A Stochastic-OT Account for English Liquid Codas in Mandarin

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This paper gives a Stochastic-OT analysis of the adaptation of postvocalic liquids from English to Mandarin, asserting that its nature of seeing constraints as ranges of value offers a more unified resolution to the rich variation observed in loanword adaptation. The retention or deletion of the liquid relies greatly on the perceptibility of the liquid and the prosodic requirement of the native language. The observed tendencies are projected to the assignment of raking values of constraints on the linear scale by which precise probabilities can be predicted.

Keywords: postvocalic liquids, loanword adaptation, Stochastic Optimality Theory phonological theory

1. Introduction

Ever since the introduction of Optimality Theory (hereafter OT, Prince and Smolensky 1993/2004), loanword phonology has gained intensive attention through its key notions of violable constraints that suitably model the oftentimes contradicting demands of preservation of input information and the conformity with the sound system of the recipient language (Yip 1993, 2002, 2006, Paradis 1995, 1996, Kenstowicz 2001, 2003, Shinohara 2001, 2004, Labrune 2002, Kang 2003, Shih 2004, Miao 2005, Lu 2006, Lin 2009, among many others). One question, however, that remains unanswered through the fixed constraint ranking in conventional OT and deserves serious reconsideration is the coexistence of adaptation forms by way of both retention and deletion of excess consonants in the source. This paper intends to offer a resolution to the variation between retention and deletion of an ill-formed coda consonant in the word-borrowing process, induced by the phonotactics of the recipient language, within the framework of Stochastic Optimality Theory (hereafter Stochastic OT, Boersma 1997 and 1998, Boersma and Hayes 2001), and examines the adaptation of liquid codas of English loanwords and transliterations ('loanwords' throughout) in Mandarin as the preliminary study. With the central ideas of seeing constraints as ranges of value on a continuous scale, Stochastic OT serves to properly formalize the variation in adaptation strategy within one single constraint ranking, since the dominance of one constraint over the other may be reversed in the overlapping area of their ranges. The otherwise multiple constraint rankings intended for variable output forms in classic OT may seem theoretically untenable.

In the rest of this paper, Section 2 briefly introduces the relevant phonotactic basics of the two languages, and presents the adaptation patterns of the liquid in each context with examples. The factors responsible for the patterns are also discussed. Section 3 is the Stochastic-OT analysis, preceded by a potentially problematic OT account. This paper is concluded in Section 4.

2. Phonotactics and the data

English allows maximally four consonants in the coda position, as in '[tʰɛksts]' (*texts*), and all of its consonants can appear in this position. Mandarin has 21 consonants, while 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'), where an onset consonant is also forbidden. Liquids, if any, are bound be adjacent to the nucleus vowel under the government of SSP. Despite the legitmate structure of [əɹ] in Mandarin, an English input containing [əɹ] does not obligatorily surface as [əɹ] in Mandarin, e.g. '[əɹg] *Erg* → [əɹ21.gɤ35] 爾格', but '[həɹts] *Hertz*→ [xɤ53.tsɨ55] 赫茲'.

All the loanwords in discussion are based on the loanword corpus originally built in Lu (2006), now containing 1,472 English loanwords in Mandarin. Among them, 69 monosyllabic loanwords with liquids in coda position, either as a singleton consonant (e.g. [fɪl] *Phil* → [fei55.əɹ21] '菲爾') or as part of a consonant cluster (e.g. [fɪld] *Field* → [fei55.əɹ21.tɤ35]

‘菲爾德’), are chosen for analysis. Critically, we simply select monosyllabic words and exclude polysyllabic ones due mainly to our attempt to explore the interaction between prosodic and perceptual factors in the adaptation process, since the effect of disyllabic preference in Mandarin may become invisible if the source has more than two syllables already. The adaptation patterns of each category along with examples are given in (1)[1].

(1) Adaptation patterns of English liquid codas in Mandarin

a. Retention (L: liquid, LC(C): liquid + consonant(s))

	Coda type	Number	Total	Percentage	Example (English→Mandarin)		
V[-back]	L	23	23	100%	[jɛl] *Yale*	→	[je.lu] 耶魯
	LC(C)	7	8	87.5%	[wels] *Wales*	→	[wei.ər.sɨ] 威爾斯
V[+back]	L	8	9	88.89%	[dʒul] *Joule*	→	[tʂu.ər] 珠兒
	LC(C)	5	29	17.24%	[gɑlf] *golf*	→	[gau.ər.fu] 高爾夫

b. Deletion

	Coda type	Number	Total	Percentage	Example (English/Mandarin)		
V[-back]	L	0	23	0%		NA	
	LC(C)	1	8	12.5%	[aɪlts] *IELTS*	→	[ja.sɨ] 雅思
V[+back]	L	1	9	11.11%	[kʰul] *cool*	→	[kʰu] 酷
	LC(C)	24	29	82.76%	[volt] *volt*	→	[fu.tʰɤ] 伏特

When the vowel is [-back], a following liquid is bound to be retained if it is the only coda consonant and nearly bound to be retained if it is part of a consonant cluster in coda through vowel (and sometimes with a glide) epenthesis. When the vowel is [+back], on the other hand, the liquid as a singleton consonant in coda is still greatly liable to retention, but it becomes vulnerable and tends to be deleted if the liquid is embedded in a consonant cluster. The contrasts shown by the demarcation between vowels with distinctive properties of backness may seem asymmetric at first glance, but they are attributable to the interaction between perceptual and prosodic factors militating against one another. First, for both British and American English speakers, a syllable-final lateral, or a ‘dark l’, is pronounced with the center

[1] Tones in Mandarin are not the main concern in this paper and are thus ignored to save space.

of the tongue pulled down and the back arched upward like a back vowel, a process known as 'velarization' (Ladefoged 2001). When producing a retroflex approximant, likewise, the tongue tip is curled back toward the hard palate, whether or not it actually makes contact there (Bickford and Floyd 2006). Either way, a liquid sound is similar to a [+back] vowel in that the articulation of both involves the back part or the backward movement of the tongue. Hence, in the sequence of 'V[+back] + L', the liquid in a sense 'blurs' with the preceding vowel, weakening the perception of the latter in such an environment. By analogy, the ease of perception of liquids after a [-back] vowel is predictable with the reverse rationale. This articulation-induced similarity is also reflected in their acoustic properties of F2. Refer to (2).

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

	[-back] vowels	[+back] vowels	Liquids
F2	**1600-2300Hz**	**900-1100Hz**	**1100Hz**

It is widely known in acoustic phonetics that the second formant frequency correlates with the degree of backness of the vowel: significantly higher for front vowels and lower for back vowels. In the sound sequence of 'V + L', the F2 transition from a [-back] vowel to a liquid undergoes a dramatic drop, from 1600-2300Hz to 1100Hz, while that from a [+back] vowel to a liquid is 'flatter', from 900-1100Hz to 1100Hz, in a sense that F2 does not change but simply lasts a bit longer. It is accordingly the 'sharper fall' of F2 transition during 'V[-back] + L' that makes the postvocalic liquid robust and the 'overlapping' F2 transition during 'V[+back] + L' that weakens the perception of the postvocalic liquid.

The above reasoning may well account for the overwhelmingly dominant strategy of retention of the liquid following a [-back] vowel whether it is a singleton consonant or within a longer consonant cluster, but the asymmetry of retention and deletion between coda types 'L' and 'LC(C)' after a [+back] vowel remains unsolved. The answer is the prosodic preference for disyllabicity: as the only coda consonant, the disyllabic requirement prevail over the perceptual weakness of the liquid and forces the liquid to surface via vowel epenthesis as the second syllable. As part of a consonant cluster, in contrast, the perceptually weak liquid is not the only choice and hence apt to be deleted, allowing the other consonant(s) to be preserved to form a disyllabic or polysyllabic output. To map the contradicting forces to a phonological theory, however, the problem is that every tendency has some exceptions. In what follows, we first conduct a standard OT analysis to see the potential flaws within this framework. Next we turn to Stochastic OT, a later version of OT, for a more tenable explanation for the same data.

3. The Analyses

Before we go further to Stochastic OT, let us try a conventional OT-account first. Optimality Theory proposes that differences among languages reside in the language-specific rankings of violable universal constraints. Generally, there are two types of constraints, namely markedness, which regulates the structure of the output forms, and faithfulness, which prohibits divergence between input and output. In the case of English loanwords in Mandarin, the English phonetic form is the input to Mandarin speakers, and the potential outputs are evaluated by faithfulness constraints requesting the input-output similarity, but are meanwhile governed by markedness constraints on the well-formedness of Mandarin.

3.1 Constraints

Based on the phonotactics of Mandarin, the markedness constraints on coda in (3) and (4) are relevant to this study.

(3) *Complex^{Cod}: Assign one violation mark for every complex coda.

(4) No-Coda(liquid): Assign one violation mark for every liquid in coda position, except for [ɹ] in [əɹ].

Constraint (3) forbids a consonant cluster to be the syllable coda, and the constraint in (4) excludes liquids as the coda consonant in Mandarin, with the only exception of [ɹ] in the '[əɹ]' syllable. Moreover, Mandarin, like other quantity-sensitive languages, highly prefers two syllables as the minimal size of a word by Foot-Binarity. The constraint defined in (5) is thus mostly observed, though not as dominantly as (3) and (4).

(5) MinimalWord: Assign one violation mark for every word that has fewer than two syllables.

The other type of constraints that advance the identity between input and output are the faithfulness constraints, which may militate against the well-formedness constraints since observance of them may threaten the legitimacy of the output structure. Refer to (6) and (7).

(6) Max-liquid: Assign one violation mark for every liquid in the input that does not have a correspondent in the output.

(7) Dep-V: Assign one violation mark for every vowel in the output that does not have a correspondent in the input.

Max-liquid prohibits deletion of liquids, while Dep-V is against vowel insertion. The choice between retention and deletion of the liquid relies on the mutual ranking of the two constraints. The above constraints are proposed for the two constraint-based theorems below.

3.2 Paradox in OT

The adaptation of liquids reveal a variety of tendencies, which can be clarified by the demarcation of the backness values of the preceding vowel as well as whether the liquid is the singleton coda or embedded in a consonant cluster. It is then plausible to attribute them to a set of sub-grammars. In what follows, we separately discuss the adaptation of liquids preceded by [-back] and [+back] vowels.

3.2.1 V[-back] + Liquid

When the preceding vowel is [-back], a critical assumption is that Max-liquid outranks Dep-V, considering the predominantly high percentages (100% as a singleton coda and 87.5% as part of a cluster) of retention. Though MinimalWord is never violated in this group of data, it is still ranked lower than the two coda markedness constraints, since violations against it can still be found in other loanword data. The ranking argument in (8) activates obligatory retention of the liquid as a singleton coda and the tableau[2] in (9) illustrates this category.

(8) Ranking argument of liquid coda in 'V[-back] + L'

*Complex^{Cod}, No-Coda(liquid) >> MinimalWord >> Max-liquid >> Dep-V

(9) English: [jɛl] *Yale* Mandarin: [je.lu] 耶魯

[jɛl]	*Comp^{Cod}	No-Coda(liq)	MinWd	Max-liq	Dep-V
a. ☞ je.lu					*
b. jɛl		*W	*W		L
c. jɛ			*W	*W	L

By outranking MinimalWord and Max-liquid over Dep-V, the liquid is retained by way of vowel epenthesis. The ranking argument in (8) predicts the correct outputs of most of the liquids in a cluster just as well, as exemplified in (10).

[2] The tableaux throughout this paper are presented in a combination fashion (McCarthy 2008), whereby candidates are listed to the left and constraints on the top in the order of their ranking, as in a traditional violation tableau. An asterisk refers to a violation of a certain constraint. A "W" next to the asterisk(s) in a loser's row means under the evaluation of this constraint, the Winner is favored, while an "L" in a cell indicates that the Loser is favored by another constraint. Since a constraint favoring a loser has to be dominated by a constraint favoring the winner for the winner to win, there must be a W to the left of an L in the same row.

(10) English: [wɛlz] *Wales* Mandarin: [wei.əɹ.sɨ] 威爾斯

[wɛlz]	*Comp^Cod	No-Coda(liq)	MinWd	Max-liq	Dep-V
a. ☞ wei.**əɹ**.sɨ					*
b. wɛ**l**z	*W	*W	*W		L
c. wei.sɨ				*W	L

An OT-account seems rather feasible thus far. The same ranking, however, fails to account for the only one exception, '[aɪlts] *IELTS* → [ja.sɨ] 雅思', as (11) shows.

(11) English: [aɪlts] *IELTS* Mandarin: [ja.sɨ] 雅思

[aɪlts]	*Comp^Cod	No-Coda(liq)	MinWd	Max-liq	Dep-V
a. 👎 ja.**əɹ**.sɨ					*
b. aɪ**l**ts	*W	*W	*W		L
c. ? ja.sɨ				*W	

Candidate (a) would be the optimal output, rather than the de facto [ja.sɨ]. There is no way for a single grammar that predicts both retention and deletion of the same segment. An inevitable solution then is to reverse the ranking of Max-liquid >> Dep-V into Dep-V >> Max-liquid, as in (12).

(12) English: [aɪlts] *IELTS* Mandarin: [ja.sɨ] 雅思

[aɪlts]	*Comp^Cod	No-Coda(liq)	MinWd	Dep-V	Max-liq
a. ☞ ja.sɨ					*
b. aɪ**l**ts	*W	*W	*W		L
c. ja.**əɹ**.sɨ				*W	L

The problem is that even within such a delicate demarcation of environments, namely 'a liquid consonant in a consonant cluster in a monosyllabic structure', there still have to be two independent sub-grammars under standard OT, which renders the analyses pointless. An alternative is to admit the coexistence of multiple sub-grammars, as Cophonology (Anttila 2002, Zoll & Inkelas 2005) points out, where the choice among variable rankings is free by the speaker. Yet they still fail to predict the precise tendencies of each.

3.2.2 V[+back] + Liquid

Let us now turn to liquids preceded by [+back] vowels. Unlike liquids after a [-back] vowel, where both contexts of 'VL' and 'VLC(C)' indicate a roughly consistent pattern, liquids of this category, however, reveal asymmetric tendencies. Let us examine the latter situation first. For liquids as part of a cluster, an initial argument is that the relatively weak perception of liquids in this environment should be translated into OT by ranking Dep-V higher than Max-liquid. Accordingly, when the liquid is part of a cluster, where the liquid is the least probable choice to surface, the main-stream repair strategy is to delete it (82.76%). The ranking argument for this adaptation is given in (13), and the tableau illustrating this ranking appears in (14).

(13) *Complex^{Cod}, No-Coda(liquid) >> MinimalWord >> Dep-V >> Max-liquid

(14) English: [volt] *volt* Mandarin: [fu.tʰɤ] 伏特

[volt]	*Comp^{Cod}	No-Coda(liq)	MinWd	Dep-V	Max-liq
a. ☞ fu.tʰɤ					*
b. volt	*W	*W	*W		
c. fu.əɹ.tʰɤ				*W	

With the crucial ranking of Dep-V over Max-liquid, candidate (a), which deletes the liquid, wins over candidate (c), which preserves it via vowel insertion and segmental change. Likewise, the constraint ranking is soon challenged by cases with retention of the liquid and must be revised through the converse ranking of Max-liquid >> Dep-V, as shown in (15).

(15) English: [gɑlf] *golf*   Mandarin: [gau.əɹ.fu] 高爾夫

[gɑlf]	*Comp^{Cod}	No-Coda(liq)	MinWd	Max-liq	Dep-V
a. ☞ gau.əɹ.fu					*
b. gɑlf	*W	*W	*W		L
c. gau.fu				*W	L

Similar to liquids following a [-back] vowel, we are confronted with a paradox in the adaptation of liquids after a [+back] vowel too: a theory may become untenable with the coexistence of two independent grammars that lead to contradictory phonological processes in a single language. The situation is not any better when the liquid is the singleton coda, since both cases with retention and deletion are also observed, with the only difference that , conversely, retention remarkably outnumbers deletion (88.89% to 11.11%). However, the scenario is not the battle between Max and Dep anymore, but between MinimalWord and Dep-V instead. The high probability for a liquid to survive in the environment 'V[+back] + L' is not due to the dominance of Max-liquid over Dep-V, but attributed to that of MinimalWord over Dep-V. Consider (16).

(16) English: [dʒul] *Joule*   Mandarin: [tʂ̩u.əɹ] 珠兒

[dʒul]	*Comp^{Cod}	No-Coda(liq)	MinWd	Dep-V	Max-liq
a. ☞ tʂ̩u.əɹ				*	
b. dʒul		*W	*W	L	
c. tʂ̩u			*W	L	*W

In (16), the primary competitor (c) is eliminated by the fatal violation of the higher ranked MinimalWord, which allows candidate (a) to survive as the winning candidate at the expense of violating Dep-V, which outranks Max-liquid. It is interpreted that the prosodic preference for two syllables in Mandarin overrides the perceptual weakness of liquids preceded by [+back] vowel in English.

Unexceptionally, even such a prominent prosodic structure in Mandarin may yield to the liquid's perceptual weakness, which is translated to OT through the dominance of Dep-V over MinimalWord. Observe the interjection loanword in (17), which is widely used by younger generations in Taiwan.

(17) English: [k^hul] *cool* Mandarin: [k^hu] 酷

[k^hul]	*Comp^{Cod}	No-Coda(liq)	Dep-V	MinWd	Max-liq
a. ☞ k^hu				*	*
b. k^hul		*W		*	L
c. k^hu.əɹ			*W	L	L

The victory of the monosyllabic candidate (a), though disfavored by Mandarin prosody, over candidate (c) is resultant from the violator against the higher Dep-V of the latter.

The analyses done thus far are summarized in (18).

(18) Summary of OT analyses

	Type	Retention	%	Deletion	%
V[-back]	VL	Max-liq >> Dep-V	**100%**	NA	0%
	VLC(C)	Max-liq >> Dep-V	**87.5%**	Dep-V >> Max-liq	**12.5%**
V[+back]	VL	MinWd >> Dep-V	**88.89%**	Dep-V >> MinWd	**11.11%**
	VLC(C)	Max-liq >> Dep-V	**17.24%**	Dep-V >> Max-liq	**82.76%**

It follows that we may need up to seven sub-grammars to deal with the whole possibilities within OT, which features fixed constraint rankings. A theoretical architecture with higher unity is thus prompted.

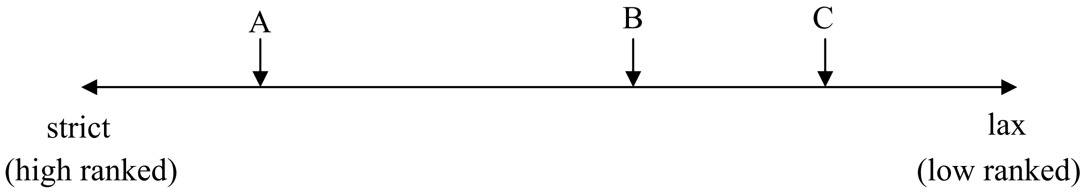
3.3 A Stochastic-OT analysis

In this subsection, we first give a brief introduction of Stochastic OT, followed by the reexamination of the same data appearing in the previous subsection under this theory.

3.3.1 Stochastic Optimality Theory

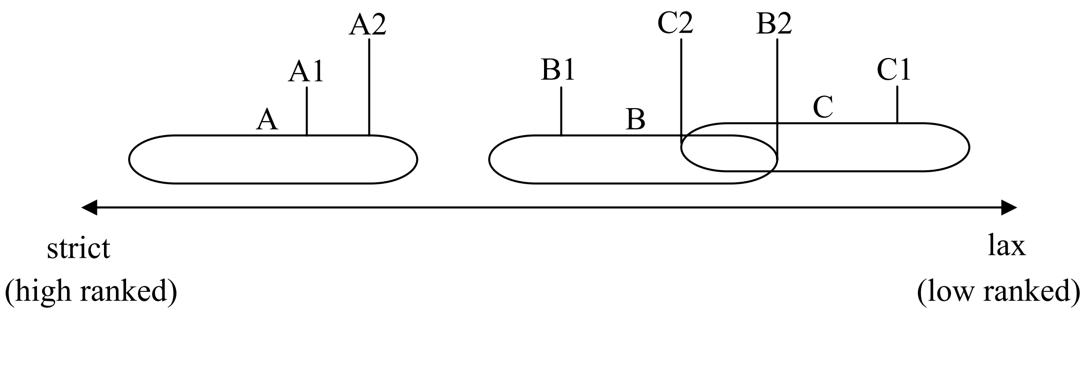
Based on the Optimality-Theoretic framework, Stochastic OT features a linear scale of constraint strictness. On the scale, each constraint falls on a certain point, which is given a value. Higher values correspond to higher-ranked constraints, and vice versa. The schema in (19) reveals a categorical ranking, where constraint A >> constraint B >> constraint C.

(19) A continuous ranking scale (categorical)



The idea of a continuous ranking scale is of more theoretical significance if each constraint is assigned a "range" of value, rather than a single point on the scale, on grounds 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 central point of a constraint range), and the resultant value used at actual evaluation time is termed the *selection point*. Under this assumption, 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 free, depending on which selection points are chosen as the real values:

(20) A continuous ranking scale with ranges



As depicted in (20), constraint A is too far from the other constraints to overlap, and hence it is ranked highest in both evaluations. In selection points 1, constraint B1 is higher than B2. This is a more common ranking since the ranking value along with its range of constraint B is higher than those of constraint C most of the time. In selection points 2, however, constraint 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, can still be predicted to be rarer since it only occurs in the comparatively small overlapping area.

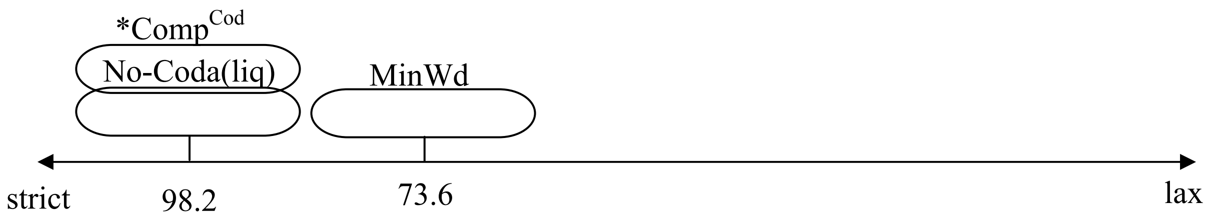
3.3.2 The analyses

In this study, the range of value for each constraint is hypothesized as 20. Beginning with the placement of the undominated markedness constraints on coda in both contexts, we assume that they are arranged to the very left on the scale, with the arbitrary ranking value of 98.2, as schematized in (21).

(21) Coda markdness constraints on the scale

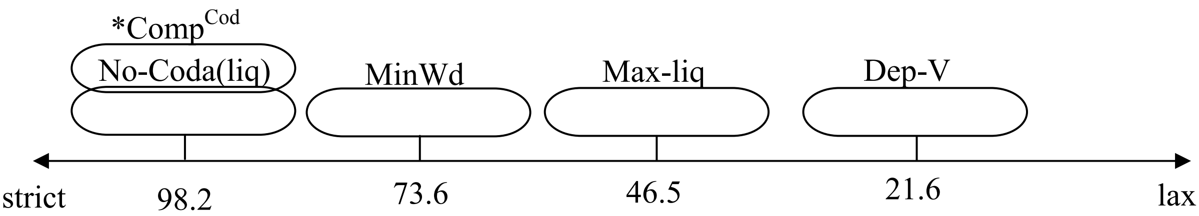
Secondly, the ranking value of MinimalWord is assigned 73.6, simply to ensure its sufficient distance from the coda markedness constraints to avoid an overlapping area.

(22) The prosodic markdness constraint on the scale



We are now ready for the specific situations after the arrangement of markedness constraints are all set. First, in the context of 'V[-back] +L', deletion never happens, and this leads to the absolute separation between Max-liquid and Dep-V, of which the ranking values are assigned 56.5 and 21.6 through mathematical calculation. The final schema is thus achieved in (23).

(23) Constraint ranking of 'V[-back] +L' along the continuous scale



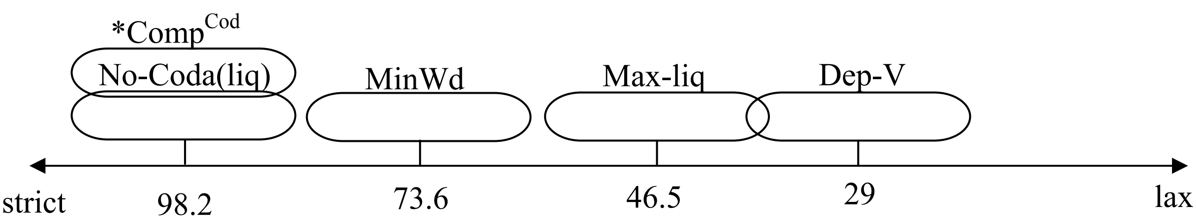
With the constraint assignment on the scale, the output is bound to undergo deletion of the liquid with no exception, as illustrated below.

(24) Illustrative stochastic evaluations of 'Yale' and 'Claire'

Input	Max-liq	Dep-V	Result	Output	Gloss
a. [jɛl]	48.73	19.26	Retention	[je.**lu**]	'Yale'
b. [klɛɹ]	41.63	26.4	Retention	[kʰɤ.lai.**ə**ɹ]	'Claire'

With no overlapping area, any selection points that fall in the ranges of Max-liquid and Dep-V will trigger deletion of the liquid. As for the context of 'V[-back] +LC(C)', 87.5% of the liquids are preserved and 12.5% of them are deleted, indicating that Max-liquid and Dep-V should overlap to some extent. Again, we arrive at the schema in (25) through calculation.

(25) Constraint ranking of 'V[-back] +LC(C)' along the continuous scale



The calculation process is specified as follows. The bottom value of Max-liquid is 36.5 (46.5 −20÷2). The overlapping area accounts for 2.5 (20×12.5%) on the scale. The top value of Dep-V can thus be obtained by adding 2.5 to 36.5, which equals to 39. The central point, i.e. the ranking value, of Dep-V can be worked out by 39 minus 10 (half length of the range), which amounts to 29. See (26) for evaluation examples.

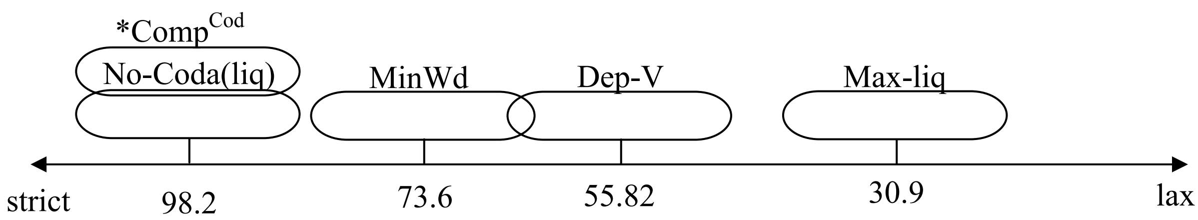
(26) Illustrative stochastic evaluations of 'Wales' and 'IELTS'

Input	Max-liq	Dep-V	Result	Output	Gloss
a. [wɛlz]	45.42	31.89	Retention (common)	[wei.əɹ.sɨ]	'Wales'
b. [aɪlts]]	37.2	38.76	Deletion (rare)	[ja.sɨ]	'IELTS'

87.5% of the outputs undergo retention, and hence (26a) represents the common result, whereas (26b), where deletion occurs, is the case that happens less frequently.

Now turn to the context of '[+back] + L', whereby 88.89% of the liquids are retained while 11.11% of them are deleted. This is stochastically schematized in (27).

(27) Constraint ranking of 'V[+back] +L' along the continuous scale



The ranking value 55.82 of Dep-V is derived from the same mathematical rationale as specified above. The relative positions of MinimalWord and Dep-V lead to the inevitable overlapping area of 11.11% of each range, precisely the percentage of the rarer cases with deletion. Illustrative evaluations are given in (28).

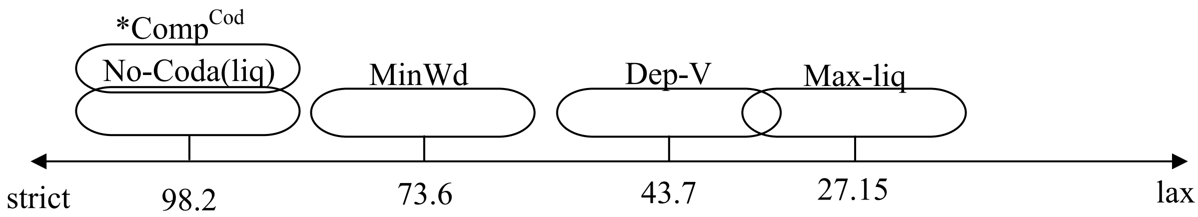
(28) Illustrative stochastic evaluations of ‘Joule’ and ‘cool’

Input	MinWd	Dep-V	Result	Output	Gloss
a. [dʒul]	76.35	53.12	Retention (common)	[tʂu.əɹ]	‘Joule’
b. [k^{h}ul]	63.9	64.66	Deletion (rare)	[k^{h}u]	‘cool’

As the majority of MinimalWord is completely higher than Dep-V, (28a), with retention, serves as the more common result, and (28b) exemplifies the output structure with deletion, though the chance is slim.

The patterns shown in the context of ‘[+back] _LC(C)’ are roughly the mirror image of ‘[+back] + L’: retention drops dramatically to 17.24% and deletion soars to 82.76%. Obviously it is once more a story back to Max-liquid and Dep-V, with MinimalWord being no more active. The distribution leads us to the schema in (29). Later, consider (30).

(29) Constraint ranking of ‘V[+back] +LC(C)’ along the continuous scale



(30) Illustrative stochastic evaluations of ‘volt’ and ‘golf’

Input	Dep-V	Max-liq	Result	Output	Gloss
a. [volt]	42.88	21.39	Deletion (common)	[fu.t^{h}ɤ]	‘volt’
b. [gɑlf]	34.1	36.41	Retention (rare)	[gau.əɹ.fu]	‘golf’

As Dep-V is generally higher than Max-liquid on the scale, deletion turns out to be the standard repair strategy and retention to be uncommon.

3.3.3 Summary

All the analytical results are summarized in (31) for clearer comparisons.

(31) Ranking values of constraints in each sub-grammar (range length: 20)

	*Complex^{Cod}	No-Coda(liquid)	MinimalWord	Max-liquid	Dep-V
a. [-back] + L	98.2	98.2	73.6	46.5	21.6
b. [-back] +LC(C)	98.2	98.2	73.6	46.5	29
c. [+back] + L	98.2	98.2	73.6	55.82	30.9
d. [+back] +LC(C)	98.2	98.2	73.6	43.7	27.15

The enclosed ranking values indicate that the two constraints involved are close enough to overlap (b, c, d), and therefore the 'common' ranking may be reversed within that area. Such reversals of constraint ranking, however, never happen so long as they are completely separated (a). The numerals in the table, though some of them are hypothetical, are meaningful in that they reveal the positional information of the constraints, by which we may estimate the incidence of variation.

4. Conclusion

The adaptation patterns of liquid codas in Mandarin loanwords from English are found to be the results of two forces that may be conflicting: the perceptibility of the postvocalic liquid in a certain environment (the backnesss of the preceding vowel) in the source and the prosodic preference for the minimal syllable number in the target. The rich variation posts a problem to classic OT in that numerous independent constraint rankings are responsible. This paper offers a Stochastic-OT resolution, where constraints are defined as ranges of value and free ranking takes place within the overlapping area. Such a mechanism is considered to well simplify the analyses, and to better capture the nature of language variation.

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以機率優選理論分析國語中英語借字的流音韻尾調整現象

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本文以機率優選理論分析英語借字，並著眼於母音後的流音在國語中之調整樣貌。本理論將制約視為量化的範圍，可為借字中豐富的音韻調整現象，提供較為單一之解釋。流音之去留決定於該流音的感知度以及借入語言的韻律結構要求。觀察到的調整樣貌皆投射於線性尺度上制約排序值的分配，從而準確預測去留之可能性。

關鍵詞：母音後流音、借字調整、機率優選理論、音韻理論