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Adaptation of English onset clusters across time in Hong Kong Cantonese: the role of the perception grammar*

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In the present article we argue that the initial adaptation of English obstruent-liquid clusters into Hong Kong Cantonese is taking place in the perception grammar, which is influenced by phonological restrictions, following the proposal by Boersma & Hamann (2009) on loan adaptations in Korean. Such a perception grammar account does away with loanword-specific devices invoked by previous phonological accounts of Hong Kong Cantonese adaptations (such as Silverman 1992; Yip 1993, 2006; Kenstowicz 2012). Furthermore, we show that diachronic changes seem to have occurred in the adaptation of these English words, and we argue that such changes are due to the acquisition of a different perception grammar by younger speakers: newer loan forms (with less native-like structure) are possible because recent generations have had much more exposure to English. As a result, they have less (strong) phonotactic restrictions against English-like phonological structures and are more sensitive to English perceptual cues. We argue that this proposal is preferable to a stratified lexicon approach (Itô & Mester 1999, 2001 for Japanese) that encodes diachronic differences in adaptations as different constraint rankings within one synchronic grammar.

1 Introduction

Loanwords are a fascinating topic for phonological studies as they often introduce new phonemes or phonological structures into a language. The loan literature usually assigns the adaptation process either to perception (e.g. Peperkamp & Dupoux 2003) or phonology (e.g. Paradis & LaCharité 1997; LaCharité & Paradis 2005), but there are also several who argue that both play a

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role (e.g. Silverman 1992; Yip 1993, 2006). In the present article we follow the proposal by Boersma and Hamann (2009) that perceptual adaptations cannot be distinguished from phonological adaptations, as the perception process itself is influenced by phonological restrictions. This will be illustrated with English loanwords in Hong Kong (henceforth: HK) Cantonese.

The influence of phonological restrictions on the perception of speech has been illustrated by several psycholinguistic experiments. Dupoux, Kaheki, Hirose, Pallier & Mehler (1999) for instance show that Japanese listeners are not able to perceive the difference between a stimulus with an intervocalic consonant cluster, such as [ebzo], and the same stimulus with an intermediate vowel breaking up the cluster, i.e. [ebɯzo]. Their participants perceived both types of stimuli as containing a vowel, which can be accounted for by the Japanese phonotactic restriction that does not allow consonant clusters. This observed influence of phonological restrictions on our perception are evidence that speech perception is not independent of phonology, and that the perception process should therefore be incorporated in a model of our grammatical knowledge. In this article we employ the only existing grammar model that includes perception and models it explicitly, namely *Bidirectional Phonetics and Phonology* (BiPhon; Boersma 2007, 2011; Boersma & Hamann 2008, 2009).

The topic of our investigation is HK Cantonese, which originated from the Cantonese dialect used in Guangzhou (Bauer 1984: 76). HK Cantonese has various English loanwords that entered the language due to extensive contact with English since colonial times (Morrison 1828; Ansaldo, Matthews & Smith 2010: 71). It has been described as having only a closed set of syllables, and many combinations of onset consonants and following vowels were reported to be absent in its native words. This changed due to the incorporation of new loanwords over the last 30 years, and new syllables appeared. These new syllables fill previous gaps in the inventory, but are in line with the native HK Cantonese restriction against consonant clusters.

The adaptation of non-native clusters has been the topic of several studies on HK Cantonese loans (e.g. Silverman 1992; Yip 1993; Leci & Poon 2004; Kenstowicz 2012). In the present study we focus on the adaptation of English onset clusters of obstruent plus liquid (OL-clusters), such as /pr/, /kl/, etc. The input variety for perceptual borrowings into HK Cantonese is traditionally assumed to be British English, though it seems reasonable to assume that younger generations have more contact with American English (via mass media, etc.). As pointed out by Yip (2006), the variety of English spoken in Hong Kong itself can also be considered a source language. For the present study of onset OL-clusters, the differences between these varieties can be neglected.

The following discussion does not deal with tone assignment to English loanwords; the interested reader is referred to Kiu (1977), Silverman (1992), and

Hao (2009), amongst others. The transliteration system for HK Cantonese that we use follows the *Linguistic Society of Hong Kong Cantonese Romanization Scheme* (Jyutping, set up in 1993, cf. http://www.lshk.org/node/31), where tone is transcribed as follows: 1 is Chao tone number 53/55, 2 = 25, 3 = 33, 4 = 21, 5 = 23, 6 = 22. The phonetic and phonological transcriptions in the present article do not include tone. Following the notation in BiPhon, we use pipes for underlying/phonemic forms, slashes for surface/allophonic forms and square brackets for phonetic forms, in order to make a systematic distinction between these three levels of representations.

This article is structured as follows. Section 2 gives a brief overview of the syllable and word structure in HK Cantonese, and section 3 provides examples of loan adaptation of OL-clusters from English. Section 4 formalizes these adaptations with a BiPhon perception grammar. Section 5 illustrates recent changes in the adaptation strategy and argues that these changes are due to a different perception grammar in recent borrowers. Section 6 discusses previous loanword accounts that are relevant to the present study, and section 7 concludes.

2 Native restrictions in HK Cantonese

HK Cantonese has the consonantal phonemes |p p^h t t^h ts ts^h k k^h k^w k^{wh} m n ŋ f s h j w l|. All of these can occur in onset position. In coda position, only glides, nasals and unreleased stops occur. We assume that diphthongs are actually monophthongs followed by a glide (|j w|) belonging to the coda position (following e.g. Silverman 1992; Yip 1993; Bauer & Benedict 1997), because these sequences are never followed by any other coda consonant. For an alternative analysis, see e.g. Zee (1999).

Following Yip (1993, 2006), we assume that there are eight vowel phonemes in HK Cantonese. Five of them (|ɛː iː ɔː uː œː|) have long and short allophones. The three exceptions are the two low vowels, which contrast in quality and length (|aː| vs. |ɐ|), and the front high rounded vowel, which only occurs long (|yː|).

HK Cantonese syllables are minimally bimoraic (Yip 1993: 274), a restriction that is formalized in (1a). Consonant clusters do not occur phonologically (Yip 1993; Bauer & Benedict 1997)[1]; cf. the constraint in (1b):

[1] It is possible to have consonant clusters in the phonetic form due to a reduction process, see e.g. Bauer (1985). This native reduction process is responsible for variation in loan such as [p^hiːnliːn] ~ [p^hiːliːn] ~ [p^hliːn] 'print', and for loans of English OL-clusters that are occasionally reported as having intact clusters, e.g. [p^hliːntaː] 'printer' (Yip 1993: 288f. fn 15) or [fliːsaː] 'freezer' (Bauer & Benedict 1997: 380).

(1) Structural constraints relevant for the present analysis of HK Cantonese:

a) */.μ./: Do not have a syllable consisting of one mora only.
b) */CC/: Do not have consonant clusters in the surface form.

The correct distribution of the vowel allophones is regulated by structural restrictions that we comine in the cover constraint ALLOPHONE in the following analysis. For an alternative account, see e.g. Kenstowicz (2012), who proposes four separate constraints to regulate the combinations of vowels and coda consonants.

With respect to word structure, HK Cantonese nouns seem to require at least two syllables, as evidenced in the native phonology with hypocoristics and kinship names, see Silverman (1992) and Yip (1993, 2002). This is expressed with the constraint in (2).[2]

(2) MIN(IMAL)WORD: a phonological word has to have at least two syllables.

Recent loans seem to obey this restriction to a lesser degree, as we will discuss in section 5.

For the adaptation of loan words with obstruent-liquid onset clusters, it is relevant to note that HK Cantonese does not have a rhotic, neither phonetically nor phonemically. This will be expressed in the following with the phonemic restriction in (3).

(3) */r/: Do not have /r/ in the surface form.

Syllable-initial rhotics in English loanwords are usually borrowed with an /l/, as the examples in (4a) illustrate, though occasional replacement by /w/ also occurs, see (4b). The last column here and in the following examples gives the source of the loanword. The year in brackets given for Bauer & Wong (2008), which is an online database, refers to the publishing year of their source for the respective word.

(4)	a)	*lim1*	/.lɪm./	ream	Bauer & Benedict 1997: 379
		lam1	/.lɐm./	rum	Yip 2006: 953
		lou1laa2	/.low.laː./	roller	Bauer & Benedict 1997: 367

[2] Luke & Lau (2008) point out that the preference for a words that have at least two syllables holds for nouns but not for verbs, and that it reflects a tendency rather than a strict rule in the native lexicon. This was also attested in the data collected by Li, Wong, Leung & Wong (2016).

(4)	b)	*wat1fu14*	/.wɐt.fuː./	rough	Leci & Poon 2004: 105
		wep1	/.wɛːp./	rap	Bauer & Wong 2008 (2006)

The rhotic is replaced by a liquid because the latter is the phoneme of HK Cantonese that is perceptually closest: It has continuous formants but lower amplitude than vowels; see Leci & Poon (2004) for a similar argument. How this can be formalized in a perception grammar is shown in section 4 below.

The adaptation of rhotics and laterals in onset clusters is the topic of the following section.

3 Adaptation of English OL-clusters

English loans with onset clusters of the form obstruent-liquid are often borrowed with an inserted vowel due to the structural restriction against consonant clusters, see the examples in (5). Many of these examples also show consonant insertion (mostly reduplication), which is not further discussed.

(5)	*fu3luk1*	/.fuː.lʊk./	fluke	Bauer & Benedict 1997: 380
	pe1lit1	/.pʰɛː.liːt./	pleat	Yip 2006: 953
	gaak3laan4	/.kaːk.laːn./	Grand (Prix)	Yip 1993: 270
	pin1lin1	/.pʰiːn.liːn./	print	Silverman 1992: 290
	bok6lok1	/.pɔːk.lɔːk./	block	Bauer & Wong 2008 (2000)
	gik6lik6tsi2	/.kɪk.lɪk.tsiː./	clutch	Bauer&Benedict 1997: 380
	pej1lej1si2	/.pʰej.lej.siː./	place	Bauer&Benedict 1997: 380
	po3lau1si2	/.pʰow.lɐw.siː./	blouse	Bauer&Benedict 1997: 380
	baak3laan1dei2	/.paːk.laːn.tej./	brandy	Bauer&Benedict 1997: 380
	si6lik6fu3	/.siː.lɪk.fuː./	slacks	Bauer & Benedict 1997: 403
	tou3lam4bit1	/.tʰow.lɐm.piːt./	trumpet	Lai 2010: 261
	tung1lou6bou3	/.tʊŋ.low.pow./	trombone	Lai 2010: 259

An alternative adaptation strategy is the deletion of the liquid in such clusters; see the examples in (6) on the next page.

(6)	*pen1taa2*	/.pʰɛːn.tʰaː./	printer	Silverman 1992: 290
	pei1si2	/.pʰej.siː./	place	Bauer & Benedict 1997: 380
	buk1kaa2	/.pʊk.kʰaː./	broker	Silverman 1992: 290
	fi1saa2	/.fiː.saː./	freezer	Silverman 1992: 290
	pi6sen1	/.pʰiː.sɛːn./	present	Bauer & Wong 2008 (1999)
	pou6mou1	/.pʰow.mow./	promo	Bauer & Wong 2008 (2006)
	ban3daa2	/.pɐn.taː./	blunder	HKEJ 2011[3]
	hen1fi1	/.hɛːn.fiː./	handfree	Bauer & Wong 2008 (2006)
	bou3fu1	/.pow.fuː./	proof	Leci & Poon 2004: 109
	caa4bou1	/.tsʰaː.pow./	trouble	Leci & Poon 2004: 109
	haai1kaa1si2	/.haːj.kʰaː.siː./	high-class	Bauer & Wong 2008 (1972)

Deletion of the plosive or fricative is never found. We follow Yip (1993) in accounting for this by the saliency of plosive and fricative cues as opposed to the less salient auditory cues of liquids in this position. For the formalization of this observation, see section 4.1 below.

4 Analysis in terms of a perception grammar

In the present article, we formalize the observation that the perception of speech is influenced by the listener's native phonological knowledge, and use this to account for the observed loanword adaptations in HK Cantonese. For this, we employ the only linguistic model that includes a formalization of speech perception, namely the BiPhon model (Boersma 2007).

This model makes a principled distinction between phonetics and phonology, and formalizes both. The model therefore handles not only the usual two phonological representations (underlying and surface form) but also a phonetic form. Figure 1 presents these three levels of representation, and their mappings in comprehension (on the left) and production (on the right). In addition, this figure includes the type of constraints that regulate the mappings between these three levels of representation. In both directions of processing, the same constraints and constraint rankings are used. Faithfulness and structural constraints are already familiar to phonologists from traditional Optimality-Theoretic approaches (Prince & Smolensky 1993 [2004]). In addition, cue constraints are employed, which map the phonetic form onto the phonological surface form in perception, and the phonological surface onto the phonetic form in production.

[3] *Hong Kong Economic Journal*, 07/04/2011, http://www1.hkej.com/dailynews/articlePrint/id/559184

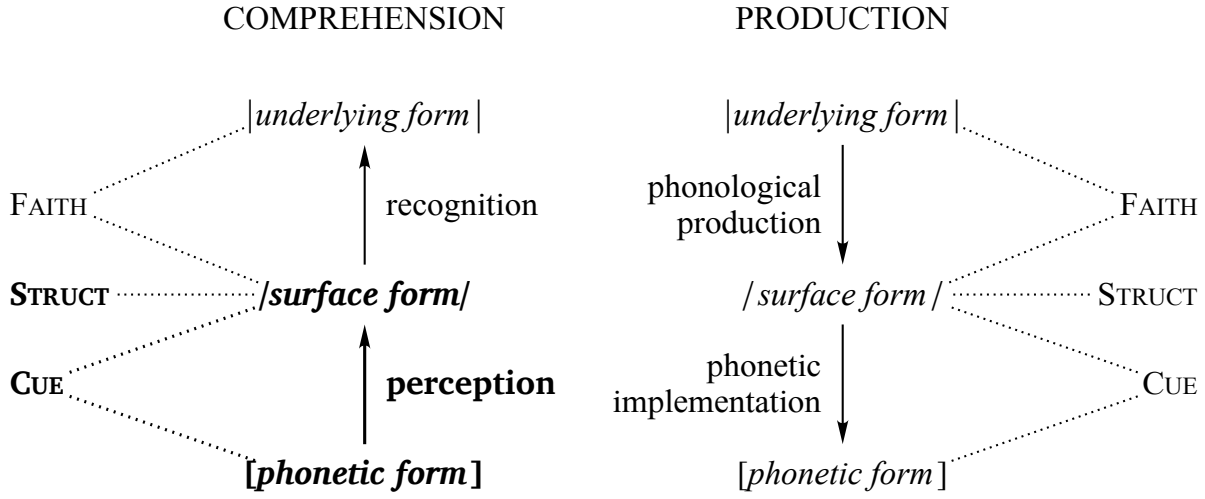

Figure 1: The BiPhon model (Boersma 2007). In boldface the representations, mapping and constraints relevant for the present study.

The present study focuses on the perception process (in boldface), i.e. how a listener maps an incoming phonetic form onto a phonological surface form, as we argue that this is were the perceptual adaptation of loanwords happens (following Boersma & Hamann 2009). In the perception process, cue constraints interact with structural constraints; the latter capture phonological restrictions on the surface form. These are the same structural constraints that play a role in native phonological production, i.e. in the mapping from underlying to surface form.

The auditory phonetic form that provides the input to an initial borrower is the same as that for a listener of the source language, but due to their different perception grammars, the two listeners most likely map the same auditory form onto different phonological forms. A language-specific perception grammar, i.e., the ranking of cue and structural constraints that yields the native percept, is acquired on the basis of the auditory input the learner receives throughout the acquisition process. The acquisition of this ranking can be modelled in BiPhon with the help of the *Gradual Learning Algorithm* (Boersma 1997, Boersma & Hayes 2001).

The native HK Cantonese structural constraints that are relevant for the perceptual adaptation of English OL-clusters were introduced already in section 2. In the following, we will introduce the relevant cue constraints (section 4.1) and illustrate the interaction of cue and structural constraints in the perception grammar for two example loanwords (section 4.2). Section 4.3 discusses how the perceptually borrowed words are then stored in the lexicon and subsequently produced, but also elaborates on other adaptation strategies than perception.

4.1 Cue constraints for the adaptation of English OL-clusters

The loanwords in (5) and (6) showed that HK Cantonese listeners seem to perceive the obstruents in the OL-onset cluster perfectly well (they always preserve them in the adaptation), but are less sensitive to the cues of the liquids. This is due to the less salient cues of liquids in this position, as already proposed by Yip (1993). The mapping of liquid and obstruent cues onto phonological categories is performed in our perception grammar by cue constraints, see (7).

(7) a) *[*liquid*] / /: Auditory liquid cues must correspond to a phoneme in the surface form.
b) *[*obstr*] / /: Auditory obstruent cues must correspond to a phoneme in the surface form.
c) *[*obstr*] / / ≫ *[*liquid*] / /

The cue constraint in (7a), for instance, is violated if a listener does not map the auditory cues of liquids (such as low amplitude energy and lowering of higher formants) onto a segment in the surface form. Similarly, the constraint in (7b) is violated if the listener does not map obstruent cues (such as silence closure and plosive burst for plosives and friction noise for fricatives) onto a segment in the surface form. The fact that liquid cues are less salient than obstruent cues is expressed with the ranking in (7c). This ranking emerges automatically in the acquisition process, due to the fact that salient obstruent cues are almost always perceived while the less salient liquid cues adjacent to vowels are sometimes not perceived as cues to separate segments (and therefore not mapped onto a separate phoneme in the surface form).

To model the perception of [ɹ] as a native approximant that results in the borrowings in (4) and (5), further cue constraints are necessary that prohibit the mapping of rhotic cues onto anything but an approximant. The same holds for the mapping of fricative cues onto non-fricative segments, etc. Such constraints, however, are not relevant for the present analysis of loanwords and therefore not included in the following analyses.

With respect to the perception of the English voiceless plosives in initial position, some further considerations are necessary. While English is phonologically usually described as having a voicing contrast in plosives (one of the reasons being the intervocalic voicing of the /+voice/ segments; but see e.g. Beckman, Jessen & Ringen 2013 for an alternative view), Cantonese is usually described as having an aspiration contrast (e.g., Chao 1947, Matthews & Yip 1994). Phonetically, the English voiceless plosives are aspirated in syllable-initial position. This aspiration is mapped in the English perception process onto the phonological feature /–voice/, while the non-aspirated voiceless plosives are

mapped onto /+voice/. In Cantonese, aspirated initial plosives are mapped onto /+aspiration/, and non-aspirated onto /–aspiration/. We are thus dealing with a case of (almost) the same phonetic forms being mapped onto different phonological contrasts. In a formal perception grammar, this difference is expressed by language-specific cue constraints. This is illustrated with the cue constraints referring to the aspiration cue [^{h}] for English in (8a) and for HK Cantonese in (8b):

(8) a) English:
*[^{h}] /+voice/: Don't map aspiration noise onto voiceless segments.

b) HK Cantonese:
*[^{h}] /–asp/: Don't map aspiration noise onto non-aspirated segments.

Though initial English /p t k/ are often adapted as /p^{h} t^{h} k^{h}/ into HK Cantonese (e.g. Silverman 1992; Yip 1993: 267; Bauer & Benedict 1997), this is not always the case. There are several exceptions to this generalisation, e.g. *toast* as /.tɔː.siː./, *port* as /.pɔːt./ or *coffee* as /.kaː.fɛː./ (Bauer & Benedict 1997), and see several of the cluster adaptations in (5) and (6). In the list of loanwords with English initial voiceless stops as only onset segment by Bauer & Benedict (1997: 361–371), almost a third of the words are borrowed with voiceless non-aspirated plosives. Three of the seven words with a following liquid are not aspirated in the adapted form (Bauer & Benedict 1997: 380f.). Both findings refute a proposal by Yip (1993: 288 footnote 4) that non-aspiration occurs in the borrowing of English voiceless stops before liquids because the aspiration might be less salient in this position. We assume that the variation in adaptation is due to the generally shorter duration of plosive aspiration in English compared to that in HK Cantonese: see the voice-onset times measured by Lisker & Abramson (1964). As a result, HK Cantonese listeners perceive long aspiration [^{hː}] always as aspirated segments, while shorter, English-like aspiration [^{h}] is sometimes perceived as non-aspirated. This is expressed with the HK Cantonese cue constraints and their ranking in (9). These constraints generalize across the place-specific differences in aspiration (with more back places of articulation having longer aspiration), which seem to hold for all languages (see Lisker & Abramson 1964 for English, Cantonese and several other languages).

(9) *[^{hː}] /–asp/ ≫ *[^{h}] /–asp/ ≫ *[^{h}] /+asp/ ≫ *[^{hː}] /+asp/

The two middle cue constraints in (9) referring to English-like aspiration duration [^{h}] are assumed to be ranked fairly close on the ranking scale so that a stochastic evaluation of their ranking values can lead to the observed variation in

output forms (see Boersma 1997, Boersma & Hayes 2001 for stochastic evaluation). The constraints in (9) are not included in the following analyses.

While the constraints introduced in (7) concerned the mapping of existing perceptual cues, our analysis of cluster adaptation also requires the opposite type of constraint, where non-existent cues lead to the perception of a phonological segment, i.e. vowel insertion. This happens in the cases where HK Cantonese listeners insert a vowel to break up the OL-cluster for the loanwords in (5). The constraint that these forms violate is given in (10).

(10) *[ ] / V/: Don't map the absence of cues onto a vowel in the surface form.

The epenthetic vowels breaking up the clusters in (5) are preserving the perceptual cues of the vowels that follow the cluster, which are partially already perceivable in the formant transitions of the liquid.[4] The quality of the epenthetic vowel can therefore be regulated by cue constraints that refer to these transitions. For the sake of simplicity, the following analyses only include constraints or candidates with epenthetic vowels that copy the quality of the vowel following the liquid. Note that this type of perceptual "vowel copying" is of course restricted by the distribution of vowel allophones in HK Cantonese (thus cue constraints determining the quality of the vowel interact with the structural constraint ALLOPHONE).

4.2 Adaptation in the perception grammar

In the following we illustrate the perceptual adaptations of English OL-clusters in the perception grammar of HK listeners with the words /.fuː.lʊk./ *fluke*, showing vowel epenthesis, and /.pʰɛːn.tʰaː./ *printer*, showing liquid deletion.

Tableau (11) provides an analysis of the adaptation of *fluke*. The input to this tableau is the auditory form. The "k¯" in the auditory form stands for the formant transitions from a vowel into a velar plosive, the underscore "_" stands for a silent closure (as is usual for voiceless plosives in English), and "ᵏ" for a voiceless velar plosive release burst. Output candidates are surface phonological forms. They are written with phonemic symbols (which can be interpreted as shortcuts for feature representations) and contain syllable boundaries (".").

[4] For an articulatory account of how such vowel-like transitions in initial consonant-liquid clusters have led to the insertion of copied vowels, namely due to gestural overlap in liquid-vowel sequences, see Hall (2006) in general and Recasens (2014: 53f.) specifically for Romance languages. We assume here that listeners do not have direct access to articulatory information (apart from what can be deducted on the basis of visual cues), and therefore do not include articulatory considerations in the modeling of the perception grammar. For the inclusion of visual cues in perceptual loanword adaptation, see Seinhorst (2016).

constraints that regulate the perception of the vowel cues as /uː/ are not included in this tableau.

(11) HK Cantonese perception of the English word *fluke*

[fluːkˀ_ᵏ]	*/CC/	*/.μ./	*/r/	*[*obstr*] / /	ALLO-PHONE	MIN WORD	*[ ] /V/	*[*liquid*] / /
/.fluːk./	*!				*!	*!		
/.lʊk./				*!		*!		
/.fʊk./						*!		*
/.fʊ.lʊk./		*!					*	
/.fuː.luːk./					*!		*	
☞ /.fuː.lʊk./							*	

The first candidate violates not only */CC/, but also the phonotactic constraint ALLOPHONE, as the rhyme /uːk/ is not acceptable in HK Cantonese: before a velar coda, the allophone /ʊ/ occurs. The second candidate illustrates that the deletion of the obstruent to rescue the cluster is problematic, as the resulting output is too short to fulfil the bisyllabicity requirement for phonological words, and in addition this candidate has ignored the obstruent cues. Candidate three is slightly better, as neglecting the liquid cues violates a lower-ranked constraint (the liquid cues are less salient). This candidate is still too short. The last three candidates are all in line with the minimality requirement because they have an epenthetic vowel (and therefore violate the low-ranked constraint against vowel epenthesis), but they differ in terms of their syllabic structure. Candidate six, the winner, does not have monomoraic syllables and fulfils all Cantonese allophonic restrictions.

A formalization of the perceptual adaptation of *printer* is given in tableau (12). In the auditory input form, "ʰ" stands for the aspiration noise,[5] and "ɹ" for the lowered second and third formant of the postalveolar approximant rhotic in English.

[5] In the word *printer* (and in other words with initial plosive-lateral clusters) aspiration is of course realized as devoicing of (part of) the liquid rather than devoicing of the initial part of the vowel, which is traditionally transcribed as aspiration noise. We treat the two as being identical.

(12) HK Cantonese perception of English *printer*

[_^{ph}ɹɪnt$^{\urcorner}$_^{t}ə]	*/CC/	*/.μ./	*/ɾ/	*[*obstr*] / /	ALLO-PHONE	MIN WORD	*[ ] /V/	*[*liquid*] / /
/.p^{h}rɛ:n.t^{h}a./	*!		*!					
/.p^{h}lɛ:n.t^{h}a./	*!							
/.lɛ:n.t^{h}a./				*!				
☞ /.p^{h}ɛ:n.t^{h}a./								*
/.p^{h}ɛ:.lɛ:n.t^{h}a./							*!	

As in the adaptation of *fluke*, the candidates with intact clusters (candidate one and two) and the candidate without initial obstruent (candidate three) violate high-ranked constraints. None of the given candidates is monosyllabic, and thus no violation of MINWORD occurs. The choice between the candidate without a liquid (four) and that with a liquid and an epenthetic vowel (five) is decided by two lower-ranked constraints. The present example adaptation of *printer* as /.p^{h}ɛ:n.t^{h}a./ seems to indicate that for HK Cantonese listeners, the hallucination of a vowel is worse than ignoring liquid cues (as indicated by the ranking of the two respective cue constraints). However, many loanwords of more than two syllables with liquid and an inserted vowel exist (more than half of the examples in (5)), and some words even show variation, e.g. *place* is attested as /.p^{h}ej.si:./ and /.p^{h}ej.lej.si:./ (cf. (5)) and (6)). These observations indicate that the last two constraints are probably very closely ranked in the HK Cantonese perception grammar, so that variability in adaptation strategies is possible. This perception grammar can then account for the adaptation of all the English words with initial OL-clusters given in section 3.

4.3 Beyond the perception grammar

The above perception grammar formalized how the first perceptual adaptation of English loanwords happened, namely as native perception of a non-native auditory input, where perception involved auditory cues as well as native phonological restrictions. We thus formalized the *initial* borrowing process. The perceived surface forms (the outputs of the perception process) are stored without allophonic information (which is predictable) in the lexicon, and these stored forms are used subsequently for all following productions, as illustrated in (13) for the loanword *fluke*:

(13) [flu:k$^{\urcorner}$_^{k}] → /.fu:.luk./ → |fuluk| → /.fu:.luk./ → [fu:luk$^{\urcorner}$_^{k}]
perceived as *stored as* *produced as* *implemented as*

Every perceptually adapted word thus initially runs through the whole comprehension and production process of our model (from lower left to lower right in Figure 1). The mapping of the phonological surface form onto the underlying form (or the reverse in phonological production) is not the topic of the present article. This mapping is mostly faithful in HK Cantonese, which is an isolating language that does not have any inflection or conjugation (Matthews & Yip 1994) and therefore shows no interesting segmental phonological alternations apart from mappings of allophones onto underlying phonemes. The workings and the relevance of non-straightforward surface to underlying mappings for loan adaptation are illustrated by Boersma & Hamann (2009) for Korean.

While the input to the perception-production loop in (13) is a non-native phonetic form, the output is a native phonetic form. Such native phonetic forms then provide the perceptual input to other speakers and learners of the same language. Subsequent productions by the same speaker do not involve any perceptual adaptations any more, but start with the stored underlying form.

It is important to note that we assume *Richness of the Base* (Prince & Smolensky 1993 [2004]) not to apply to underlying representations (i.e. the input to traditional OT tableaux) but to the perceptual input form (the input to perception tableaux). This means that the perceiver is able to make sense of every possible auditory input, but that there is only a restricted set of underlying forms, namely those constructed by the language learner from the surface representation via faithfulness constraints in the comprehension process, doing away with the OT-concept of *Lexicon Optimization* (Prince & Smolensky 1993 [2004]).

In the following section, we illustrate how the BiPhon model can account for a change in adaptations across generations.

5 Differences in the adaptation strategy as a window on change

This section deals with the observation that adaptations of OL-clusters seem to have changed over time, as illustrated by the loan doublet in (14). Both forms of this doublet are borrowings of the English word *cream* (Yip 2006; Wong, Bauer & Lam 2007; Bauer & Wong 2008).

(14)	a) *gei6lim1*	/kej.liːm/	bakery cream	early borrowing
	b) *kwim1*	/k^{wh}iːm/	facial/drinkable cream	recent borrowing

The first borrowing (14a) occurred between the mid-19th century and the end of World War II (Bauer 2010). It involves epenthesis of a vowel to break up the

initial English consonant cluster /kr/, resulting in a bisyllabic loanword with both syllables occurring in native HK Cantonese (see Bauer 1985 table 2). The later borrowing (14b) is fairly recent, as the syllable /k^{wh}i:m/ was reported as non-occurring by Bauer in 1985 (p.103), but listed as HK Cantonese syllable in the study by Bauer & Wong in 2008 (see also Bauer 2010). Here, the onset cluster is adapted as a labialized aspirated velar (a native phoneme). The resulting loan is monosyllabic.

The earlier adaptation can be accounted for by the perception grammar we introduced in section 4, see tableau (15).

(15) HK Cantonese perception of the English word *cream* (earlier form) with the perception grammar from section 4

[_^{kh}ɹi:m]	*/CC/	*/.μ./	*/r/	*[*obstr*] / /	ALLO-PHONE	MIN WORD	*[ ] /V/	*[*liquid*] / /
/.kri:m./	*!		*!			*!		
/.kli:m./	*!					*!		
/.li:m./				*!		*!		
☞ /.kej.li:m./							*	
/.ki:m./						*!		*
/.k^{wh}i:m./						*!		

The winning candidate in tableau (15) is the bisyllabic form /.kej.li:m./, the older form of the loan doublet. This tableau also contains the more recent borrowing of the loan doublet /.k^{wh}i:m./ as candidate six (with aspiration, but recall the discussion of variable adaptation of aspiration in section 4.1). This candidate violates the high-ranked MINWORD constraint.

We propose that the more recent borrowing reflects a difference in the perception grammar between borrowers from the earlier stage and those from the later stage, i.e. a difference in the perception grammar across generations of HK Cantonese speakers. We furthermore propose that this difference in the perception grammars is due to larger exposure to and use of English by HK Cantonese speakers: most speakers had a moderate amount of English input at the time of the earlier borrowing, while in recent times HK Cantonese speakers have had much more input and hence have a much better knowledge of English (Bauer 1984; Lau 1999), with an increasing number of bilingual speakers due to the relevance of English (Bauer 1985, 2006; Lau 1999; Ding 2010) and more use of English at school (Li, Wang, Leung & Wong 2016: 14). This change in the overall exposure caused younger HK Cantonese speakers to acquire a different perception grammar. This difference is apparent in the forms in (14):

for the same source form, the grammar of younger borrowers yields a different adaptation than that of early borrowers.

Though there is no other HK Cantonese loan doublet with attested times of borrowing, the near doublet in (16) based on two homophonic English words is a close candidate:

(16)	a)	*bik1lik1*	/.pɪk.lɪk./	brake for car	Bauer & Benedict 1997: 380
	b)	*bik1*	/.pɪk./[6]	recess, break	pers. observation second author

Again, we can observe a bimoraic older adapted form (16a), and a monomoraic borrowing (16b) that is more recent.

In addition to the newer forms in these two (near-)doublets, there are several other loans that depart from the adaptation pattern we observed in section 3 and 4, as they are not in accordance with the MINWORD constraint, see the examples in (17). Note that most of these examples have been reported fairly recently. The examples from Leci & Poon (2004) stem from an online-adaptation task with one native speaker, are thus not established loans.

(17)	*bang1*	/.pɐŋ./	prom	Yip 2006: 953
	gip1	/.kiːp./	creep	Yip 2006: 953
	paai1	/.pʰaːj./	pry	Leci & Poon 2004: 109
	caai11	/.tsaːj./	try	Leci & Poon 2004: 109
	gu1	/.kuː./	crew	Leci & Poon 2004: 109
	kem1	/.kʰɛːm./	claim	Bauer pers. observation 2007
	pin1	/.pʰiːn./	print	pers. observation second author
	kek1	/.kʰɪk./	mouse click	Bauer & Benedict 1997: 380
	fen1	/.fɛːn./	friend	Bauer & Benedict 1997: 380
	gip1	/.kiːp./	grip	Bauer & Wong 2008 (1999)

On the basis of such data, Yip (2006) dismisses the use of the MINWORD constraint for HK Cantonese, but adds in a footnote: "The minimal word effect reported in Silverman and Yip *does* seem to be true for the more established loans" (p. 953). Yip's observation corroborates our proposal that a change seems to have occurred in the adaptation strategies of HK Cantonese, with the data in (17) representing newer adaptations.

Tableau (18) formalizes the perception grammar of younger borrowers with *cream* as example. Note that the candidates all show aspiration, the tableau

[6] This word also exists as /.prɪk./, but the presence of an /r/, which never occurs in HK Cantonese, leads us to conclude that this form is due to code switching to HK English, and not loan adaptation.

thus does not include the decision between aspirated and non-aspirated candidates; for the relevant constraints and their rankings see section 4.1.

(18) HK Cantonese perception of the English word *cream* (by younger generation)

[_^{kh}ɹiːm]	*/CC/	*/.μ./	*/r/	*[*obstr*] / /	ALLO-PHONE	*[ ] /V/	MIN WORD	*[*liquid*] / /
/.k^{h}riːm./	*!		*!				*	
/.k^{h}liːm./	*!						*	
/.liːm./				*!			*	
/.k^{h}ej.liːm./						*!		
/.k^{h}iːm./							*	*!
☞ /.k^{wh}iːm./							*	

In this grammar, the bisyllabic fourth candidate /.k^{h}ej.liːm./ violates a fairly high-ranked constraint against the hallucination of a vowel. The fifth candidate /.k^{h}iːm./ loses to the sixth candidate /.k^{wh}iːm./ because the latter preserves some of the liquid cues in the secondary labialization of the velar, whereas the former ignores the liquid cues altogether.

The ranking of the two constraints MINWORD and *[ ] /V/ has changed in the perception grammar of the newer generation compared to that of the older borrowers in (15). How did this change come about? As elaborated above, we propose that the larger exposure to English (including HK English) that speakers received in recent years is responsible for this. Younger generations have heard more monosyllabic English nouns than preceding generations, and due to the larger amount of English input they are also more sensitive to the presence or absence of vowels in the auditory input of English forms than older generations were. The difference in input results in the acquisition of a different perception grammar. Note that the present proposal thus assumes that L2 input influences the L1 perception grammar to some degree. Evidence for such language transfer effects is abundant in the literature (see e.g. Ribbert & Kuiken 2010 and Ulbrich & Ording 2014 for recent studies on phonetic and phonological transfer).

This different perception grammar does not prevent the younger generation to acquire and use the word /.kej.liːm./ ‘bakery cream’, as this is not perceptually adapted anymore but learned via the native phonetic input [_^{k}ejliːm], recall the nativization of *fluke* as [fuːlʊkˀ_^{k}] in (13). A change in the perception grammar of the younger generation thus does not influence the perception and production of loanwords that were adapted by older generations.

6 Previous loanword accounts relevant to the present study

The present analysis follows the generalization made by Silverman (1992) and Yip (1993, 2002) that loanword adaptation in HK Cantonese seems to be influenced by a native minimally bisyllabic word restriction (though Silverman used a binary foot template, thereby also proposing a maximum boundary of two syllables). Furthermore, the proposed analysis is in line with Yip's (2006) observation that the MINWORD restriction does not seem to hold for newer adaptations. Thirdly we adopted Silverman (1992)'s and Yip's (1993) ideas that borrowers are more sensitive to certain aspects of perceptual information than to others (Yip's distinction in saliency between obstruents and post-consonantal liquids, Silverman's different treatment of liquids and vowels). However, both authors assume an extragrammatical perception module that precedes the adaptation in the phonological module, the latter being production-oriented only (as standardly assumed in phonological theory). This assumption forces Yip (1993) to reduplicate some of the perceptual information in the phonological module: she employs a phonological PARSE constraint that is only violated if perceptually salient segments are deleted. Silverman (1992), on the other hand, assumes an operative level, a separate domain from the native phonological system, that brings the non-native percept in line with native phonological structures. He furthermore makes an arbitrary distinction between phonological knowledge applying at the perceptual level (where auditory input is parsed via a prosodic template) and phonological knowledge applying on the operative level. In his account we thus observe a reduplication of phonological knowledge. Our proposal does away with such reduplications of perceptual or phonological knowledge: the BiPhon model makes a strict division between phonetic and phonological representations, formalizes the interaction of both, and incorporates the comprehension process in its formalization. We showed that by assuming such a model, we can furthermore account for possible changes in the adaptation strategies of HK Cantonese loanwords.

Four further studies on HK Cantonese loanwords need to be mentioned here. The study by Leci & Poon (2004) formalizes an OT grammar for the online adaptations of their one participant. They assume that the input to the (production-only) grammar is the English surface form, and cast the whole adaptation process in terms of markedness constraints, thereby ignoring the influence of perception entirely. Yip (2002, 2006) introduces so-called MIMIC constraints that are specific to mimicking foreign inputs, and thereby moves away from her original idea of using the native OT grammar to account for loan adaptations. A similar loan-specificity can be found in the work by Kenstowicz (2012), who employs loanword-specific rankings of phonotactic restrictions to account for borrowings of rhymes. Interestingly, Kenstowicz assumes that the

phonotactic restriction *ET (avoidance of rhymes consisting of a mid front vowel and a non-velar consonant) is high ranked for native HK Cantonese words and two loanwords, namely *pence* /.piːn.siː./ and *offset* /.ɔː.sɪk./, but is violated by and therefore low ranked for the loan *Benz* /.pɛːn.siː./ (p. 75). This seemingly arbitrary difference between the two sets of loans (which is awkwardly formalized as word-specific rankings) could indicate a similar diachronic change in the perception grammar as proposed in the present article, with earlier borrowings avoiding sequences of mid front vowels and non-velar consonants and latter borrowings accepting them.

Itô and Mester (1999, 2001) do not deal with adaptations in HK Cantonese. Their work is relevant for the present study as it accounts for "the fact that the phonological lexicon of a language is usually not a homogeneous structure, but shows considerable internal subdivision" (2001: 4), where this internal structure is assumed to be the result of borrowings at different diachronic stages of a language. This stratified lexicon is formalized by Itô and Mester as the interaction of markedness constraints (in a fixed ranking) with a FAITH constraint; the ranking of the latter depending on the stratum. Applied to the present data, Itô and Mester's account would have to distinguish two lexical strata in one grammar instead of a different perception grammar at the two points of borrowing. FAITH then would have to be ranked above MINWORD in one stratum (for the newer loans), and below MINWORD for the other stratum (the older loans).

Like the alternative accounts discussed above, Itô and Mester assume a traditional production-only phonological grammar without a strict division between phonetic and phonological representations, and are not concerned with the perception process. An incorporation of perceptual considerations as markedness constraints would thus result in a duplication of phonetics in phonology (see also the criticism of Haspelmath 2006 of this general problem with markedness constraints in traditional OT accounts).

In the present account it is not necessary to differentiate lexical strata by assigning them different constraint rankings, as a stratified lexicon emerges automatically with borrowings at different times and a diachronic change in the perception grammar. This is illustrated for the HK Cantonese data in (19) on the next page. The perception grammar of the older generation in (19a) results in the adaptations presented in section 3, which form one homogeneous "lexical stratum" (S_1). As elaborated in section 4.3, this generation subsequently uses the stored lexical representations for production, resulting in native phonetic forms. These native phonetic forms are then the input for the younger generation, cf. (19b), whose perception grammar does not have to adapt the forms as they are already in line with native restrictions. These forms thus result in a set of underlying representations (S_1) that is similar to the one of the previous

generation. Newly incoming foreign structures such as the data presented in section 5, however, are adapted on the basis of the perception grammar of the younger generation, resulting in underlying representations that can fundamentally differ from those of established loans, forming a new lexical stratum (S_2).

(19) a) Perception and lexical storage by the older generation

[_^{kh}ɹiːm]	*Perception grammar 1:*	→	/.kej.liːm./	→	|kejlim| 'bakery cream'
[fluːk$^{\urcorner}$_^{k}]	MINWORD >> *[ ]/ V/	→	/.fuː.luk./	→	|fuluk| 'fluke' S_1

b) Perception and lexical storage by the younger generation

[_^{k}ejliːm]		→	/.kej.liːm./	→	|kejlim| 'bakery cream'
[fuːluk$^{\urcorner}$_^{k}]	*Perception grammar 2:*	→	/.fuː.luk./	→	|fuluk| 'fluke' S_1
[_^{kh}ɹiːm]	*[ ]/ V/ >> MINWORD	→	/.k^{wh}iːm./	→	|k^{wh}im| 'facial cream'
[_^{kh}lɛjm]		→	/.k^{h}ɛːm./	→	|kem| 'claim' S_2

We therefore argue that for the HK Cantonese loanword data our present account is preferable to Itô and Mester's stratified lexicon account.

7 Conclusion

The present article provided an illustration of how a perception grammar can account for HK Cantonese loan adaptations of English OL-clusters without specific devices such as loanword-specifi rankings or constraints. This is possible by making a principled distinction between phonological and phonetic representations, and by including the comprehension process in the grammar model, as in the BiPhon model that has been applied in this article. Earlier approaches such as Silverman (1992) and Yip (1993, 2002) already acknowledged the role of perception but let phonological restrictions only apply in the "phonology" (concerned with production only), which resulted in reduplication of phonological or phonetic knowledge (as elaborated in section 6 above). By illustrating that phonological restrictions apply in the perception process, the present account avoids such duplication and further solves the long-standing discussion whether loan adaptation is perceptual, phonological or both: perception itself is phonological (Boersma & Hamann 2009).

In addition, the present article illustrated that changes in the adaptation strategy might be caused by a change in the perception grammar of the

borrowers across generations. In the present case, this change is due to the fact that younger speakers receive much more English input than earlier generations. As proposed by Kang (2012, 2013), loanword adaptations can thus be a window to diachronic changes in the borrowing language. We illustrated that a minimal word restriction does not seem to hold for recent loanwords in HK Cantonese, in line with a comment by Yip (2006: 953). In contrast to Yip, who for this reason rejects an influence of MINWORD on HK Cantonese loanword adaptation altogether, the present article provides an analysis in terms of a changing status of this constraint over time in the perception grammar of the borrowers. We are positive that future studies on changes in the borrowers' perception grammar can account for further seemingly disparate loanword adaptation patterns within languages.

8 References

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