

Perceptual influences in Cantonese loanword phonology

Moira Yip, University College London

Loanword adaptation as a window into phonology has grown steadily in importance in recent years, as this volume attests. The goal of this contribution is to broaden the scope of this book beyond Japanese to other East Asian languages, particularly Chinese. Two early papers on loanword phonology concern Cantonese - Silverman 1992, and Yip 1993 - and I use these as my starting point. First, I will take an updated look at some of the claims in the literature in the light of nearly ten years of intervening work on the phonetics-phonology interface and in Optimality Theory. Second, I extend the data coverage and analysis to vowel adaptations. The largest body of data are from English loans into Cantonese, but I will also include some facts from Mandarin, and even Maori.

The paper has two main parts. In the first part, I review consonant adaptations, in which excess consonants are either salvaged by epenthesis, or deleted. I begin by suggesting that, contra the usual OT view of loanword adaptation (including Yip 1993), it may not be possible to account for all the facts with an unadorned host language grammar, and that we may need to add a faithfulness constraint specific to loanword adaptation, which I will call MIMIC. Still focussing on consonants, I then argue that loanword data confirm recent research that proposes direct reference to perceptual information in the phonology proper, since liquid deletion in Cantonese is conditioned by a combination of perceptual non-salience and a purely phonological prosodic output requirement. In the second part of the paper I look at vowel adaptation, and explore to what extent acoustic similarity determines the choice of vowel. I will suggest that visual cues also play a role, and that mimicking vowel quality and length is less important than mimicking the pitch contour and the syllable type. The parallels to L1 acquisition are striking.

1. Consonant adaptation and the initial-state ranking of Faithfulness constraints

1.1 Standard OT view of loanword phonology:

A standard OT view of loanword phonology maintains that it is simply the host language grammar acting on the new foreign inputs, and that there is no such thing as a “loanword phonology”. If this is correct, the constraint rankings must be either detectable and identical both in the host language and in loans, or at least detectable in loans, and compatible with the host language phonology (Broselow et al 1998, 1999, Shinohara, 2001). In the latter case, any “extra” rankings which could not have been learnt on the basis of the host language should presumably be those of the UG initial state, meaning either an unmarked ranking, or possibly constraints which are unranked with respect to each other.

Paradis (1995, 1997) has questioned the validity of this hypothesis, on the following grounds. She begins by observing that there is a cross-linguistic preference for excess consonants to be retained in loans, rather than deleted. She then suggests that OT cannot explain this preference, because the choice between retention and deletion depends on the relative ranking of MAX/DEP, and thus each should occur in roughly 50% of the world’s languages. This does not necessarily follow. Suppose in UG $MAX \gg DEP$ is the unmarked and initial ranking. In that case only languages which provide the learner with positive evidence for re-ranking DEP above MAX would show deletion, and the preference for retention would be expected. We thus arrive at two much more limited claims

- (i) If the host language has marked $DEP \gg MAX$, so should the loans

(ii) A single host language should have a single loanword phonology
 Unfortunately, both these predictions appear to be false.

A counter-example to the first prediction would be a language which demonstrably deletes excess consonants in its native phonology, but which retains excess consonants in loans, with epenthesis. The closest I have found to this at present is Maori, although Hale (1973) suggests an alternative view of Maori which does not involve deletion, so the argument is not as strong as it could be. The facts are as follows. Maori verb roots end in consonants, and these surface before a vowel-initial suffix, as in the passive and gerund forms below, but delete in the unsuffixed form, since Maori does not allow codas:

(1) *Deletion in host language: DEP >> MAX*

		<i>Passive</i>	<i>Gerund</i>	
/inum/	inu	inumia	inumaja	'drink'
/hopuk/	hopu	hopukia	hopukaja	'catch'
/maatur/	maatu	maaturia	maaturaja	'know'

In loans from English, by contrast, excess consonants are deleted (data from de Lacy, p.c.)

(2) *Retention in loans: apparent MAX >> DEP*

kirimi	'cream'	ha:riata	'chariot'
wu:ru	'wool'	hanarete	'hundred'

Unlike in acquisition, an adult steady-state grammar does not change radically under exposure to a limited number of new inputs. Instead I propose that Maori continues to rank DEP >> MAX, and that loanword consonant retention is a symptom of a high-ranked constraint I will call MIMIC. MIMIC is the OT instantiation of active loan word incorporation, and enforces faithfulness to the percept. In Maori, MIMIC >> DEP >> MAX. MIMIC is a faithfulness constraint, but it relates the output to a specific sub-type of input, a demonstrably foreign form. Under this view, loanword phonology is the native phonology, plus one extra element, namely a family of MIMIC constraints. We will see this in action later in the paper.

The second prediction - that one host language should have one loanword phonology - is falsified by Mandarin. Lin (1998) gives data showing a strong bias towards consonant retention in mainland Chinese Mandarin, but deletion in Taiwanese Mandarin. Although there are differences in the two varieties of Mandarin, they do not seem to be relevant to explaining these differences. In particular, both have the same simple CVC syllable structure, with codas limited to nasals. Yet a consonant like the final /k/ of *Titanic* is retained with epenthesis on the Mainland (left column) but deleted in Taiwan (right column).

(3)

<i>Mainland : preservation</i>	<i>Taiwan: deletion</i>	<i>English</i>	<i>Cons.</i>
t ^h aj.ta.ni.k ^h ə	t ^h je.ta.ni	Titanic	k
a.ti.ta.s	aj.ti.ta	Adidas	s
pwo.t ^h ə	pi	Burt (Reynolds)	t

təŋ. tsə. r.	tan. tswə	Denzel (Washington)	l
k ^h ə. r. pa. tɕ ^h jaw. fu	kə. pa. tɕ ^h i. fu	Gorbachev	r
fu. li. tə. man	fu. li. man	Friedman	d
na. fu. la. ti. nwo. wa	na. la. t ^{hi} . nwo. wa	Navratilova	v
haj. hwa. s.	haj. hwa	(Rita) Hayworth	θ
s. p ^{hi} . r. pwo. kə	s. p ^{hi} . pwo	(Steven) Spielberg	l, g

A plausible explanation for these surprising data might attribute it to the particular properties of Chinese morpho-phonology, as follows. The Mandarin host grammar shows no obvious evidence for the relative ranking of MAX vs. DEP, since the sparse morphology means that excess consonant sequences never arise. The loanword inputs are thus the first time a decision is needed. Suppose the initial decisions for ranking MAX ~ DEP are random. It is then possible that within a given speech community after adaptation of some relatively large number of loans a pattern emerges: a new grammar. On the Mainland this grammar has MAX >> DEP, but in Taiwan, it has DEP >> MAX. For other cases similar to Taiwanese Mandarin, see Golston and Yang 2001 on deletion in White Hmong loanwords and Burenhult 2001 on deletion in Jahai.

There are two problems with this proposal. First, it is not compatible with my earlier suggestion that the universal initial state might have MAX >> DEP. Second, it is also not compatible with a universally high-ranked MIMIC constraint. We thus arrive at the following tentative conclusions. MIMIC may be a separate constraint, but if so like any other it may be ranked anywhere. Ranked very high, and loans will stay noticeably foreign. Ranked very low, and they will be fully nativized. If either MIMIC or MAX is high-ranked, retention results, so retention will be more common than deletion.

1.2 The Role of Perceptual Salience in Consonant Deletion

1.2.1 Evidence from Cantonese

Although some languages treat all excess consonants uniformly, by deletion or epenthesis, in other languages the type of consonant and its phonological environment can determine whether it is deleted or retained. In this section I argue that a major factor is the perceptual salience of a particular consonant, with less salient ones most likely to delete. I further argue that the deletion is clearly phonological since it can be affected by such things as prosodic minimal word requirements, and that the phonology must thus have direct access to perceptual information. From here onwards, unless otherwise stated, the data will be drawn from English loans adapted into Cantonese. Many of the conclusions of this section have been foreshadowed in Silverman (1992) and Yip (1993), but here I bring to bear additional phonetic evidence, and the insights of recent work on the phonetics-phonology interface in OT.

We will be concerned here with three consonant types: word-final post-consonantal stops, liquids in obstruent-liquid onset clusters, and fricatives and affricates in any context. Cantonese has a very simple CVC syllable structure, with codas limited to stops or nasals. As a result no English cluster may survive unscathed, and many simplex codas, including fricatives, must also undergo adaptation. Silverman (1992) proposes that loanword adaptation takes place in two steps. The first step is a Perceptual Scan (Scansion One), in which Cantonese listeners may fail to detect certain contrasts present in the English forms but

absent in Cantonese, such as voicing in obstruents. The output of this scan is then the input to the phonology proper (Silverman's Operative Level, also called Scansion Two). For the sounds under scrutiny here, the Perceptual Scan has the following effects:

- (4) a. Some segments are not detected at all: e.g. post-consonantal word-final stops, such as the /d/ of *band*
- b. Highly salient segments are detected, perceived as syllabic, and assigned syllable nodes: e.g. /s/ in all contexts, such as *bus* or *spanner*.
- c. Less-salient segments are detected, but not assigned their own syllable nodes, such as the liquids in *plum*, *freezer*.

On entering the phonology proper, undetected segments obviously never show up: *band* becomes [pɛ:n]. Segments assigned a syllable node always show up: *bus* becomes [pasi:]. Segments detected but not assigned a syllable node will only survive if some phonological process assigns them a syllable node. In Cantonese, this happens only under pressure to achieve bi-syllabic minimal word size, so we get epenthesis in *plum* which becomes [powlɛm], but no epenthesis in the already bisyllabic *freezer*, which becomes [fi:sa:]. Note that Cantonese has no [r], so [l] is always used, and that deletion vs. retention is independent of the liquid's origin as English [r] or [l].

Silverman's proposal has been challenged by Jacobs and Gussenhoven (2000), who point out that in some cases a highly salient contrast not present in the host language must surely be perceived, such as English [s] vs [k] perceived by Hawaiian listeners. Work by Best et al (2001) also confirms that under certain circumstances L2 contrasts absent in L1 can nonetheless be perceived. Jacobs and Gussenhoven also point out that foreign segments are often retained (and thus perceived) but featurally changed, and that it is possible to find instances where two host languages with the same segmental inventory retain different features of the foreign input, showing that both features are successfully perceived, even in the foreign combination. For example, French [ü] becomes rounded [u] in older Haitian Creole, but front [i] in Mauritian Creole, showing that the rounding and frontness of [ü] are both detected.

Even if we then accept these arguments, and depart from Silverman by assuming that Cantonese listeners do detect at least the presence of all the relevant segments, we need not go as far as denying any role at all for perception in the loanword process, especially given what we know about the role played by inherent acoustic salience in the perception of L2 sounds (Werker and Logan 1985). Indeed, Steriade (2001) points out that Cantonese can be viewed as providing strong evidence for the role of perception in consonant deletion, and more specifically for the role played by perceptual salience as the result of the strength or weakness of the acoustic cues. The cues that help in accurate perception can be divided into internal cues - those that reside within the duration of the segment itself - and contextual cues - those provided by the surrounding context, such as formant transitions. Fricatives (and affricates) are the segments with their own strong internal cues, rendering contextual cues less crucial, and they are precisely the segments that are rescued by epenthesis in all environments - *stamp* [si:tʰa:m], *tips* [tʰi:psi:], *forecast* [fo:kʰa:si:]. Unsyllabifiable stops, which have few internal cues and are heavily dependent on good contextual cues, surface only when adjacent to a vowel or a liquid - *plum* [powlɛm], (*wide*)*angle* [ɛ:ŋkow] and delete after another

consonant - *post* [p^ho:si:], *soft* [so:fu:], *stamp* [si:ta:m], *band* [pɛ:n], exactly the position in which the cues are least salient. One can extend Steriade's observations to the liquids: non-syllabic liquids are retained word-initially or after vowels, but in polysyllabic words they delete after consonants, where the cues are the least salient, as in *freezer* [fi:sa:].

Let us look more closely at the evidence for the non-salience of these liquids. Fay and Cutler (1977) give speech error data in which stop-liquid clusters are simplified. There is a striking asymmetry as to which consonant is lost: out of twelve cases, eleven lose the liquid and only one loses the stop. The acoustics of English word-initial C + liquid clusters makes this unsurprising. The following observations are drawn from a number of sources, including particularly Olive et al (1993).¹ The post-consonantal liquid has a very short steady state duration - 16msec vs. 46-84msec in other contexts. After voiceless aspirated obstruents, liquids are usually devoiced, being produced during the period of aspiration. The overlap between stop and liquid may be even more complete, with the formation of the liquid articulation often preceding the stop closure, so that Cr clusters are in fact produced as retroflex stops. The /tr/ vs. /t/ distinction is thus reduced phonetically to [t̠] vs [t], and acoustically this shows up as a lowered F3 during the transition from the vowel preceding a /Cr/ cluster. We know that in languages in which retroflex and alveolar stops contrast, the acoustic difference is mainly one of a high F3 locus (about 2750 Hz) for alveolars, and low F3 locus (about 1800 Hz) for retroflexes, and Steriade (1995) points out that this contrast is primarily heard on the preceding vowel, and that the contact configuration on release of these consonants is quite similar. Indeed, in many Australian languages they only contrast post-vocally. Returning to English, we may suppose that the word-initial /C/ vs /Cr/ contrast, reduced as it often is to [t] vs. [t̠], lacks the preceding vowel necessary to carry the appropriate cues, and the distinction will be hard to perceive.

All this might reasonably lead us to expect that Cantonese speakers would fail to perceive the liquid at all, or at any rate that the clusters might be perceived as simplex segments, not clusters. This cannot be correct, since in short words the stops and liquid are reproduced independently in loans, as in *plum* becoming [powlɛm]. Conversely, there have been suggestions that English infants and adult speakers of Japanese, which lacks C-liquid clusters, might perceive these clusters as extra syllables: Werker et al (1998) show that English infants do not discriminate *clone* and *cologne* until 10 months, and Dupoux et al (1999) show that Japanese listeners confuse [ebzo] and [ebizo]. Peperkamp (2001) has thus suggested that in Japanese loanword adaptation, "epenthesis" takes place during perception, but again this cannot be right for Cantonese, because some liquids delete, as in *freezer* becoming [fi:sa:].

We must conclude, then, that although the contrast between /#C/ and /#Cr/ (or /#Cl/) is perceptually hard to discern, nonetheless it is discernible, since some liquids survive as independent segments. Since however some do delete, we are forced to the conclusion that deletion takes place in the phonology. Further, the fact that other consonants, such as fricatives, never delete requires that the phonology must be able to distinguish between highly salient, non-deletable consonants, and non-salient deletable ones.

1.2.2 Cross-linguistic evidence for role of perception in the phonology of deletion

There are a number of recent studies which explore the role of perception in conditioning consonant deletion, starting with Steriade (2000), and including Kenstowicz

(2001), Mielke (2001), and Kang et al (2001). Côté (2001) shows that deletion of the medial C in CCC clusters in Hungarian is related to perceptual strength: only the perceptually weakest consonants - stops - may delete, while fricatives and affricates do not. She observes that the perceptual salience of a consonant depends on its own internal cues (which differ between different consonant types), the adjacent segments (which affect the cues present during the onset and offset phases), and the prosodic position and stress. Further, the perception of stops depends crucially on transitional cues present in the CV transition, whereas fricatives and affricates have their own internal cues. As a result, stops survive best in those environments where they have the most contextual cues. She suggests that perceptual salience is encoded in an OT grammar by two mechanisms (i) “markedness constraints that militate against consonants that lack auditory salience” and (ii) “faithfulness constraints that encode the relative perceptual impact of a modification to the input.” Wilson (2001) works out the markedness approach, proposing the following principle:

(5) **Weak Element Principle:**

A representation x that contains a poorly cued (or ‘weak’) element α is marked relative to the representation y that is identical to x except that α has been removed.

In this section, I will use a faithfulness line of attack on the Cantonese facts, summarized below:

(6) *The facts of Cantonese consonant deletion in English loanwords:*

- Fricatives and affricates always survive: *bus* [pa:si:] *spanner* [si:pa:la:]
- Stops are always lost in C__#, irrespective of word size. *band* [pɛ:n]
- Liquids are lost in #C__V if output is at least bi-syllabic, otherwise retained
freezer [fi:sa:], *plum* [powlɛm], *brake* [piklik]

Like the previous authors, I incorporate the perceptual factors directly into the grammar, and dispense with a separate perceptual scan. The relative saliency of different consonants in different environments can be referred to explicitly by the grammar. All that is needed is some sort of threshold of saliency such that post-consonantal final stops, and post-consonantal non-syllabic liquids, are too poorly cued to rise above this threshold and are considered weak or non-salient. All others are above the saliency threshold, and considered salient. For a more explicit discussion of the possible mechanisms, see Steriade 2000, 2001 on the P-Map. The following constraints are needed:

- (7) MIMIC-SALIENT: Do not delete “salient” segments
ALIGN-R (PhWd, morpheme): No epenthesis at right word edges
MINWD: The minimum word is bi-syllabic
DEP: No epenthesis
MAX: No deletion

The rankings and justification necessary are as follows:

- (8) MIMIC-SALIENT >> ALIGN-R *bus* [pa:si:]: /s/ always rescued
 ALIGN-R >> MINWD *band* [pɛ:n], final stops not rescued, even if result is sub-minimal²
 MINWD >> DEP *plum* [powlɛm], post-consonantal liquids rescued to keep word bi-syllabic.
 DEP >> MAX *freezer* [fi:li:sa:], in all other cases, non-salient segments delete.

If MIMIC-SALIENT is replaced by MIMIC-S (or MAX-S, or perhaps MAX-STRIDENT), roughly as done by Jacobs and Gussenhoven (although they do not cover the full range of facts), we thereby remove direct reference to perception in the phonology, and the above account will still work, but crucially it fails to make any predictions about which segments are cross-linguistically prone to deletion in which environments. One possible solution might be to propose a mapping from the saliency facts to a universally ranked set of faithfulness constraints which do not themselves refer directly to saliency, much as is done for the relationship between the sonority hierarchy and the constraint set that governs the well-formedness of syllable nuclei. I will not explore this further here.

The main conclusion of this section is that reference to perceptual salience within the phonology proper resolves the paradox that quite subtle non-native distinctions are clearly perceived, but nonetheless less salient segments are more likely to be sacrificed than highly salient ones.

2. The Role of Perception in Vowel Quality Adaptations:

2.1 The acoustics of English and Cantonese vowels

Vowel adaptations are much less studied than consonant adaptations, but interesting nonetheless. This section is exploratory, and raises as many questions as it answers. The first thing to note is that vowels are never deleted, even in contexts where this might be a possibility, such as in unstressed vowels in onsetless syllables. So *import* becomes [i:mpʰɔ:t], and *assignment* becomes [a:saimɛn]. No clear examples of word-medial onsetless syllables - i.e. vowels in hiatus - can be found in my data. If all vowels are salient enough to require retention, the problem shifts to finding the Cantonese vowels that most closely match the acoustics of the English vowels. In many cases the vowels are fairly similar, but English has two particular vowels that Cantonese lacks entirely, [æ] and [ə]. The Cantonese vowel inventory is given below. [œ] and [ø] are phonetically central, not front (Lee 1985, Zee p.c.), as shown by their relatively low F2. Note that in open syllables, all vowels are long. In closed syllables, long and short vowels are found, subject to various phonotactic restrictions. In particular, in stop-final syllables with high tones, only short vowels are allowed. Since stressed vowels are borrowed with high tones, stop-final stressed syllables will have to have short vowels.

- (9) *Cantonese vowels:*

<i>Long</i>			<i>Short</i>		
i:	ü:	u:	ɪ		ʊ
ɛ:		ɔ:		ø	
	œ:	a:			e

Let us consider what the Cantonese speaker might do when trying to reproduce an English vowel that is not part of the Cantonese inventory.

The first question is how the Cantonese listener perceives English [æ] and [ə]. The best way to answer this question would be with perceptual experiments either asking for a forced choice between two or more Cantonese counterparts, or asking for a suitable Cantonese rhyme for the English vowel. To my knowledge no-one has conducted such experiments, so we must fall back on acoustic data, and see what the likely acoustic matches would be. We will then compare the expectations to the actual loanword reflexes, and discuss the role of the phonology in the final result. I start with [æ].

The first two formants of English [æ] are given below:

(10) *Formants of English [æ]:*

	F1	F2
American [æ] (Ladefoged 2001a)	690	1660
UK [æ] (Bates 1995)	756	1503

Here are formants for the most plausible Cantonese counterparts (data from Zee, p.c. See Appendix for formant values for all Cantonese vowels).

(11) *Cantonese formant values:*

<i>Closed σ:</i>	F1	F2	<i>Open σ:</i>	F1	F2
[ɛ:]	679	1886	[ɛ:]	537	2088
[œ:]	597	1410	[œ:]	531	1447
[a:]	896	1270	[a:]	827	1229
[ɪ]	520	2127			
[ə]	820	1287			

No Cantonese vowel comes very close to English [æ], but the closest is [ɛ:] in closed syllables followed by [œ:], then [a:], and, if the vowel stays short, [ɪ] and [ə]. None of the open syllable vowels (where the vowel must be long) is a very good match, not even [ɛ:].

Moving on to schwa, data on English schwa are notoriously problematic because of the large amount of contextual variation. Olive et al (1993:325) : “The formant structure of schwa is completely dependent on its surrounding sounds”. Bates (1995) for medial schwa has F1 around 450Hz, but F2 varying from 900-1500 Hz, showing that tongue height is fairly stable, but front/backness is heavily context-dependent. There seem to be no real data on word-final [ə]. See also Stevens (1998:575).

(12) *Formant values for English [ə]: Average values; F2 is highly context-dependent*

	F1	F2
US [ə] (Stevens 1998)	500	1500
UK [ə] (Ladefoged 2001b)	500	1400

Many loanwords end in orthographic *-er*, and which would be r-coloured in U.S. English. For this reason I also give below average formant values for this vowel:

(13)	<i>English</i> [ɜ]/[ɝ]	F1	F2
	US [ɜ] (Olive et al 1993)	500	1250
	UK English [ɜ] (Ladefoged 2001b)	500	1450

The Cantonese long vowel (recall that in open syllables length is obligatory) that comes much the closest to English schwa, is [œ:]. [a:] is a very poor second choice. If the vowel is to stay short, [ø] and [e] are the best of a bad lot.

(14)	<i>Cantonese vowel formants:</i>					
	<i>Closed</i> σ:	F1	F2	<i>Open</i> σ:	F1	F2
	[œ:]	597	1410	[œ:]	531	1447
	[a:]	896	1270	[a:]	827	1229
	[ø]	572	1181			
	[e]	820	1287			

I now turn to what we actually find.

2.2 Cantonese loanword data:

The following table summarizes expected and actual reflexes for [æ]:

English vowel	Output length	Expected first choice(s)	Expected alternate(s)	Actual
æ	Long	ɛ:	a: œ:	ɛ: a:
	Short	ɪ e		ɪ e

Some data are given below. We find [a:] or [ɛ:] in the obligatorily long open output syllables, and before nearly all nasals. Before stops, the vowel is always short, and the reflex is usually [ɪ], with one [e] before the only [t]. There is also one [ɪ] before [m].

(15)	<i>Reflexes of English [æ]:</i>					
	[a:]	carat	k ^h a:	[ɪ]	lacquer	ɪɪk k ^h a:
		pan	p ^h a:ŋ		Jack	tsɪk
		salad	sa: lət		taxi	tɪk si:
	[ɛ:]	cash	k ^h ɛ: sü	[e]	maxi (clothes)	mət s ət
		cashmere	k ^h ɛ: si mɛ			
		daddy	tɛ: ti:			
		jam	tɛ:m (or [tsɪm]; Chan & Kwok 1982)			

Turning to schwa, the following table summarizes the expected and actual reflexes of [ə]:

English vowel	Output length	Expected first choice(s)	Expected alternate(s)	Actual
ə	Long	œ:	a:	a: (œ:)
	Short		ø e	ø e

Some data are given below. We find [a:] in the obligatorily long open output syllables in (a). Before consonants, the vowel is always short, and the reflex is [ø] or [ɐ], as in (b-c). The stressed schwa-like vowel in *sir* and *per-cent* appears as [œ], as in (d).

(16) *Reflexes of English [ə]*

a.	‘cancer’	k ^h ɛ:n sa:	b.	‘foreman’	fɔ: mən
	‘major’	mɛ: tsa:		‘fashion’	fa: sən
	‘assignment’	a: sai mən		‘commission’	k ^h ɛm mi: sən
	‘jersey’	tɛ: si:			
c.	‘cushion’	k ^h u: sən	d.	‘sir’	sœ:
	‘gallon’	ka: lən		‘percent’	p ^h œ sɛ:n
	‘salad’	sa: lət			

2.3 Three main environments:

To get a grasp on what is going on here, I will divide the data up into three main environments on the basis of vowel length: long-vowel only environments (open syllables); short-vowel only environments (stressed and therefore high-toned stop-final syllables) and unrestricted environments (before nasals). In the first two environments, Cantonese syllable-structure requirements over-ride MIMICLENGTH, limiting the choice of reflexes to those vowels with the appropriate length for the particular syllabic context. I begin with open syllables. the data are summarized below:

(17) *Open syllables: Vowels must be long, to satisfy μμ minimum syllable requirement.*

English vowel	Expected first choice(s)	Expected alternate(s)	Actual
æ	ɛ:	a: œ:	ɛ: a:
ə	œ:	a:	a:

The most striking observation is that [œ:] is not used for either vowel (except stressed schwa, see below), despite the fact that it is the best match for schwa, and a good match even for [æ]. It is true that [œ] is a rather rare vowel in open syllables in Cantonese, but I’d like to suggest here that visual information is playing a role. The Cantonese vowel [œ] is rounded, and thus has a clear visual cue associated with it. The two English vowels under discussion are unrounded, so the Cantonese listener/viewer can see that the vowel he/she is hearing cannot be rounded. We know that visual information is used by the listener, a result that goes back to the famous McGurk effect, but that is confirmed by more recent research (see Massaro 1998). Ortega-Llebaria et al (2001) in an interesting pilot study show that Spanish listeners’

identification of English sounds is significantly improved when visual information is made available, with lip configuration not surprisingly one of the helpful visual cues. If this is right, and the visual cues exclude [œ], then the remaining reflexes expected from the acoustics are exactly what we find. It remains somewhat mysterious why [œ] *does* occur as a reflex of the stressed schwa-like vowel in English *sir* and *per cent* after [s] and [p], but not [dʒ] in *jersey*. Lip protrusion or rounding of these English onset consonants may perhaps be perceived here.

I should also comment on the surprisingly common choice of [a:] for English [æ], when we expect a preference for [ɛ:] on purely acoustic grounds. There is no obvious conditioning from the surrounding sounds that might explain the choices. It happens that open syllables in [ɛ:] are rare in the Cantonese lexicon, except after coronal sibilants, so it might be that this is a statistical bias effect (see Zuraw 2000 on statistical effects in loanword phonology), but again there is a possibility that visual information matters. [æ] and [a] both have a lowered jaw, whereas [ɛ] has no jaw lowering, and instead has noticeably spread lips. [a] is thus a better visual match for English [æ].

The last paragraph is, obviously, speculative, and needs experimental investigation. If any of it is right, the role of visual information in loanword adaptation has been underestimated, and demands further study.

I now move on to the second, short-vowel, environment; the data are summarized below:

(18) *Closed stop-final syllables: normally short, see below*

English vowel	Expected first choice(s)	Expected alternate(s)	Actual
æ	ɪ ɐ		ɪ, one ɐ
ə	ø ɐ		ø

To recap, before stops, we normally get a short vowel. This is because English main stress is always realized as a high [5] tone, but in Cantonese before stops only short vowels can bear [5]. This results in such strong pressure for a short vowel than even English long vowels or diphthongs which could otherwise be borrowed unchanged into good Cantonese vowels, like [a:], [ou] or [ei], are shortened

(19) shaft səp⁵ (car)-coat k^hɔk⁵ cake k^hɪk⁵

Since in addition English [ə] and [æ] are both short, it is hardly surprising then that in this environment we get only short reflexes. In stop-final syllables, the preference for [ɪ] over [ɐ] for English [æ], seems to suggest that MIMIC-BACKNESS may be high ranked above MIMIC-HEIGHT. There is only one token of English [ə] before a stop, so it is hard to know what the full range of options might be. In the case we have, we find rounded [ø] in the word *salad* [sa:løt]. As we shall see when we look at nasal-final syllables, [ø] is frequently used between two coronals (and nowhere else), and we defer discussion of this issue until the next section.

Given previous findings, we propose the following expected/actual vowels in the third and final environment, before nasals, where long and short vowels are both permitted:

(20) *Before nasals: long and short vowels permitted*

English vowel	Expected first choice(s)	Expected alternates	Actual
æ	ɛ:	a: ɪ	ɛ: a: (ɪ)
ə	a: ɐ	(ø between coronals)	ɐ (ø between coronals)

The major oddity is the lack of any [a:] for English [ə], in strong contrast to the exceptionless choice of [a:] in open syllables. The formant structure of Cantonese [a:] and [ɐ] is extremely similar, so Cantonese speakers apparently use length as the primary cue to distinguish between them (Wang 2000). In English, medial schwa is very short, and would seem that the Cantonese listener clearly perceives it as such. This forces the choice of a short reflex, eliminating [a:] as an option. MIMIC-LENGTH selects [ɐ]. For [æ], in contrast, the only short option [ɪ] is a poor match in formant structure, so it usually loses to the long options, suggesting that MIMIC-QUALITY >> MIMIC-LENGTH. (Recall that while [ɛ:] is a better match on formant structure, visual cues favour [a:]. I therefore assume below that they tie on quality-matching.)

(21) *When no reflex matches in quality and length, quality matters more:*

/æ/	MIMIC-QUALITY	MIMIC-LENGTH
☞ ɛ:		*
☞ a:		*
ɪ	*!	

The next tableau shows that since on quality grounds, [a:] and [ɐ] are equally good matches for [ə], MIMIC-LENGTH decides.

(22) *When quality difference not detectable, length decides the issue*

/ə/	MIMIC-QUALITY	MIMIC-LENGTH
☞ ɐ		
a:		*!

Finally, why is [ø] suddenly an option for schwa between two coronals? Cantonese fronts the non-low back vowels between coronals, so that we find [sün] and [søn] instead of *[sun] and *[sɔn]. It is tempting to attribute the fronter [ø] to this process, but Cantonese allows both low [sɛn] as well as [søn] in the native vocabulary, and in loans: *fashion* [fa:sɛn] vs. *cushion* [kʰu:søn]. The choice seems random. One possibility is that the visual cue provided by lip protrusion after English [ʃ] may lead to the perception of a rounded vowel. As with my previous discussion of visual cues, I leave this issue open for future research.

The picture that has emerged from this discussion suggests that listeners do not

consistently assign foreign vowels to a single Cantonese reflex. Instead, the acoustic and visual cues combined define a set of possibilities from which the phonology chooses. In the phonology, choices may have to be made between matching tone, length and quality, and syllable phonotactics play an important role. Lastly, there may be some statistical bias that prefers common syllable-types over rare ones. The balance between these various factors remains to be determined.

2.4 The tension between prosody and vowel quality:

I now move on to look in more detail at situations where vowel quality preservation conflicts with other factors, in particular tonal and syllable structure ones. There are situations in loans where the vowel has a near-identical Cantonese counterpart, and yet it changes in quality during adaptation. Vowel quality in fact seems to be quite a low priority, with mimicking the pitch profile and syllable type being more important. This interaction is the final topic of this paper.

Matching vowel quality is not always possible, because other considerations can predominate. We have seen one such circumstance earlier: stressed syllables must have high tone to mimic English stress, and yet long vowels before obstruents cannot have high tone, so vowels shorten and their quality changes in order to avoid violating MIMIC-TONE, and the phonotactic constraint I will here simply call *V:O⁵, but whose real nature remains obscure:

(23) *V:O⁵: No long vowels before obstruents with a high tone.

The tableau below shows the necessary ranking to explain the surprising vowel shortening in *cake* > [k^hɪk⁵], surprising in that [k^hɛ:k] is segmentally a perfectly good Cantonese syllable, and yet the vowel that is chosen is the less-similar [ɪ]. Candidate (c) has a tone that it is too low, and is ruled out by MIMIC-TONE. Candidate (b) has a good tonal match, but this results in an illicit syllable-type, violating *V:O⁵. So candidate (a), with a good tonal match and an acceptable syllable type, wins.

(24) *Vowel quality sacrificed to prosody*

/k ^h ɛ:k ⁵ /	MIMIC-TONE	*V:O ⁵	MIMIC-QUALITY	MIMIC-LENGTH
☞ a. k ^h ɪk ⁵			*	*
b. k ^h ɛ:k ⁵		*!		
c. k ^h ɛ:k ⁴	*!			

One of the noticeable aspects of loanword adaptation is that it may be incomplete: words may remain identifiably foreign, thus adding new syllable types to the inventory of the host language. Cantonese is no different in this regard (Bauer 1985). Words like *cake* may be adopted in a second way, in which the tone is high, as before, but now the vowel's quality and length are accurately mimicked, producing a syllable which could not be a native syllable because it violates *V:O⁵. The following words show the two strategies: full nativisation, involving quality and length changes, on the left, and partial nativization, with vowel quality and length intact, on the right:

- (25) *Full and partial nativization:*
- | | |
|--|---|
| (i) <i>Vowel shortened, high tone</i> | (ii) <i>Vowel kept long, high tone</i> |
| (native) | (non-native) |
| ‘shaft’ sɛp ⁵ | ‘card’ k ^h a:t ⁵ |
| ‘(car)-coat’ k ^h ɔk ⁵ | ‘chalk’ ts ^h ɔ:k ⁵ |
| ‘partner’ p ^h ɛt ⁵ la | ‘cheap’ ts ^h i:p ⁵ |
| ‘cake’ k ^h ɪk ⁵ | ‘sexy’ sɛ:k ⁵ si: |
| ‘(milk)-shake’ sɪk ⁵ | ‘notes’ nɔ:k ⁵ si: |

In our OT grammar, the forms on the right would result from all the MIMIC constraints outranking the phonotactic constraint *V:O⁵, exactly the scenario we earlier singled out as leading to partial nativization. There is another logical option: retain the vowel length, but with a lower tone, which would give forms like [k^hɛ:k⁴]. This does not seem to be used, showing that MIMIC-TONE is unviolated. This proposal results in a stratified vocabulary for Cantonese (along the lines of work by Itô and Mester 1999 on Japanese), where *V:O⁵ is low-ranked and thus violable in the loanword stratum of the vocabulary. Full nativization, by definition, means a word now conforms to the full native grammar, or in other words that it has left the loanword stratum, with the ranking shown above in (24).

A final option deserves comment: why not keep the vowel long and high toned, and either delete the stop or move it into a new syllable followed by an epenthetic vowel. For example, *card* would become * [k^ha:⁵⁵] or * [k^ha:⁵⁵ ti:]. This never happens: deletion or epenthesis caused by faithfulness to vowel quality and length are never optimal, suggesting that MAX, DEP >> MIMIC-QUALITY, MIMIC-LENGTH.

- (26) *MAX and DEP violations are not allowed merely for vowel quality/length reasons:*

/k ^h a:t/	MIMIC-TONE	MAX	DEP	*V:O ⁵	MIMIC-QUALITY	MIMIC-LENGTH
☞ a. k ^h ɛt ⁵					*	*
b. k ^h a:t ⁵				*!		
b. k ^h a: ⁵⁵ ti:			*!			
c. k ^h a: ⁵⁵		*!				
d. k ^h a:t ⁴	*!					

It appears, given these facts, that mimicking the presence or absence of a segment (MIMIC-SEG) is more important than mimicking quality and length. Presumably this follows in some way from the need to record the very existence of segments before their particulars can be paid attention to. For Cantonese, one other reason might lie behind the lack of deletion or epenthesis in these circumstances. For Cantonese speakers, stop-final syllables are prosodically different from all other syllables. They are shorter overall, and cannot have contour tones. Traditional Chinese linguistic terminology calls them the Ru-sheng. English inputs like *card* are, in Cantonese terms, Ru-sheng syllables, and if epenthesis were to take place they would cease to be Ru-sheng. This is a major shift of syllable category, and this may be why it is not

allowed (Itô et al 1992).

Before closing, I should note that these stop-final syllables are not the only area where nativisation may be either total or partial. Bauer (1985) gives several examples of new syllable types found only in loans. One of the most interesting to our present concerns are outputs in [ɛ:n], [ɛ:m] and [ɛ:p]. In native Cantonese the vowel [ɛ:] is found before velar consonants, but not before labials and coronals. Instead we get [i:], so that pre-consonantly [i:] and [ɛ:] are in complementary distribution. In loans, however, [ɛ:] is used for English [ɛ], as in *cent* [sɛ:n], English [æ], as in *band* [pɛ:n], and English [e], as in *game* [kɛ:m]. This would seem to be a clear case of MIMIC-QUALITY over-riding a phonotactic constraint of Cantonese, and creating new syllable types.

A second case is even more interesting, because it shows two different stages in the loanword adaptation process. Cheung, Y-S (1986:44) observes that unstressed final syllables are normally adapted into the low [21] tone in Cantonese, but only by Cantonese speakers with a high level of English. Speakers with a low-level of English instead use the [35] tone. For example, *cover* may be adapted as either [kɛp⁵ fa:²¹] or [kɛp⁵ fa:³⁵]. The low falling tone is a reasonable facsimile of the unmarked pitch contour in English, and thus to be expected if MIMIC-TONE is ranked high. So where does the 35 tone come from? In Cantonese, many colloquial nouns end in a high rising tone, analysable as the result of adding a high-toned suffix to the word (Hashimoto 1972, Yip 1980). In compounds, the underlying tone re-emerges. This tonal suffix is particularly common with words whose underlying tone is [21]. Loanwords are usually nouns, and usually colloquial, so it is not surprising if they are treated as part of the same morphological class as these native nouns, and given the high-tone suffix. In such cases, then, the words have been nativized to the extent that they undergo native morpho-phonology, even though it results in violations of MIMIC-TONE.

3. Conclusions

There are three main results of this paper. Firstly, loanword preservation effects cannot all be attributed to MAX >> DEP in the host language phonology, and in at least some cases must be attributed to faithfulness constraints that relate the output to an identifiably foreign percept, here called MIMIC. Second, phonological deletion must make direct reference to perceptual strength/weakness. Third, prosodic mimicking - mimicking of tone contour and syllable type - is generally more important than segmental mimicking. The importance of prosody suggests interesting parallels to the early acquisition of prosody in L1

Acknowledgements:

A version of this paper was given at the Conference on The Architecture of the Grammar, CIEFL, Hyderabad, India, Jan 2002. Thanks to Vijaykrishnan for giving me the chance to present this work, to various audience members at the conference, the members of the Phonology Reading Group at University College London, and also to the following people for help of various kinds: Lisa Cheng, P-M Cheung, Sam Cheung, Paul de Lacy, John Harris, Valerie Hazan, Paul Iverson, Stuart Rosen, Sze-Wing Tang, Zoe Toft, and Eric Zee. All errors are of course my own.

Endnotes

1.

Note that what interests us here is the contrast between the presence vs. absence of a liquid, and not the contrast between the two liquids [r] and [l], although we do know that this is very hard for some non-English speakers. There is a huge literature showing that Japanese speakers have greater difficulty in discriminating between [r] and [l] after a consonant than in any other position (Mochizuki 1981, Sheldon and Strange 1982, Takagi 1993), and Iverson et al (2001) show that Japanese speakers show reduced sensitivity to F3.

2.

Final liquids, as in *angle* [ɛŋkɔw], *hustle* [hɑ:sɔw], appear to violate ALIGN-R, but English inputs have syllabic [l], [hɹ.sl], which vocalizes in Cantonese. This explains why the vowel is the non-epenthetic [ɔw], not the epenthetic [i]. (Yip 1993).

References:

- Bates, S.A.R. 1995. Towards a definition of schwa: an acoustic investigation of vowel reduction in English. PhD thesis, University of Edinburgh.
- Bauer, Robert 1985. The Expanding Syllabary of Hong Kong Cantonese. *Centre Langues de L'Asie Orientale*, Vol XIV .1:99-111
- Best, C.T., G.W.McRoberts, and E.Goodell 2001. Discrimination of non-native consonant contrasts varying in perceptual assimilation to the listener's native phonological system. *Journal of the Acoustical Society of America* 109.2: 775-794
- Broselow, E. 1999. Stress, epenthesis and segment transformation in Selayarese loans. ROA# 334-0799.
- Broselow, E. S-I Chen, and C. Wang. 1998. The emergence of the unmarked in second language phonology. *Studies in second language acquisition*. 20: 261-280.
- Burenhult, N. 2001. Loanword phonology in Jahai. *Lund Working Papers* 48: 5-14.
- Chan, Mimi and Helen Kwok. 1982. *A Study of Lexical Borrowing from English in Hong Kong Chinese*. Hong Kong: University of Hong Kong.
- Cheung, Kwan-Hin. 1986. *The Phonology of Present-Day Cantonese*. PhD Dissertation, University College, London.
- Cheung, Yat-Shing. 1986. "Xianggang Guangzhouhua Yingyu yinyi jieci de shengdiao guize." [On the tone system of loanwords from English in Hong Kong Cantonese] *Zhongguo Yuwen* 1986-1:42-50
- Côté, M-H. 2001. The role of perception in the resolution of consonant clusters. Paper given at the *Conference on the Phonetics-phonology interface*, ZAS, Berlin.
- Dupoux, E., K. Kahehi, Y. Hirose, C. Pallier, and J. Mehler. 1999. Epenthetic vowels in Japanese: a perceptual illusion? *Journal of Experimental Psychology: Human perception and performance*. 25: 1568-1578.
- Fay, David and Anne Cutler. 1977. "Malapropisms and the Structure of the Mental lexicon". *Linguistic Inquiry* 8.3 pp. 505-520
- Golston, C. and P. Yang. 2001. White Hmong loanword phonology. In C. Féry, A.D.Green, R. van de Vijver eds., *Proceedings of HILP 5*, pp 40-57. University of Potsdam.
- Hale, K. 1973. Deep-surface canonical disparities in relation to analysis and change: an Australian example In T. Sebeok, ed.. *Current Trends in Linguistics 9: Diachronic, areal and typological linguistics* 401-458. The Hague, Mouton.
- Hashimoto, Anne Oi-Kan Yue. 1972. *Studies in Yue Dialects 1: Phonology of Cantonese* Cambridge: Cambridge University Press.
- Ito, Junko , Kitagawa, Yoshi and Rolf Armin Mester. 1992. "Prosodic Type Preservation in Japanese: Evidence from *zuujā-go*". Ms., UCSC.
- Itô, J. and A. Mester. 2000. Covert Generalizations in Optimality Theory. NELS 31, Georgetown.
- Itô, J. and A. Mester. 1999. The phonological lexicon. In N. Tsujimura, ed., *A Handbook of Japanese*

- Linguistics. *Blackwell, Oxford: 62-100.*
- Iverson, P., P. Kuhl, R. Akabane-Yamada, E. Diesch, Y. Tohkura, A. Kettermann, and C. Siebert. 2001. A perceptual interference account of acquisition difficulties for non-native phonemes. Ms, UCL.
- Jacobs, H. and C. Gussenhoven. 2000. Loan phonology: Perception, salience, the lexicon, and OT. in J. dekkers, F. van der Leeuw, and J. van der Weijer, eds., *Optimality Theory: Phonology, syntax and acquisition*. 193-210.
- Kang, H., J-I Han and W-I Baik. 2001 Taps in Korean dialects. Paper given at the *Conference on the Phonetics-phonology interface*, ZAS, Berlin.
- Kenstowicz, M. 2001. The role of perception in loanword phonology. A review of *Les emprunts linguistiques d'origine européenne en Fon*. by Flavien Gbéto, Köln: Rüdiger Köppe Verlag. Ms, MIT and ILPGA. To appear in *Linguistique Africaine*.
- Ladefoged, P. 2001a. *A course in phonetics*. (4th Edition). Harcourt. Fort Worth, TX
- Ladefoged, P. 2001b. *Vowels and consonants: Introduction to the sounds of languages*. Basil Blackwell, Oxford.
- Lee, T. 1985. The phonetic quality and long/short distinction of Cantonese vowels. (In Chinese). *Fangyan* 7.1: 28-38.
- Lin, Jonah T-H 1998 From Transliteration to grammar: a study of adaptation of foreign names into Chinese and Taiwanese Mandarin. Ms, UC Irvine.
- Massaro, D. 1998. *Perceiving talking faces: from speech perception to a behavioral principle*. The MIT Press, Cambridge, MA.
- Miehlke, J. 2001. Turkish /h/ deletion: evidence for the interplay of speech perception and phonology. Paper given at the *Conference on the Phonetics-phonology interface*, ZAS, Berlin.
- Mochizuki, M. 1981. The identification of /r/ and /l/ in natural and synthesized speech. *Journal of Phonetics*. 9: 283-303.
- Olive, J.P., A. Greenwood, and J. Coleman. 1993. *Acoustics of American English Speech: A dynamic approach*. Springer-Verlag. New York.
- Ortega-Llebaria, M. A. Faulkner, and V. Hazan. 2001. Auditory-visual L2 speech perception: effects of visual cues and acoustic-phonetic context for Spanish learners of English. In *Speech, hearing and language. UCL Work in Progress*. Vol 13: 39-51.
- Paradis, Carole. 1988. "On Constraints and Repair Strategies" *The Linguistic Review* 6:71-97
- Paradis, C. 1995. Derivational constraints in phonology: evidence from loanwords and implications. In A. Dianora et al, eds. *Proceedings of the Chicago Linguistics Society* 31. Chicago: Chicago Linguistics Society. 360-374
- Paradis, C. and D. LaCharité. 1997 Preservation and minimality in loanword adaptation. *Journal of Linguistics* 33: 379-430.
- Paradis, C. 1986. *Phonologie et morphologie lexicales: Les classes nominales en Peul (Fula)*. Ph.D. Dissertation, U. de Montreal.
- Peperkamp, S. and E. Dupoux. 2001. Loanword adaptations: three problems for psychology (and a psycholinguistic solution). Ms., Université de Paris 8.
- Sheldon, A. and W. Strange. 1982. The acquisition of /r/ and /l/ by Japanese learners of English: Evidence that speech production can precede speech perception. *Applied Linguistics* 3: 243-261.
- Shinohara, S. 2001 Emergence of Universal Grammar in foreign word adaptation. To appear in R. Kager, J. Pater and W. Zonneveld, eds., *Fixing priorities: constraints in phonological acquisition*. Cambridge University Press.
- Silverman, Daniel. 1992. Multiple Scansions in Loanword Phonology: Evidence from Cantonese. *Phonology* 9.2.
- Singh, Rajendra. 1987. "Well-formedness Conditions and Phonological Theory" in W. Dressler et al, eds., *Phonologica* 1984, Cambridge University Press, Cambridge
- Sommerstein, Alan. 1974. On Phonotactically-motivated Rules *Journal of Linguistics* 10:71-94
- Steriade, D. 1995. Positional neutralization. Ms., UCLA.
- Steriade, D. 2000. The phonology of perceptibility effects: the P-map and its consequences for constraint organization. Ms., UCLA.
- Steriade, D. 2001. Directional asymmetries in place assimilation: a perceptual account. In E. V. Hume and K. Johnson (eds.) *The role of speech perception phenomena in phonology*. San Diego, Academic Press.

C:\moira\LOANS\japanfin.wpd

- Stevens, K. 1998. *Acoustic Phonetics*. MIT Press.
- Takagi, N. 1993. *Perception of American English /r/ and /l/ by adult Japanese learners of English: A unified view*. UC Irvine PhD Dissertation.
- Wang, X. 2000. Training Mandarin and Cantonese speakers to identify English vowel contrasts: Long-term retention and effect on production. *JASA*: 108.5, p.2653.
- Werker, J.F. and J. Logan 1985. Phonemic and phonetic factors in adult cross-language speech perception. *Perception and Psychophysics*, 37: 35-44.
- Werker, J., J.E.Pegg, R. Shi, C. Stager. 1998 Updates on becoming a native listener. *JASA* 103.5: p2932.
- Wilson, C. 2001. Consonant cluster neutralization and targeted constraints. *Phonology* 18.1:147-196.
- Yip, M. 1980. *The tonal phonology of Chinese*. MIT PhD Dissertation, published 1990 by Garland, New York.
- Yip, M. 1993. Cantonese Loanword Phonology and Optimality Theory. *Journal of East Asian Linguistics* 2: 261-291.
- Zoll, C. 1998 Positional Asymmetries and Licensing. Talk given at LSA, Jan 1998, and Ms, MIT.
- Zuraw, K.R. 2000. Patterned exceptions in phonology. PhD Dissertation, UCLA.

Appendix: Cantonese vowel formants

Mean values for 10 male speakers, kindly provided by Eric Zee. Similar data may be found in Lee (1985).

Cantonese long vowels in open syllables:

V:	F1	F2
[i]	322	2357
[ü]	302	2010
[ɛ]	537	2088
[œ]	531	1447
[a]	827	1229
[ɔ]	544	871
[u]	338	720

Cantonese short vowels (always in closed syllables):

V	F1	F2
[ɪ]	520	2127
[ø]	572	1181
[e]	820	1287
[ɒ]	518	882

Cantonese long vowels in closed syllables:

V:	F1	F2
[i]	322	2320
[ü]	362	1810
[ɛ]	679	1886
[œ]	597	1410
[a]	896	1270
[ɔ]	618	923
[u]	405	789