The Role of Acoustic Cues in Nonnative Cluster Repairs

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1. Introduction

In loanword adaptation, when a consonant cluster in a source language is phonotactically illegal in the borrowing language, phonological repairs may take place. The most frequent repair is vowel epenthesis; for example, Russian *tkan^j* 'fabric' is adapted as [t**i̲**kan] in Ewen (Choi, 2010), with an inserted vowel between the two stops. The next most frequent repair is deleting one of the consonants in the cluster; for example, English 'belt' is adapted as [bêl] in Hausa (Awagana & Wolff, 2009), omitting the final stop. Of special interest is that sites of vowel epenthesis and consonant deletion differ depending on the cluster. Particularly, epenthesis sites have been paid much attention by phonologists (Broselow, 1992; Fleischhacker, 2001, 2005; Gouskova, 2002; Steriade, 2006). Previous generalizations about epenthesis sites refer to sonority profile between consonants in a cluster; clusters with rising sonority are likely to be split by internal epenthesis, whereas clusters with flat or falling sonority are likely to undergo external epenthesis, not breaking the cluster. For example, Russian word *trupka* 'pipe' is borrowed into Kirghiz as [t**u̲**rupke] with internal epenthesis, whereas *lbovskij* 'nonce last name' is borrowed as [**y̲**lbovskij] with external epenthesis (Gouskova, 2002). Unlike epenthesis sites, which consonant to delete in a cluster has not been well studied so far. Even for the epenthesis patterns, previous work has only focused on epenthesis either in stop-sonorant and sibilant-stop clusters (Broselow, 1992; Fleischhacker, 2001, 2005) or in word-initial clusters even including other kinds of clusters (Gouskova, 2002; Steriade, 2006).

This study aims to provide comprehensive cross-linguistic generalizations concerning sites of vowel epenthesis and consonant deletion in nonnative cluster repairs, by considering all possible types of clusters both in word-initial and word-final positions. Also, I will argue that it is acoustic cues that play a key role in determining sites of epenthesis or deletion, rather than sonority contour between consonants in a cluster. It will be shown that phonetically-based constraints and interactions between their fixed ranking and other relevant constraints can successfully explain the typology of nonnative cluster repairs in a uniform way.

2. Typology

I surveyed loanwords including a consonant cluster that consists of two consonants, either in word-initial or word-final position, from 51 languages of which donors are mostly from English, Russian, or Arabic. The current survey considered only the cases where language-specific markedness does not obligatorily determine the position of epenthesis or deletion. For example, Russian *rtut* 'mercury' is adapted as [**u̲**rtut] in Kirghiz (Gouskova, 2002), which is not taken into consideration here because Kirghiz does not allow word-initial [r], and *[r**u̲**tut] is not a possible repair in this language. Also, this paper will not discuss clusters containing a word-initial/-final fricative, which show more complex patterns, due to the page limit.

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2.1. Epenthesis

Let us first look at the survey results concerning epenthesis sites. With regard to epenthesis in clusters including a stop, a clear tendency we can find is that if a cluster contains a stop at the word edge, a vowel is epenthesized *after* the edge stop, as shown in (1). (T: stop, F: fricative, N: nasal, L: liquid, ə: epenthetic vowel; data from my own elicitation hereafter, unless otherwise noted)

(1) Epenthesis in stop-edge clusters (epenthetic vowels underlined)

Contexts	*Examples*
#TT → #TəT	gdansk (Polish; city name) → [gədænsk] (English)
#TF → #TəF	thon (Thai; 'endure') → [tahan] (Indonesian) (Tadmor, 2009)
#TN → #TəN	kniʃka (Russian; 'book') → [kineʃke] (Kirghiz) (Gouskova, 2002)
#TL → #TəL	klub (Russian; 'club') → [kɨlub] (Tatar)
TT# → TTə#	'Egypt' → [icipt^{h}ɨ] (Korean)
FT# → FTə#	most (Russian; 'floor') → [mosta] (Ewen) (Choi, 2010)
NT# → NTə#	'paint' → [p^{h}ɛint^{h}ɨ] (Korean)
LT# → LTə#	ʃolk (Russian; 'silk') → [ʃelki] (Tatar)

Here we can see that across many donor and borrowing languages, epenthesis occurs after a word-initial or word-final stop. Notice that even though epenthesis before the stop is okay in the borrower language phonotactics, epenthetic vowels are uniformly located after an edge stop. In English, for example, both [gədænsk] and *[əgdænsk] are phonotactically possible, but Polish *gdansk* is borrowed only as the former.

In contrast, if a cluster contains a sonorant at the word edge, a vowel tends to be epenthesized *before* the edge sonorant, as demonstrated in (2). This tendency is not exceptionless as in clusters with an edge stop shown above, and word-initial nasals preceding a heterorganic nasal or liquid have an epenthetic vowel after them.[1]

(2) Epenthesis in sonorant-edge clusters (epenthetic vowels underlined)

Contexts	*Examples*
#LT → #əLT	lbovskij (Russian; nonce last name) → [ylbovskij] (Kirghiz) (Gouskova, 2002)
#LF → #əLF	l'vov (Russian; city name) → [ilvop] (Kirghiz) (Gouskova, 2002)
#NT → #əNT	mbira (Shona; 'mbira') → [əmbirə] (English)
#NN → #NəN	mnemosine (Greek; 'mnemosyne') → [minemosine] (Korean)
#NL → #NəL	mladic (Serbian; nonce last name) → [məladitʃ] (English)
TL# → TəL#	karabl' (Russian; 'ship') → [karabɨl] (Tatar)
FL# → FəL#	'waffle' → [wafel] (Indonesian)
NL# → NəL#	kreml' (Russian; 'the Kremlin') → [kremɯl] (Kirghiz)
LL# → LəL#	'earl' → [eʁel] (Hebrew) (Cohen, 2009)
TN# → TəN#	hukm (Arabic; 'law') → [hokum] (Indonesian) (Tadmor, 2009)
FN# → FəN#	ʒism (Arabic; 'body') → [ʒisim] (Indonesian) (Tadmor, 2009)
NN# → NəN#	gimn (Russian; 'hymn') → [gimun] (Kirghiz)
LN# → LəN#	'film' → [filim] (Hebrew) (Cohen, 2009)

Here, again, markedness does not play a role in determining epenthesis sites. In Hebrew, for instance, 'film' is adapted as [filim] with internal epenthesis, even though *[filmi] with external epenthesis should be allowed in Hebrew phonology.

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1 There is an exception to this statement, although it is a single data point. In Kirghiz, word-initial nasal-nasal clusters are reported to show external epenthesis: mnemonicheskij (Russian; 'mnemonic') → [ymnemonicheskij] (Gouskova, 2002).

Summing up, an epenthetic vowel goes: (i) *after* word-initial or word-final stops and initial nasals preceding a heterorganic sonorant, and (ii) *before* word-initial or word-final sonorants (excluding initial nasals preceding a sonorant). By considering wide-ranging data in both word-initial and word-final positions, it is shown that the previous generalization that clusters with rising sonority undergo internal epenthesis and clusters with flat or falling sonority undergo external epenthesis cannot hold; word-initial stop-stop and nasal-nasal clusters (#TT → #TəT, #NN → #NəN) and word-final nasal-nasal and liquid-liquid clusters (NN# → NəN#, LL# → LəL#) with flat sonority are split by vowel insertion, and so are word-final liquid-nasal clusters (LN# → LəN#) with falling sonority.

2.2. Deletion

A common target of deletion in cluster adaptation is a word-final stop, as shown in (3). Unlike word-final stops, word-initial stops are rarely omitted (I have only a single example of initial stop deletion in Finnish), and I have no example showing deletion of a non-edge stop (e.g., *#CTV → #CV). The reverse goes for sonorants. Whereas non-edge, vowel-adjacent sonorants, particularly liquids, frequently delete as in (4), sonorants at the word edge do not delete but mostly undergo epenthesis as in the examples seen above or sometimes undergo vocalization (e.g., 'shuttle' → [ʃátà] (Hausa; my elicitation)).

(3) Deletion of word-final stops

Contexts	*Examples*
T_1T_2# → T_1#	'compact' → [kompak], 'intercept' → [intəsɛp] (Indonesian)
NT# → N#	'camp' → [kem], 'pump' → [pam] (Thai)

(4) Deletion of non-edge, vowel-adjacent liquids

Contexts	*Examples*
LN# → N#	'film' → [fi:m] (Thai) 'Köln' → [ko:n], 'Stockholm' → [stukum] (Tatar) 'Melbourne' → [melbo:n] (Tatar), 'modern' → [modən] (Korean)
LL# → L#	'pearl' → [pʰəl] (Korean)

Since both word-final stops and non-edge liquids are targets of deletion, either could delete in LT# clusters, and in #TL clusters it is the liquid that almost always deletes, as exemplified in (5).

(5) #TL or LT# cluster adaptation

edge stop del	*Examples*
#TL → #L	gramatika (Russian 'bible') → [ra:mattu] (Finnish) (Karttunen, 1977: the only example)
LT# → L#	'belt' → [bêl] (Hausa) (Awagana & Wolff, 2009) 'milk' → [miw], 'gold' → [gow] (Thai)
sonorant del	*Examples*
#TL → #T	'class' → [ka:t]~[kla:t] (Thai)
LT# → T#	'volt' → [fɔːt] (Cantonese) (Kenstowicz, 2012) 'shirt' → [cəːt] (Thai)

To summarize, targets of deletion in clusters include stops in word-final position and liquids adjacent to a vowel. Word-initial stops are hardly omitted, and non-edge stops and word-edge sonorants do not disappear cross-linguistically. The patterns of nonnative consonant cluster repairs introduced here are summarized in (6).

(6) Attested cluster repairs (R: sonorant; frequently occurring patterns in bold face)

	source	*epenthesis repair*	*deletion repair*
Word-initial clusters	#TC	**#TəC**	(#C,) #T (if the C is a liquid)
	#NT	**#əNT**	
	#NR	**#NəR**	
	#LC	**#əLC**	
Word-final clusters	CT#	**CTə#**	**C#, T#** (if the C is a liquid)
	CR#	**CəR#**	CV# (if the R is a liquid)

3. Acoustic Cues

The goals of this section are to argue that it is acoustic cues that determine sites of vowel epenthesis and consonant deletion in nonnative consonant cluster repairs, and to discuss what kind of acoustic cues specifically plays a central role. My argument is crucially based on the P-map hypothesis (Steriade, 2008), which assumes that perceptually smaller modifications are preferred and selected by fixed rankings between correspondence constraints that reflect perceptual distinctness; a faithfulness constraint against more salient perceptual change invariantly dominates a faithfulness constraint against less salient perceptual change. In the cluster adaptation, specifically, a vowel is inserted to a position that makes the resulting sequence perceptually more similar to the original sequence, and a deletion target is chosen as the one whose deletion would bring about perceptually smaller change from the original cluster than others. In the following subsections, I will discuss acoustic cues that may affect perceptually similarity between the original cluster and repaired forms.

3.1. Epenthesis

We have seen in the typology of epenthesis sites that a vowel is inserted (i) *after* a word-edge stop or a word-initial nasal followed by a heterorganic sonorant, or (ii) *before* the rest of word-edge sonorants, and this typology could not be explained by sonority profile between consonants in a cluster. I propose that an epenthetic vowel is located at an *acoustic disjuncture*, if any, and if there is no acoustic disjuncture, an epenthetic vowel appears outside the cluster. Here I define an acoustic disjuncture as perceptually salient acoustic discontinuity in speech signal, which appears between the two consonants in a cluster. Acoustic disjunctures show abrupt spectral change mostly accompanied by a rise of intensity. A perceptual hypothesis is that epenthesis at an acoustic disjuncture would be a perceptually smaller modification from the original cluster than epenthesis at a non-acoustic-disjuncture. This is because at an acoustic disjuncture, the two consonants in the original cluster are already somewhat discontinuous acoustically due to changes in intensity or formant movements, and thus splitting the cluster by a vowel would just make the discontinuity larger and clearer. In a consonant cluster where there is no acoustic disjuncture, on the other hand, epenthesis would create a new discontinuity that does not exist in the cluster at all.

The acoustic disjuncture is basically formed by a release of an occlusive. That is, acoustic disjunctures following released stops and nasals would become preferred epenthesis sites. Also, formant movements between heterorganic sonorants might form acoustic disjunctures.

First of all, stop releases begin with a burst, brief high amplitude noise, which is produced when air pressure behind the closure is suddenly released. This release burst yields rapid spectral change accompanied by a rise of intensity, forming an acoustic disjuncture. Contexts where a stop is always released in a cluster involve word-initial position ($\#T^hC$) as in Figure 1[2] and pre-sonorant position in word-final clusters ($T^hR\#$) as in Figure 2. On the other hand, stops in a word-final stop-stop cluster might be released or not ($T_1^{\urcorner}T_2^h\#$ or $T_1^hT_2^h\#$), depending on the language, style, speaker, speech rate, and so on. Figure 3 shows a case in which both of the stops are audibly released. It is expected that when epenthesis happens, epenthetic vowels would be likely to be posited after a released stop, i.e., a word-initial stop or a stop followed by a sonorant, and optionally after a stop preceding a word-final stop, depending on whether it is released or not. A piece of evidence for the role of stop release bursts can be found in loanwords in Korean. In Korean, English loanwords ending in a stop-stop cluster are adapted

[2] All clusters of which spectrograms are provided here are pronounced by a male Russian speaker.

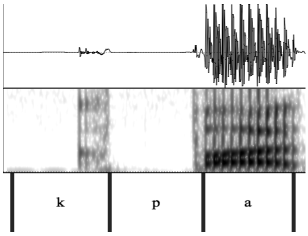


Figure 1: [kpa]

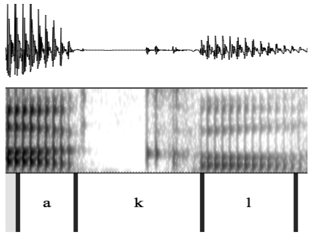


Figure 2: [akl]

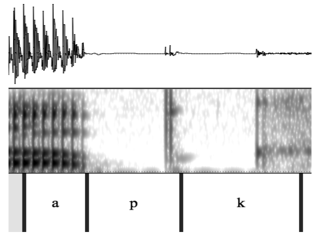


Figure 3: [apk]

with a single epenthetic vowel after the final stop: e.g., 'compact' → [k^{h}əmpɛkt^{h}ɨ] (Kang, 2003). On the other hand, Russian word-final stop-stop clusters are optionally borrowed with two epenthetic vowels, after both of the stops: e.g., *relikt* → [ɾellik^{h}ɨt^{h}ɨ]~[ɾellikt^{h}ɨ] (my elicitation). I attribute this difference in cluster adaptation to different phonetic realizations of stops in English and Russian. While in word-final stop-stop clusters the first stop is only optionally released in English, in Russian both of the stops are always audibly released. This shows that when there exists an acoustic disjuncture formed by a stop release burst, an epenthetic vowel is likely to be inserted there.

Acoustic disjunctures may also be found after a nasal consonant. Nasals are released too, possibly with audible vocalic release, before the following sonorant. It also generates abrupt spectral change with rising intensity. Contexts in which a nasal might be audibly released include word-initial and word-final heterorganic nasal-sonorant clusters (#mn, #ml, #mr, mn#, ml#, mr#; no loanword example beginning with [n]), as shown in Figures 4, 5, and 6. In addition, when the following sonorant is heterorganic to the preceding nasal, an open transition between the release of the nasal and the constriction of the following sonorant may exist. This will also result in some discontinuity between the initial nasal and the following sonorant, strengthening the acoustic disjuncture formed by a release of the nasal, which would make vowel insertion in that position to be quite perceptually similar to the original cluster.

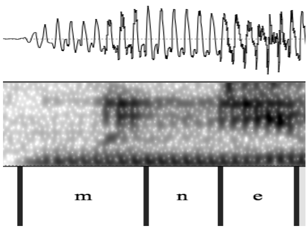


Figure 4: [mne]

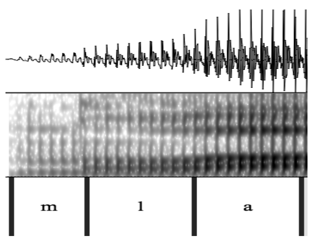


Figure 5: [mla]

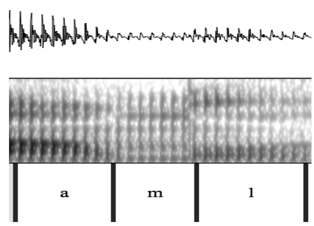


Figure 6: [aml]

The question is what kind of acoustic disjuncture exists in word-final liquid-nasal clusters. As seen earlier, epenthesis occurs between the two sonorant consonants in liquid-nasal clusters: e.g., 'film' → [fîm] (Hausa; my elicitation). Word-final liquid-nasal clusters, unlike other clusters having internal epenthesis, show spectral change with falling intensity. I assume here that formant movements from the liquid into the (heterorganic) nasal function as an acoustic disjuncture. It might be supported by the fact that examples with a homorganic [ln] cluster show deletion of the [l], not epenthesis, (e.g., *Köln* (German; city name) → [ko:n] (Tatar; my elicitation)), and no loanword has an epenthetic vowel between the two. One might wonder whether word-initial [lm] clusters also show the same epenthesis pattern. Unfortunately, I was not able to find any example of loanwords whose source begins with [lm].

On the other hand, I assume that all the other contexts have no acoustic disjuncture. Any unreleased stop has an inaudible release, and thus produce no disjuncture after it. Liquids have no release and thus there is no discontinuity into the following consonant, as shown in Figure 7 and 8.[3] Homorganic nasal-consonant clusters also yield no acoustic disjuncture as seen in Figure 9 since nasals are typically unreleased under their overlap with the following homorganic consonant.

[3] Laterals and rhotics are phonetically very different, although they are classified as liquids together. Unlike laterals, rhotics such as flap or trill consonants may have release-like intervals. Due to the page limit, I only discuss laterals in this paper and the term 'liquid' hereafter refers to [l].

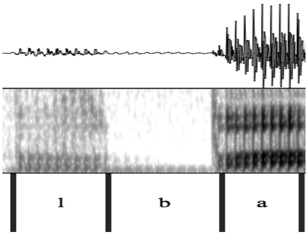


Figure 7: [lba]

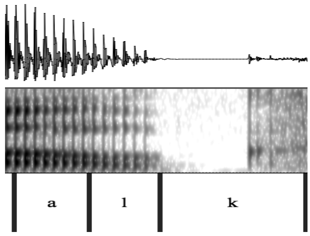


Figure 8: [alk]

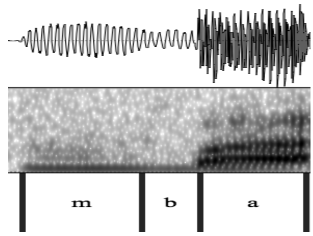


Figure 9: [mba]

Consonant clusters with or without acoustic disjunctures and the corresponding epenthesis patterns are summarized in (7). Acoustic disjunctures are represented as ǁ, and otherwise there is no acoustic disjuncture. We can see here that the position of acoustic disjuncture corresponds to the position of vowel insertion. In contrast, when there is no such disjuncture, an epenthetic vowel goes outside the cluster.

(7) Clusters with/without acoustic disjunctures

	acoustic disjuncture	epenthesis	*no acoustic disjuncture*	epenthesis
word-initial	#TǁC #NǁR	#TəC #NəR	#LC #NT	#əLC #əNT
word-final	T(ǁ)Tǁ# TǁR# LǁN# (heterorganic)	T(ə)Tə TəR# LəN#	RTǁ# LN# (homorganic)	RTə# –

I have argued that acoustic disjunctures play an important role in determining epenthesis sites in consonant cluster adaptation, and have assumed that vowel epenthesis in an acoustic disjuncture is a perceptually less salient change from the original cluster than vowel epenthesis in a non-acoustic-disjuncture, as schematically represented in (8), where Δ(A-B) is read as "the perceptual distinctness between A and B". This will serve as a basis for a universal ranking, which will be discussed in section 4.

(8) Δ(ø-ə)/¬ACOUSTICDISJUNCTURE >Δ(ø-ə)/ACOUSTICDISJUNCTURE

3.2. Deletion

Acoustic cues play a role also in determining which consonant to delete in a cluster. My hypothesis with regard to consonant deletion is that what is important is preserving acoustic cues that a consonant has, if any, and presence or absence of acoustic cues of a consonant in question determines whether the consonant deletes or not. That is, deletion targets, i.e., word-final stops and vowel-adjacent liquids, are prone to delete since they have little loss of acoustic cues in case of deletion, while the others, i.e., non-edge stops and word-edge sonorants, are not since they have acoustic cues that will be lost if they delete. This hypothesis also is based on perception; loss of acoustic cues would be perceptually more noticeable than the little loss, and thus consonants having certain acoustic cues are reluctant to disappear so as to avoid a perceptually salient change from the original cluster.

First, let us consider stops. Stops have no internal cues,[4] but do have transitional cues; if a stop is adjacent to a sonorant, it has formant transition cues into the sonorant, and stop release is accompanied by bursts, unless a stop is unreleased. So unreleased stops, which might occur word-finally (CT˺#) or preceding a final stop (T_1˺T_2^h#), are likely to be a target of deletion since it does not have transitional cues, as well as internal cues, by not preceding a sonorant and not being audibly released. On the other hand, final released stops and non-edge stops are not likely to delete because they have transitional cues, release bursts (and possibly formant transitions), to be preserved. Rather, they usually undergo epenthesis after them since their release bursts yield an acoustic disjuncture.

4 I assume that internal voicing cues of voiced stops are too weak to have an effect on the deletion of the stop in question.

On the other hand, sonorants have both internal and transitional cues. In particular, liquids have formant structures like vowels, and nasals have nasal resonance, as well as formant structures. Sonorants also have transitional cues, i.e., formant transitions into a neighboring vowel. So the deletion of a sonorant would be avoided because we must lose acoustic cues, either internal or transitional cues, of the deleting sonorant in any position. As seen in the previous section, however, liquids not in a word edge, particularly postvocalic liquids, are frequently omitted. I attribute the omission of vowel-adjacent liquids to the phonetic similarity of liquids to vowels. That is, acoustic cues of liquids are formant structures, which are very similar to the adjacent vowel. So even if a liquid adjacent to a vowel deletes, the resulting form would not be perceptually highly noticeable, especially when the liquid deletion is accompanied by compensatory lengthening of the adjacent vowel (e.g., 'film' → [fiːm] (Thai), 'volt' → [fɔːt] (Cantonese)), because the resulting form still shows formant structures that the liquid had. Thus, the deletion of a liquid adjacent to a vowel would be more tolerant than the deletion of a liquid not adjacent to a vowel, i.e., at the word edge, which results in no remaining formant structures (e.g., *TL# → T#). The fact that word-final liquids sometimes are vocalized (e.g., 'shuttle' → [ʃátà] (Hausa)) may also support the perceptual hypothesis; unlike the total deletion of the word-final liquid, vocalization maintains formant structures of the liquid, and thus is allowed.

The following table in (9) summarizes presence or absence of acoustic cues of consonants and the corresponding deletion patterns. What deletes, when the cluster is not allowed, are unreleased stops that do not bear both internal and transitional cues and non-edge liquids of which acoustic cues are very similar to the adjacent vowel.

(9) Contexts of consonants with/without acoustic cues (Yes: presence of cues; No: absence of cues)

consonant	position	*internal cues*	*transitional cues*	*deletion*
stop (released)	word edge	No	Yes	No
stop (unreleased)	word edge	No	No	Yes
stop (released)	non-edge	No	Yes	No
sonorant	word edge	Yes	Yes	No
sonorant (liquid)	non-edge	Yes	Yes	Yes

4. Analysis

This section provides a formal analysis of the typology of nonnative cluster repairs based on the P-map hypothesis (Steriade, 2008), within the framework of Optimality Theory (Prince & Smolensky, 2004). It will be shown that interactions between suggested perceptually-driven constraints and their rankings can correctly derive the typology introduced above.

Before embarking on the analysis, we need to clarify what exactly the input represents in loan adaptation. Here I assume that in loanword adaptation the input is auditory representation of the source language that includes phonetic details as well as phonemic status of the sounds in the source. So a given phoneme of the source language can be adapted differently in different segmental contexts depending on its surface phonetic characteristics in the source language (cf. Kang (2003), Shinohara (2006)). Therefore, information about acoustic cues such as acoustic disjunctures and internal/transitional cues discussed earlier should be available in the input.

4.1. Epenthesis

Let me introduce constraints we need to analyze the consonant cluster repairs. First of all, there would be a markedness constraint prohibiting consonant clusters, which triggers either epenthesis or deletion. I assume here that *COMPLEX defined in (10) penalizes consonant clusters in question in the borrowing language, although in fact different markedness constraints might be working in each language. When vowel epenthesis takes place, a faithfulness constraint prohibiting vowel insertion, DEP-V in (11), will be violated. So if *COMPLEX outranks DEP-V, epenthesis may occur. If the epenthetic vowel is posited between two consonants, CONTIGUITY in (12) will be additionally violated.

(10) *COMPLEX (cf. Prince & Smolensky, 2004): No tautosyllabic consonant sequences

(11) DEP-V (McCarthy & Prince, 1995): No insertion of a vowel.

(12) CONTIGUITY (McCarthy & Prince, 1995):
Elements adjacent in the input must be adjacent in the output.

In the previous section, I argued that epenthesis at an acoustic disjuncture would be a perceptually smaller modification from the original cluster than epenthesis at a non-acoustic-disjuncture, as schematically represented in (8). By the P-map, this perceptual difference is projected to correspondence constraints and their fixed ranking. I suggest two types of DEP-V constraints in (13).

(13) a. DEP-V/ACOUSTICDISJUNCTURE (DEP-V/AD):
No insertion of a vowel in acoustic disjunctures
b. DEP-V/¬ACOUSTICDISJUNCTURE (DEP-V/¬AD):
No insertion of a vowel in non-acoustic-disjunctures

DEP-V/AD penalizes vowel epenthesis in acoustic disjunctures: between a released stop and the following consonant, and between heterorganic sonorants. In contrast, DEP-V/¬AD penalizes vowel epenthesis in the other contexts. Based on the perceptual disparity that epenthesis in a non-acoustic-disjuncture is perceptually more salient than epenthesis in an acoustic disjuncture, DEP-V/¬AD always dominates DEP-V/AD.

(14) Universal ranking: DEP-V/¬AD ≫ DEP-V/AD

The total ranking for the epenthesis typology is given in (15). Both of the DEP-V constraints are ranked below the markedness *COMPLEX, so epenthesis in either position may take place when a consonant cluster is illegal in the borrowing language. Also, CONTIGUITY should be dominated by DEP-V/¬AD since if CONTIGUITY outranks DEP-V/¬AD, epenthesis will always occur outside the cluster. So if there is an acoustic disjuncture, the cluster is split by internal epenthesis since DEP-V/¬AD, which a candidate with external epenthesis violates, always outranks DEP-V/AD, as shown in (16). On the other hand, if there is no acoustic disjuncture, epenthesis occurs outside the cluster, because both internal epenthesis and external epenthesis violate DEP-V/¬AD and internal epenthesis also violate CONTIGUITY by splitting the cluster, as shown in (17).

(15) Ranking for the epenthesis typology:
*COMPLEX ≫ DEP-V/¬AD ≫ DEP-V/AD, CONTIGUITY

(16) Epenthesis at an acoustic disjuncture: #T॥C → #TəC

Input: /#Tʰ॥C/	*COMPLEX	DEP-V/¬AD	DEP-V/AD	CONTIGUITY
a. #TʰC	*!			
b. ☞ #TʰəC			*	*
c. #əTʰC		*!		

(17) Epenthesis at a non-acoustic-disjuncture: #LC → #əLC

Input: /#LC/	*COMPLEX	DEP-V/¬AD	DEP-V/AD	CONTIGUITY
a. #LC	*!			
b. #LəC		*		*!
c. ☞ #əLC		*		

4.2. Deletion

As for the deletion repair, we need another faithfulness constraint prohibiting consonant deletion. In general, MAX-C in (18) penalizes outputs with consonant deletion. So when this constraint is dominated by the markedness constraint *COMPLEX, consonant deletion may take place.

(18) MAX-C: No deletion of a consonant.

Notice that MAX-C I assume here is not the standard MAX-C (cf. McCarthy & Prince, 1995) but should be written as MAX-[+consonantal] to be more exact. So this constraint not only penalizes consonant deletion (e.g., #TL → #L) but also penalizes vocalization of a liquid (e.g., TL# → TV#). When this constraint is ranked below *COMPLEX, either consonant deletion or vocalization may happen.

Also, we need phonetically-based faithfulness constraints that require acoustic cues to be preserved, as listed in (19).

(19) a. PRESERVE(INTERNALCUES) (PRES(INT)): Preserve internal cues of the input..
b. PRESERVE(TRANSITIONALCUES) (PRES(TRAN)):
Preserve transitional cues of the input, such as release burst and formant transitions.

First, I suggest PRESERVE(INTERNALCUES) in (19-a) that penalizes loss of internal cues of a consonant. So if a sonorant deletes and loses its internal cues, PRESERVE(INTERNALCUES) is violated. I assume, however, that deletion of a liquid that is adjacent to a vowel does not violate PRESERVE(INTERNALCUES) because it is assumed that internal cues of the deleting liquid are preserved in the adjacent vowel. In addition, deletion of a stop at a word edge and vocalization of a word-final liquid do not violate PRESERVE(INTERNALCUES) since the former does not have internal cues to lose, and the latter preserves the internal cues in the resulting vowel. Word-edge sonorants may be vocalized but not deleted cross-linguistically, which indicates that PRESERVE(INTERNALCUES) is ranked above MAX-C.

For the preservation of transitional cues, I propose that PRESERVE(TRANSITIONALCUES) in (19-b) requires a candidate to be faithful for the acoustic cues of inputs, such as release bursts and formant transitions. This constraint not only penalizes deletion of a released stop (e.g., #TC → #C, TL# → L#, possibly TT# → T#), but also penalizes loss of a release burst (e.g., T^h → $T^˺$).

All these constraints are ranked as shown in (20), and their interactions derive the typology of consonant deletion. As seen in (21), a word-final unreleased stop is a target of deletion, since it lacks both internal and transitional cues, and thus does not violate any PRESERVE constraints. In contrast, the deletion of a released stop is less likely because it causes a violation of PRESERVE(TRANSITIONALCUES), as well as MAX-C, as shown in (22). On the other hand, the liquid preceding the released stop in (22) does not violate any PRESERVE constraints when it deletes, and the optimal output omits the liquid but keeps the stop. At a word edge, however, liquids do not delete because they would lose their internal cues and violated PRESERVE(INTERNALCUES) in the case of deletion. So as shown in (23), the vocalization of the liquid is preferred to the deletion.

(20) Ranking for the deletion typology:
*COMPLEX, PRESERVE(INTERNALCUES) ≫ PRESERVE(TRANSITIONALCUES), MAX-C

(21) Deletion of a word-final unreleased stop

Input: /CT˺#/	*COMPLEX	PRES(INT)	PRES(TRAN)	MAX-C
a. CT˺#	*!			
b. ☞ C#				*

(22) Deletion of a vowel-adjacent liquid and no deletion of a word-final released stop

Input: /LT^h#/	*COMPLEX	PRES(INT)	PRES(TRAN)	MAX-C
a. LT^h#	*!			
b. L#			*!	*
c. ☞ T^h#				*

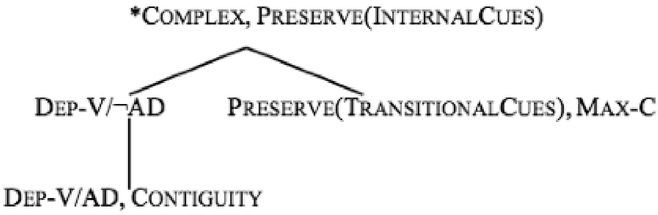
(23) No deletion but vocalization of a word-final liquid

Input: /CL#/	*COMPLEX	PRES(INT)	PRES(TRAN)	MAX-C
a. CL#	*!			
b. C#		*!		
c. ☞ CV#				*

Here I just considered interactions between constraints that are related to consonant deletion, but constraints involved in vowel epenthesis also interact with these constraints. Depending on how they interact, not only epenthesis-only or deletion-only patterns but also mixed patterns, such as Indonesian in which word-initial stops have epenthesis after them and word-final stops may delete, may be derived.

Due to the page limit, I am not able to discuss factorial typology that interactions between all the constraints suggested in this paper would predict, but just summarize the total ranking of them in (24).

(24) Total ranking



5. Conclusion

The main purposes of this paper have been to provide a comprehensive description of the typology of nonnative consonant cluster repairs and to argue that acoustic cues play a central role in forming the typology. I have shown that sites of vowel epenthesis is determined by presence or absence of acoustic disjunctures, not by sonority profile between consonants in a cluster, and sites of consonant deletion is determined by presence or absence of acoustic cues that need to be preserved. Based on differences in perceptual similarity between an original cluster and its possible repair forms, which are derived from the relevant acoustic cues, phonetically-based constraints and the fixed rankings account for the cross-linguistic patterns of nonnative cluster adaptation.

References

Awagana, Ari & H. Ekkehard Wolff (2009). Loanwords in Hausa, a Chadic language in West Africa. Haspelmath, Martin & Uri Tadmor (eds.), *Loanwords in the World's Languages: A Comparative Handbook*, De Gruyter Mouton, 144–165.

Broselow, Ellen (1992). Transfer and universals in second language epenthesis. Gass, Susan M. & Larry Selinker (eds.), *Language Transfer in Language Learning*, John Benjamins, Amsterdam, 71–86.

Choi, Moonjeong (2010). The Russian loanwords in Ewen and Ewenki. *Altai Hakpo* 20, 1–40.

Cohen, Evan-Gary (2009). *The role of similarity in phonology: Evidence from loanword adaptation in Hebrew*. Ph.D. thesis, Tel Aviv University.

Fleischhacker, Heidi (2001). Cluster-dependent epenthesis asymmetries. Albright, Adam & Taehong Cho (eds.), *UCLA Working Papers in Linguistics*, vol. 7, 77–116.

Fleischhacker, Heidi (2005). *Similarity in Phonology: Evidence from Reduplication and Loan Adaptation*. Ph.D. thesis, University of California, Los Angeles.

Gouskova, Maria (2002). Falling sonority onsets, loanwords, and syllable contact. Andronis, Mary, Christopher Ball, Heidi Elston & Sylvain Neuvel (eds.), *CLS 37: The Main Session. Papers from the 37th Meeting of the Chicago Linguistic Society*, vol. 1, 175–186.

Kang, Yoonjung (2003). Perceptual similarity in loanword adaptation: English post-vocalic word-final stops to Korean. *Phonology* 20:2, 219–273.

Karttunen, Frances (1977). Finnish in America: A case study in monogenerational language change. Blount, Ben & Mary Sanches (eds.), *The social dimensions of language change*, Academic Press, New York, 173–184.

Kenstowicz, Michael (2012). Cantonese loanwords: Conflicting faithfulness in VC rime constraints. *Catalan Journal of Linguistics* 11, 65–98.

McCarthy, J. & A. Prince (1995). Faithfulness and reduplicative identity. *University of Massachusetts Occasional Papers 18: Papers in Optimality Theory*, University of Massachusetts, GLSA, Amherst, MA, vol. 249–384.

Prince, Alan & Paul Smolensky (2004). *Optimality Theory: Constraint interaction in generative grammar*. Blackwell, Malden, Mass. & Oxford.

Shinohara, Shigeko (2006). Perceptual effects in final cluster reduction patterns. *Lingua* 116, 1046–1078.

Steriade, Donca (2006). Contour correspondence: Evidence from cluster interruption. Handout from Old World Conference of Phonology 3.

Steriade, Donca (2008). The phonology of perceptibility effects: the P-Map and its consequences for constraint organization. Hanson, Kristin & Sharon Inkelas (eds.), *The Nature of the Word: Studies in Honor of Paul Kiparsky*, MIT Press, Cambridge, 151–179.

Tadmor, Uri (2009). Loanwords in indonesian. Haspelmath, Martin & Uri Tadmor (eds.), *Loanwords in the World's Languages: A Comparative Handbook*, De Gruyter Mouton, 686–716.

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