. Constraint ranking 2: CodaCon >> Max-R(V[+back]_) >> Dep-V >> Max-R(V[-back]_)

Context	Strategy	Percentage	Example
V[-back]+[ɹ]	Deletion	34.78%	[.æm.pʰɪ**ɹ**.] → /.an.pʰei./
V[+back]+[ɹ]	Retention	5.58%	[.da**ɹ**.wɪn.] → /.ta.**əɹ**.wən./

What is for sure is that Dep-V is sandwiched between Max-R(V[-back]_) and Max-R(V[+back]_), while their respective ranking values are determined by to what extent the two Max-R constraints overlap with Dep-V on each side. Based on the data, the responsible ranking values are listed as follows:

(35) Ranking for codas (added)

Constraint	Ranking value
CodaCon	135.56
Max-R(V[-back]_)	97.2
Dep-V	93.55
Max-R(V[+back]_)	82.89

As mentioned in 6.1, the closer the ranking values are, the larger the resultant overlapping area will be, which in turn infers a higher probability for the reversed ranking to occur. This is well illustrated in this case, where the percentage of [ɹ]-deletion after a [-back] vowel (34.78%) is way higher than that of [ɹ]-retention after a [+back] vowel (5.58%).

6.5 Summary

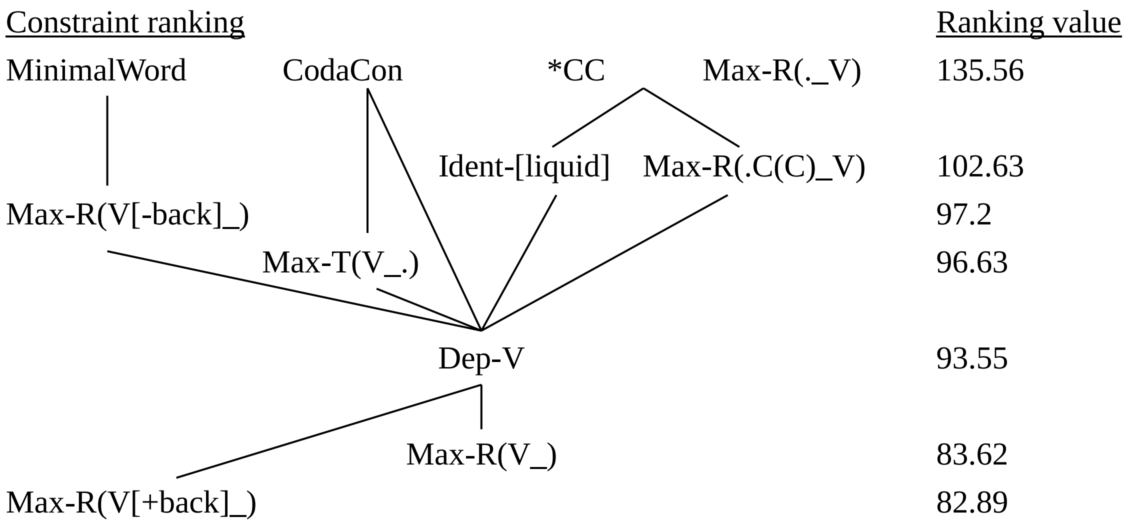
This section begins with a brief introduction to the working mechanism in stochastic candidate evaluations. The ranking paradoxes confronted in a standard-OT analysis in Section 5 are resolved from a Stochastic-OT viewpoint. The ranking values obtained thus far are summarized in (36), including the categorical rankings derived from 5.1.1 for simplex onsets and 5.4 for similarity-prosody interaction.

(36) Summary ranking values

Constraint	Ranking value
Max-R(._V)	135.56
*CC	135.56
CodaCon	135.56
MinimalWord	135.56
Ident-[liquid]	102.63
Max-R(.C(C)_V)	102.63
Max-R(V[-back]_)	97.2
Max-T(V_.)	96.63
Dep-V	93.55
Max-R(V_)	83.62
Max-R(V[+back]_)	82.89

The relative positions of the constraints can be presented more clearly through combining them with the style of a Hasse diagram, as sketched below:

(37) Ranking values in a Hasse diagram



Unlike the linear scale as used in GLA, whereby the ranking is presented horizontally, the above hierarchy is displayed in a vertical manner and therefore both the dominance relationship and the precise numerical ranking values can be manifested.

7. Conclusion

Based on a thorough investigation into Mandarin adaptation of English loanwords, the seemingly contradictory strategies of retention/deletion of [ɹ] are answered from the perspective of phonetic salience and its interaction with Mandarin prosody, as reflected in the percentage distribution of retention/deletion. Specifically, it is claimed that position, sonority and similarity/dissimilarity constitute the degree of salience: first onsets are perceptually the most prominent compared to second/third onsets and codas, stops are more distinctive than [ɹ] in the context of "_V" or "V_" for their lower sonority on the scale, and finally [ɹ] is phonetically more similar to, and thus more confusable with, a [+back] vowel. A more distinctive element is plausibly more subject to retention and a less distinctive one to deletion. Though lexical variations are widely found, the proportion is patterned by the above effects. As somewhat against the general tendency to retain a phonetically salient segment, when faced with a dilemma between low phonetic salience and the prosodic preference for binary feet, Mandarin speakers seem without exception to sacrifice the former and form a minimally disyllabic output.

The various effects of phonetic salience are mapped to the interaction of Max-R constraints and Dep-V in the OT framework. The dominance of Max-R over Dep-V leads to retention of [ɹ], and the reverse results in deletion of it. Due to the restriction of strict dominance between constraints in standard OT, the only solution to lexical variation is constraint re-ranking, which lacks the theoretical consistency and predictability of the probabilistic distribution between the two repair strategies.

A Stochastic-OT approach, however, has successfully dealt with the paradoxical problems posed by conventional OT. The advantages are twofold. First, Stochastic OT holds a single ranking by viewing constraints as ranges of value on a continuous strictness scale, and the overlapping area of two constraints, where free ranking may occur, becomes inevitable when the ranking values are sufficiently close to one another. Second, inheriting its superiority in modeling altering rankings in an error-driven learning algorithm, stochastic candidate evaluation also accounts for the probabilistic lexical variations in loanword adaptation.

What may need to be done to verify the effects of phonetic salience in loanword adaptation is an experimental research into the perception of [ɹ] in different contexts. A phoneme monitoring test, for example, may be appropriate for the perceptual salience of a postvocalic [ɹ] after vowels of different backness values. The results of the recorded RTs and error rates submitted to measures of ANOVAs, if they meet our expectations, will further provide our arguments with solid experimental grounds.

References

Anttila, Arto. 1997. Deriving variation from grammar. *Variation, Change and Phonological Theory*, ed. by Frans Hinskens, Roeland van Hout and Leo Wetzels, 35-68, Amsterdam /Philadelphia: John Benjamins.

Anttila, Arto. 2002. Morphologically conditioned phonological alternations. *Natural Language and Linguistic Theory* 20:1-42.

Bauer, Robert S. and Paul K. Benedict. 1997. *Modern Cantonese Phonology*. Berlin: Mouton de Gruyter.

Beckman, Jill. 1998. Positional Faithfulness. Doctoral dissertation, University of Massachusetts, Amherst.

Boersma, Paul. 1997. How we learn variation, optionality, and probability. *Proceedings of the Institute of Phonetic Sciences*, 21:43-58. Amsterdam: University of Amsterdam.

Boersma, Paul. 1998. Functional Phonology: Formalizing the Interactions between Articulatory and Perceptual Drives. Doctoral dissertation, University of Amsterdam. LOT International Series. 11. The Hague: Holland Academic Graphics.

Boersma, Paul, and Bruce Hayes. 2001. Empirical tests of the gradual learning algorithm. *Linguistic Inquiry* 32.1:45-86.

Broselow, Ellen. 2005. Stress adaptation in loanword phonology: Perception and learnability. Paper presented in the Workshop of "Speech perception within or outside phonology?" Cologne, Germany.

Espy-Wilson, and Carol Y. 1992. Acoustic measures for linguistic features distinguishing the semivowels /w j r l/ in American English. *Journal of the Acoustical Society of America* 92:736-757.

Inkelas, Sharon, and Cheryl Zoll. 2007. Is grammar independence real? A comparison between cophonological and indexed constraint approaches to morphologically conditioned phonology. *Linguistics* 45.1:133-171.

Kang, Yoonjung. 2003. Perceptual similarity in loanword adaptation: English postvocalic word-final stops in Korean. *Phonology* 20:219-273.

Kenstowicz, Michael. 2003a. Salience and similarity in loanword adaptation: a case study from Fijian. Manuscript, MIT.

Kenstowicz, Michael. 2003b. The role of perception in loanword phonology. A review of *Les emprunts linguistiques d'origine europénne en Fon* by Flavien Gbéto, Köln: Rüdiger Köppe Verlag, 2000. *Studies in African Linguistics*

32:95-112.

Labrune, Laurence. 2002. The prosodic structure of simple abbreviated loanwords in Japanese: a constraint-based account. *Journal of the Phonetic Society of Japan* 6.1:98-120.

Ladefoged, Peter. 2001. *A course in phonetics*. 4th ed. Fort Worth, Tex: Harcourt Brace Jovanovich College Publishers.

Lin, Yen-Hwei. 2007a. Loanword adaptation of English vowels in standard Mandarin. *NACCL-18: Proceedings of the 18th North American Conference on Chinese Linguistics*, ed. by Janet Xing, 331-342. Los Angeles, CA: University of Southern California.

Lin, Yen-Hwei. 2007b. *The Sounds of Chinese*. Cambridge: Cambridge University Press.

Lin, Yen-Hwei. 2008a. Variable vowel adaptation in Standard Mandarin loanwords. *Journal of East Asian Linguistics* 17:363-380.

Lin, Yen-Hwei. 2008b. Patterned vowels variation in Standard Mandarin loanword adaptation: Evidence from a dictionary corpus. *NACCL-20: Proceedings of the 20th North American Conference on Chinese Linguistics*, ed. by Marjorie Chan and Hana Kang, 175-184. Columbus, Ohio: East Asian Studies Center, The Ohio State University.

Lu, Mingchang. 2006. An Optimality Theory Approach to English and Southern Min Loanwords in Mandarin. MA Thesis, National Taiwan Normal University, Taiwan.

McCarthy, John, and Alan Prince. 1995. Faithfulness and Reduplicative Identity. *University of Massachusetts Occasional Papers in Linguistics 18: Papers in Optimality Theory*, ed. by Jill Beckman, Laura Walsh Dickey & Suzanne Urbanczyk, 249-384. Amherst: GLSA.

McCarthy, John J. 2008. *Doing Optimality Theory*. Malden, MA & Oxford: Blackwell.

Miao, Ruiqin. 2005. Loanword Adaptation in Mandarin Chinese: Perceptual, Phonological and Sociolinguistic Factors. Doctoral dissertation, Stony Brook University, New York.

Paradis, Carole. 1995. Derivational constraints in phonology: Evidence from loanwords and implications. *Proceedings of the Chicago Linguistics Society*, ed. by Audra Dainora, Rachel Hemphill, Barbara Luka, Barbara Need and Sheri Pargman, 360-374. Chicago: CLS.

Paradis, Carole. 1996. The inadequacy of filters and faithfulness in loanword adaptation. *Current Trends in Phonology*, ed. by Jacques Durand and Bernard Laks. Salford: University of Salford Publications.

Paradis, Carole and Darlene LaCharité. 1997. Preservation and minimality in loanword adaptation. *Journal of Linguistics* 33.1:379-430.

Prince, Alan, and Paul Smolensky. 2004. *Optimality Theory: Constraint Interaction in Generative Grammar*. Malden, MA: Blackwell Pub.

Shih, Lijen. 2004. Consonantal and Syllabic Adaptations in English Loanwords in Mandarin. MA thesis, Michigan State University, Michigan.

Shinohara, Shigeko. 2001. Emergence of universal grammar in foreign word adaptations. *Fixing Priorities: Constraints in Phonological Acquisition*, ed. by Rene Kager, Joe Pater and Wim Zonneveld. Cambridge: Cambridge University Press.

Shinohara, Shigeko. 2004. Perceptual effects in consonant deletion patterns in loanword phonology. Manuscript, CNRS.

Steriade, Donca. 2001b. The phonology of perceptibility effects: the p-map and its consequences for constraint organization. Manuscript, UCLA.

Yip, Moira. 1993. Cantonese loanword phonology and optimality theory. *Journal of East Asian Linguistics* 1.1:261-291.

Yip, Moira. 2002. Necessary but not sufficient: Perceptual loanword influences in loanword phonology. *The Journal of the Phonetic Society of Japan*. *Special issue on Aspects of loanword phonology* 6.1:4-21.

Yip, Moira. 2006. The Symbiosis between Perception and Grammar in Loanword Phonology. *Lingua* 116:950-975.

Zuraw, Kie. 2010. A model of lexical variation and the grammar with application to Tagalog nasal substitution. *Nat Lang Linguist Theory* 28:417-472.

[Received March 19, 2013; revised July 22, 2013; accepted November 28, 2013]

Graduate Institute of Linguistics
National Chengchi University
Taipei, TAIWAN
Mingchang Lu: oliver_yen@yahoo.com.tw

顯著性與韻律在借字調整中之模式化：以國語中英語借字的[ɹ]為例

呂明昌

國立政治大學

本文探討顯著性與韻律如何影響借字過程中型態化的詞彙變異，並以英語/ɹ/在國語中對應調整的保留與刪除為例。在語料庫的基礎上，儘管/ɹ/在國語中的去留呈現變異，然其比例分配卻由數個語音顯著性及韻律的因素決定，前者為位置、響度與相似度/相異度，後者為國語的雙音節韻律傾向。此借字調整的型態化分配，適合以機率優選理論（Boersma 1997 and 1998, Boersma and Hayes 2001）模式化。該理論將制約視為在線性化嚴格度上量化的範圍，而兩個衝突制約排序值之間的距離，可決定兩範圍值是否重疊或重疊的程度，此重疊區也是支配關係可以反轉，進而造成變異的區域。

關鍵詞：借字調整、詞彙變異、語音顯著性、位置、響度、相似度、雙音節音步、機率優選理論