Deriving Consonant Cluster Phonotactics: Evidence from Singapore English

Arto Anttila[†], Vivienne Fong[††], Stefan Benus[†], Jennifer Nycz[†]

[†]New York University
[††] National University of Singapore and New York University

1. Overview

Consonant clusters are often targeted by phonological processes that typically make them simpler.[1] This brings up two questions of theoretical interest. First, why do cluster processes occur? One possible answer is that they occur to improve syllable structure (e.g. Steriade 1982, Borowsky 1986, Itô 1988, Blevins 1995); another is that they improve the perceptibility of stop place cues (Labov 1997, Hume 1998, Côté 2000, Steriade 2001). Second, how does a language choose among possible cluster processes? In Optimality Theory (Prince and Smolensky 1993), the choice is uniquely determined by the language specific constraint ranking. A potential problem arises in languages with multiple cluster processes that sometimes interact, sometimes do not, and sometimes occur in free variation.

We will consider these issues in the light of evidence from Singapore English (Tay 1982, Mohanan 1992, Bao 1998, Poedjosoedarmo 2000). This variety of English exhibits several consonant cluster processes that fall into three types: epenthesis, reordering (Metathesis, Copy) and lenition (Fricativization, Place Assimilation, Deletion), illustrated in (1).

(1)	(a)	Epenthesis	*lap*[s+z] → *lap*[səz]
			dyspnea → *dysp*[ə]*nea* (not previously reported)
	(b)	Metathesis	*li*[sp] → *li*[ps]
	(c)	Copy	*li*[sp]*ing* → *li*[psp]*ing* (not previously reported)

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(d)	Fricativization	*li*[ps] → *li*[fs]	
(e)	Place Assimilation	*li*[ps]→ *li*[ts]	(not previously reported)
(f)	Deletion	*li*[sp+d] → *li*[sp]	

We have two main results. First, we show that segment reordering arises through the interaction of perceptual constraints and Output-Output Faithfulness. The data are highly variable: among our 56 subjects we find 20 distinct dialects, many of which are internally variable. However, the variation is entirely systematic and our constraint set derives a dialect typology that closely approximates the facts. Second, we confirm Mohanan's (1992) observation that the cluster processes result in phonological opacity: epenthesis is opacified by reordering and reordering is opacified by lenition. We examine several optimality-theoretic approaches to opacity and conclude that none of them covers all aspects of the problem.

2. Procedure

We examined /sp/ clusters in different phonological environments. 56 undergraduate students from the National University of Singapore were recorded reading short sentences containing /sp/ clusters.[2] The stimuli are presented in (2).

(2) The stimuli

	NEXT WORD	
NEXT SEGMENT	V-INITIAL	C-INITIAL
#V	*Say* lisping *again*	*Say* lisping *my way*
##	*Say* lisp *again*	*Say* lisp *my way*
#C = /z/	*Say* lisps *again*	*Say* lisps *my way*
#C = /d/	*Say* lisped *again*	*Say* lisped *my way*

In this way, we were able to study the effect of the next segment in the word (vowel, consonant, word boundary) and the effect of the initial segment of the following word (vowel, consonant). A total of 896 tokens (8 examples × 56 speakers × 2 repetitions) were transcribed by two transcribers with the aid of PRAAT (Boersma and Weenink 1996) and tagged for alternation type. Only tokens for which both transcribers agreed were included.

3. The phonology of reordering

3.1. The data

The segment reordering processes reveal plenty of variation within and across individuals. The aggregate data for all speakers are shown in (3). The variants listed in this table were attested at a frequency of at least 10 tokens each, for a total of 730. This

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[2]We are grateful to K.P. Mohanan and Tara Mohanan for advice and for recording the data.

covers about 86% of the data. These are the core data that we will try to account for in this study.

(3) Aggregate data

	_#V lisp#ing		_## lisp##		_#d lisp#d		_#z lisp#z	
Faithful + no lenition	*lisping*	146	*lisp*	76	*lispt*	37	*lisps*	54
Faithful + *p*-Deletion	--				*list*	11		
Faithful + *t/d*-Deletion					*lisp*	10		
Faithful + *s*-Deletion	--		--		--		*lisp*	13
Faithful total		**146**		**76**		**58**		**67**
Metathesis + no lenition	*lipsing*	27	*lips*	85	*lipst*	95	*lips*	68
Metathesis + Geminate	--		--		--		*lipss*	18
Metathesis + Assimilation	--		--		--		*lits*	15
Metathesis + Fricativization	--		*lifs*	13	*lifst*	10	*lifs*	15
Metathesis + *t/d*-Deletion	--		--		*lips*	15	--	
Metathesis total		**27**		**98**		**120**		**116**
Copy	*lipsping*	22	--		--		--	
Copy total		**22**	**--**		**--**		**--**	

The table in (4) shows the percentage of each process type in each environment. The generalizations are stated in (5).

(4) Summary of the reordering data (Faithful, Metathesis, Copy)

	_#V lisp#ing	_## lisp##	_#C lisp#d, lisp#z	TOTAL
Faithful	74.9% (146)	43.7% (76)	34.6% (125)	347
Metathesis	13.8% (27)	56.3% (98)	65.4% (236)	361
Copy	11.3% (22)	--	--	22
TOTAL	195	174	361	730

(5) Generalizations:

(a) Copy is only possible prevocalically.
(b) Metathesis is favored preconsonantally, disfavored prevocalically ($p \leq 0.001$).
(c) Metathesis rate at word boundary is higher than the prevocalic rate ($p \leq 0.01$), but lower than the preconsonantal rate ($p \leq 0.05$).
(d) The quality of the following consonant (/d/ vs. /z/) has no significant effect on Metathesis ($p \leq 1$).
(e) The following word (*my* vs. *again*) has no significant effect on Metathesis ($p \leq 1$), suggesting that the processes are lexical, not postlexical.

We can also look at the data in terms of individual speakers. This breakdown of the data is shown in (6). There are two types of speakers: those with invariant patterns and those with variable patterns. For example, individuals with pattern B (10 speakers) are invariant: they always produce a faithful form for /lisp#ing/, and always metathesize in /lisp/, /lisp#d/, and /lisp#z/. In contrast, individuals with pattern D (5 speakers) are variable: they differ from pattern B in that for /lisp#ing/ they sometimes produce a faithful form, sometimes a copy form.

(6) Individual patterns. F = Faithful, M = Metathesis, C = Copy.

Pattern	Speakers	_ing	_##	_d	_z
A	12	F	F	F	F
B	10	F	M	M	M
C	6	M	M	M	M
D	5	F~C	M	M	M
E	3	C	M	M	M
F	2	M~C	M	M	M
G	2	F	F~M	M	F~M
H	2	F	F	M	F
I	2	F	F	F~M	F
J	2	F	F	F	F~M
K	1	F~M	M	M	M
L	1	F~C	M	M	-
M	1	F~C	F	F~M	F
N	1	F	F~M	M	M
O	1	F	F~M	M	-
P	1	F	F~M	F~M	M
Q	1	F	F~M	F	F~M
R	1	F	F	F~M	M
S	1	F	-	F~M	F~M
T	1	-	M	M	M

The following implications hold true of all dialects, with marginal exceptions:

(7) Generalizations

(a) If Metathesis is possible prevocalically, it is obligatory elsewhere.
(b) If Metathesis is possible at word boundary, it is possible preconsonantally (1 exception, pattern Q).
(c) If Faithfulness is possible preconsonantally, it is possible prevocalically and at word boundary.
(d) If Faithfulness is possible at word boundary, it is possible prevocalically.
(e) If Copy is possible prevocalically, Metathesis is obligatory elsewhere (1 exception, pattern M).

3.2. The analysis

In this section, we attempt to derive the observed reordering asymmetries from a phonological grammar. Following Hume 1998, Côté 2000, and Steriade 2001, among others, let us pursue the hypothesis that metathesis is triggered by perception: if an oral stop surfaces adjacent to a vowel, it enhances the perception of its place cues. For example, the /p/ in *lisp* is not adjacent to any vowel, but in the metathesized *lips* it surfaces adjacent to /i/. This predicts that Metathesis should be preferred before a consonant or a word boundary where the place cues are weak, but dispreferred before a vowel where the place cues are strong. As stated in (5b), this is indeed what we find. What the perceptual hypothesis cannot immediately explain is the Copy variant where /lisp#ing/ becomes *lipsping*. Here /p/ occurs before a vowel, which is the best environment for perceiving stop place cues, hence there is no perceptual motivation for any kind of repair. One way to interpret Copy is to view it as overapplication of Metathesis, with a copy of the metathesized stop left in its original prevocalic position. The question is why Metathesis should apply at all.

We propose that *lipsping* arises from the interaction of two kinds of faithfulness constraints: faithfulness between inputs and outputs (IO-FAITH) and faithfulness among outputs (OO-FAITH) (Benua 1995). In this case, the input is /lisp#ing/ and the morphologically simplex output form (= the base) is *lips*. The output of /lisp#ing/ has three options: (i) be faithful to the input, which yields *lisping*; (ii) be faithful to the base, which yields *lipsing*; (iii) be faithful to both, which yields *lipsping*, i.e. the Copy candidate. In other words, the Copy candidate is faithful to the order of segments in both the input and the base. This predicts that Copy should be parasitic on base Metathesis: *lipsping* should only be possible in dialects where /lisp/ is realized as *lips*. As stated in (7e), this is indeed what we find.

We now formalize this analysis in Optimality Theory. The markedness constraints are shown in (8): TV and TVT strive to maximize perceptual cues for stops (Côté 2000); *PLACE is a constraint against complex consonant clusters parameterized for place nodes. The faithfulness constraints are shown in (9): LINEARITY-IO and LINEARITY-OO strive to preserve the order of segments found in the input and the base, respectively; UNIFORMITY militates against realizing an input segment at multiple locations in the output; finally, MAX and DEP militate against segment deletion and segment epenthesis, respectively.

(8) <u>Markedness constraints</u>

TV	Obstruent stops occur before a vowel.
TVT	Obstruent stops occur adjacent to a vowel.
*PL(ACE)	Minimize the number of place nodes in a cluster (gradient).

(9) <u>Faithfulness constraints</u>

LIN(EARITY)-IO	The order of input segments must be preserved in the output.
LIN(EARITY)-OO	The order of base segments must be preserved in the output.
UNI(FORMITY)	Input segments cannot be split in the output.

MAX	No segment deletion.
DEP	No segment epenthesis.

The tableaux in (10) through (13) illustrate how the grammar works. Tableau (10) shows the predictions for the morphologically simplex /lisp/ whose output is the base. The ranking LIN-IO >> TVT yields *lisp*; the ranking TVT >> LIN-IO yields *lips*. These two outputs will then serve as the bases for the evaluation of LIN-OO in the morphologically complex forms. For the analysis of reordering (Faithful, Metathesis, Copy), we assume that MAX and DEP dominate all the other constraints and for this reason we ignore the deletion and epenthesis candidates in the subsequent tableaux. We will come back to deletion and epenthesis in sections 4 and 5.

(10) LIN-IO >> TVT yields *lisp*, TVT >> LIN-IO yields *lips*

I: /lisp/	DEP	MAX	LIN-IO	LIN-OO	UNI	TV	TVT	*PL
→ lisp (Faithful)						*	*	**
→ lips (Metathesis)			*			*		**
lipsp (Copy)					*	**	*	***
lis (Deletion)		*!						
lisəp (Epenthesis)	*!					*		

The tableaux in (11) show the predictions for /lisp#ing/. If the base is *lisp*, then *lisping* is the only possible output under any ranking since it harmonically bounds the other two candidates. If the base is *lips*, all the three candidates win under some ranking.

(11) (a) /lisp-ing/ with base *lisp* (LIN-IO >> TVT)

I: /lisp-ing/, B: *lisp*	LIN-IO	LIN-OO	UNI	TV	TVT	*PL
→ lisping (F)						**
lipsing (M)	*	*		*		**
lipsping (C)			*	*		***

(b) /lisp-ing/ with base *lips* (TVT >> LIN-IO)

I: /lisp-ing/, B: *lips*	LIN-IO	LIN-OO	UNI	TV	TVT	*PL
→ lisping (F)		*				**
→ lipsing (M)	*			*		**
→ lipsping (C)			*	*		***

The tableaux in (12) and (13) show the predictions for /lisp#d/ and /lisp#z/, respectively. In these environments, the Metathesis candidate can win irrespective of the base, whereas the faithful candidate can only win if the base is *lisp*.

(12) (a) /lisp-z/ with base *lisp* (LIN-IO >> TVT)

I: /lisp-z/, B: *lisp*	LIN-IO	LIN-OO	UNI	TV	TVT	*PL
→ lisps (F)				*	*	***
→ lipss (M)	*	*		*		**
lipsps (C)			*	**	*	****

(b) /lisp-z/ with base *lips* (TVT >> LIN-IO)

I: /lisp-z/, B: *lips*	LIN-IO	LIN-OO	UNI	TV	TVT	*PL
lisps (F)		*		*	*	***
→ lipss (M)	*			*		**
lipsps (C)			*	**	*	****

(13) (a) /lisp-d/ with base *lisp* (LIN-IO >> TVT)

I: /lisp-d/, B: *lisp*	LIN-IO	LIN-OO	UNI	TV	TVT	*PL
→ lispt (F)				**	**	***
→ lipst (M)	*	*		**	*	**
lipspt (C)			*	***	**	****

(b) /lisp-d/ with base *lips* (TVT >> LIN-IO)

I: /lisp-d/, B: *lips*	LIN-IO	LIN-OO	UNI	TV	TVT	*PL
lispt (F)		*		**	**	***
→ lipst (M)	*			**	*	**
lipspt (C)			*	***	**	****

3.3. Typological and quantitative predictions

Let us now explore the typological predictions of our analysis. Recall that we are considering three variants (Faithful, Metathesis, Copy) in four environments (_ing, _##, _d, and _z). This yields $3^4 = 81$ logically possible invariant patterns, or dialects. Out of these 81 logically possible dialects, our analysis predicts exactly five, as can be easily verified by OTSOFT (Hayes, Tesar, and Zuraw 2003). The fit between the predicted typology and the observed typology is very good: the predicted five dialects cover 94% (32/34) of the attested invariant patterns. This good typological match suggests that the constraints we have posited are on the right track. The predicted typology is shown in (14).

(14) The predicted invariant patterns

	_ing	_##	_d	_z	
(i)	F	F	F	F	(A, 12 speakers)
(ii)	F	M	M	M	(B, 10 speakers)
(iii)	F	F	M	M	
(iv)	M	M	M	M	(C, 6 speakers)
(v)	C	M	M	M	(E, 3 speakers)

In order to extend the analysis beyond invariant patterns, let us assume that variation results from the presence of multiple constraint rankings within an individual (Kiparsky 1993, Anttila 2002). For example, the variable dialect F~C, M, M, M, with both *lisping* and *lipsping* in the prevocalic environment can be analyzed as a combination of two constraint rankings: one that predicts the invariant pattern F, M, M, M, and another that predicts the invariant pattern C, M, M, M.

The theory can be further extended to the quantitative dimension by assuming that the probability of an output is proportional to the number of constraint rankings that predict this output. In our example, the probabilities are F (0.5) ~ C (0.5), M (1), M (1), M (1). Under this quantitative interpretation, Faithfulness is predicted to be at least as common before a vowel as it is before a word boundary, and at least as common before a word boundary as it is before a consonant. This can be seen by inspecting (14): for all five patterns, an F in the consonant column implies an F in the word boundary column, but not vice versa, and an F in the word boundary column implies an F in the vowel column, but not vice versa. Thus, there is no way of selecting a combination of rankings such that F would be more common before consonants than vowels, for example. By analogous reasoning, the reverse quantitative pattern is predicted for Metathesis. Both quantitative predictions are borne out by the corpus, which provides further support for our analysis. On the negative side, the analysis fails to predict one attested invariant pattern: *lisping* (F), *lisp* (F), *lipst* (M), *lisps* (F) (pattern H, 2 speakers), which thus remains unexplained (but see below).

All in all, the multiple grammars theory of variation predicts 13 variable patterns, shown in (15). Here the typological coverage of our analysis is more modest: only 55% (12/22) of the attested variable patterns are predicted by the analysis.[3]

(15) The predicted variable patterns

	_ing	_##	_d	_z	
(i)	F	F~M	F~M	F~M	
(ii)	F	F	F~M	F~M	
(iii)	F~M	F~M	F~M	F~M	
(iv)	F~C	F~M	F~M	F~M	
(v)	F	F~M	M	M	(N, 1 speaker)
(vi)	F~M	M	M	M	(K, 1 speaker)
(vii)	F~C	M	M	M	(D, 5 speakers)
(viii)	F~M	F~M	M	M	
(ix)	F~C	F~M	M	M	
(x)	M~C	M	M	M	(F, 2 speakers)
(xi)	F~M~C	F~M	F~M	F~M	
(xii)	F~M~C	M	M	M	
(xiii)	F~M~C	F~M	M	M	

[3] We only report 9 speakers in (15); the variable patterns L, O, and S have been omitted. The reason is that these patterns have some empty data cells (tokens lost in recording or transcription, excluded low-frequency variants). While fully compatible with the predictions, these three patterns cannot be unambiguously mapped to the predicted patterns in (15).

The dialects that occur in the corpus, but are not predicted by our current analysis, are shown in (16). A closer examination reveals eight patterns where the two preconsonantal environments (_d vs. _z) differ, whereas our analysis predicts that all consonantal environments should behave identically. Our prediction is borne out in the aggregate corpus where we found no significant difference between the two environments, but these eight dialects do not match the overall generalization. The analysis also predicts that prevocalic Copy (*lipsping*) should imply Metathesis elsewhere, but pattern M with optional Copy (*lipsping*) has Metathesis neither at word boundary nor before /-z/.

(16) The variable patterns not predicted by the current analysis

_ing	_##	_d	_z	
F	F~M	M	F~M	(G, 2 speakers)
F	F	F~M	F	(I, 2 speakers)
F	F	F	F~M	(J, 2 speakers)
F~C	F	F~M	F	(M, 1 speaker)
F	F~M	F~M	M	(P, 1 speaker)
F	F~M	F	F~M	(Q, 1 speaker)
F	F	F~M	M	(R, 1 speaker)

Before we conclude that the analysis must be revised, we should note that at least some of these problems are probably due to sparse data. Some tokens were lost in recording or transcription and low-frequency variants were systematically excluded. Since the maximum number of tokens in each cell is only 4 per speaker, the existence of spurious gaps would not be very surprising. More data are clearly needed.

The predictions and observations are summarized in (17):

(17) A summary of predictions and observations

	PREDICTED PATTERNS	OBSERVED PATTERNS (ENTIRE CORPUS)
(a)	Metathesis is favored preconsonantally, disfavored prevocalically.	Metathesis is favored preconsonantally, disfavored prevocalically ($p \leq 0.001$).
(b)	Metathesis rate at word boundary is higher than the prevocalic rate, but lower than the preconsonantal rate.	Metathesis rate at word boundary is higher than the prevocalic rate ($p \leq 0.01$), but lower than the preconsonantal rate ($p \leq 0.05$).
(c)	The quality of the following consonant (/d/ vs. /z/) has no effect on Metathesis.	The quality of the following consonant (/d/ vs. /z/) has no significant effect on Metathesis ($p \leq 1$).
(d)	Copy is only possible prevocalically.	Copy is only possible prevocalically.
(e)	If Metathesis is possible prevocalically, it is obligatory elsewhere.	If Metathesis is possible prevocalically, it is obligatory elsewhere.
(f)	If Faithfulness is possible preconsonantally, it is possible prevocalically and at word boundary.	If Faithfulness is possible preconsonantally, it is possible prevocalically and at word boundary.
(g)	If Faithfulness is possible at word boundary, it is possible prevocalically.	If Faithfulness is possible at word boundary, it is possible prevocalically.
(h)	If Copy is possible prevocalically, Metathesis is obligatory elsewhere.	If Copy is possible prevocalically, Metathesis is obligatory elsewhere (1 exception, pattern M).
(i)	If Metathesis is possible at word boundary, it is possible preconsonantally.	If Metathesis is possible at word boundary, it is possible preconsonantally (1 exception, pattern Q).

We conclude that the perceptual constraints (TV, TVT) in combination with faithfulness among outputs (OO-FAITH) yield a good approximation of segment reordering effects in Singapore English, typologically as well as quantitatively.

4. The phonology of Epenthesis

The main observation about Epenthesis is that it is counterfed by Metathesis (Mohanan 1992):

(18)

	/læps-z/	/lisp-z/
Epenthesis	læpsəz	--
Metathesis	--	lipss
	[læpsəz]	[lips] (*[lipsəs])

In the corpus, counterfeeding opacity is clearly the norm. We have 116 examples of counterfeeding, but only 12 examples of feeding ([lipsəs], N = 9, [lifsəs], N = 3). Thus, any analysis must account for at least the opaque cases. The problem is that classical Optimality Theory can only deal with transparent interactions (feeding and bleeding).

Let us now examine the various analytical alternatives. First, it is easy to see that the [læpsəs] vs. [lips] contrast cannot be derived in classical Optimality Theory:

(19) The counterfeeding problem in classical Optimality Theory

/lisp-z/	MAX	DEP	OCP	LIN	UNI	TV	TVT	*PL
→ lipss			*	*		*		**
lipsəs		*		*		*		**

/læps-z/	MAX	DEP	OCP	LIN	UNI	TV	TVT	*PL
læpss			*			*		**
→ læpsəs		*				*		**

This pattern results in a ranking paradox: DEP >> OCP gets us [lipss], but not [læpsəs]; the reverse ranking OCP >> DEP gets us [læpsəs], but not [lipss]. Leaving the two constraints unranked does not help because then all four forms ([lipss]~??[lipsəs], ??[læpss]~[læpsəs]) should be equally good, contrary to the facts.

The second possibility is OO-Faithfulness which worked so well for reordering. This approach fails for a simple reason: the fact that Epenthesis applies in [læpsəs], but not in [lipss] crucially depends on the input, not on the output: /læps/ ends in a sibilant, /lisp/ does not, hence the difference in Epenthesis. Thus, faithfulness to an output form cannot be the solution to the opacity problem.

The third alternative is Stratal Optimality Theory where different phonological processes are located at different morphological levels (McCarthy and Prince 1993, Bermúdez-Otero 1999, Rubach 2000, Kiparsky 2000, 2003, to appear, Itô and Mester 2002, among others). This theory claims that opacity arises because phonological processes interact within a level, but not across levels. Following Kiparsky (2003, to appear), let us assume three universal morphological levels: stem level, word level, and postlexical level. In order to derive the counterfeeding pattern, Epenthesis must precede Metathesis, as in Mohanan's (1992) derivational analysis. Epenthesis must be word-level (or later) for morphological reasons: it is triggered by word-level suffixes, e.g. /læps#z/ → [læpsəz]. This implies that Metathesis must be postlexical.

There are three pieces of empirical evidence that go against this analysis. First, if Metathesis is postlexical, it should be sensitive to the initial segment of the following word. More specifically, we would expect more Metathesis before a consonant (*my*) than before a vowel (*again*). No such statistical effect is found. Second, as we will see in the next section, Fricativization (*p* → *f*) counterbleeds Metathesis (*lisp* → *lips* → *lifs*) and would thus have to be ordered after Metathesis, but we have run out of levels. Third, postlexical metathesis seems cross-linguistically unattested. We conclude that Stratal Optimality Theory fails to account for the opacity of Epenthesis.

The fourth alternative, and one that actually works, is Comparative Markedness (McCarthy 2003). Under this theory of opacity, markedness violations present in the input (“old” violations) are evaluated differently from markedness violations created through input-output mapping (“new” violations).[4] This is precisely the difference we need: Epenthesis resolves underlying sibilant clusters (“old” clusters), but not ones created through Metathesis (“new” clusters).

(20) (a) /læps-z/ → læpsəz *s-z* is “old”, repaired by Epenthesis
(b) /lisp-z/ → lipsz → lipss / *lipsəs *s-z* is “new”, not repaired

The analysis is straightforward. We assume the constraints $_{old}$OCP, which is violated by underlying sibilant clusters, and $_{new}$OCP, which is violated by derived sibilant clusters. The ranking $_{old}$OCP >> DEP (V) >> $_{new}$OCP yields the desired results.

(21) A solution to the Epenthesis problem: $_{old}$OCP >> DEP (V) >> $_{new}$OCP

/lisp z/	MAX	$_{old}$OCP	DEP	LIN	UNI	TV	TVT	*PL	$_{new}$OCP
→ lipss				*		*		**	*
lipsəs			*!	*		*		**	

/læps-z/	MAX	$_{old}$OCP	DEP	LIN	UNI	TV	TVT	*PL	$_{new}$OCP
læpss		*!				*		**	
→ læpsəs			*			*		**	

5. The phonology of lenition

So far, we have abstracted away from lenition processes (Fricativization, Place Assimilation, Deletion). We now bring them back to the analysis. The main observation about lenition is that it creates an additional layer of opacity. For example, Fricativization (*p* → *f*) counterbleeds Metathesis. In a derivational analysis, this would imply ordering Metathesis before Fricativization:

(22) Fricativization counterbleeds Metathesis

	/lisp/
Epenthesis	--
Metathesis	lips
Fricativization	lifs
	[lifs]

This pattern is theoretically interesting for various reasons. Recall our proposal that Metathesis arises from perceptual considerations: obstruent stops are preferably

[4]More precisely, “old” violations are the markedness violations shared with the Fully Faithful Candidate. All other markedness violations are “new”. See McCarthy (2003) for details.

realized next to a vowel. The problem is that in *lifs* Metathesis has apparently applied to a fricative. Two conclusions seem possible: either perceptual enhancement applies to labial fricatives as well as to labial stops (Donca Steriade, p.c.) or it applies at a level below the surface. OO-Faithfulness is of no use here since *lifs* is nonderived and has no base. Comparative Markedness fails as well: /lisp/ → *lifs* is an overapplication effect, i.e. Metathesis has applied where it should not have, but Comparative Markedness can only capture underapplication effects (counterfeeding opacity, derived environment effects).

The solution that works here is Stratal Optimality Theory: simply assume that all lenition processes are postlexical. This analysis is appealing for independent reasons: it is already implicit in our analysis of reordering where we crucially assumed that the anti-lenition constraints MAX and DEP are undominated. Since lenition clearly occurs, these constraints must rank lower in postlexical phonology, which is therefore independently necessary.

6. Conclusions

Based on a corpus of 730 consonant clusters in Singapore English, elicited from 56 speakers, we have argued that segmental reordering processes (Metathesis, Copy) arise through perceptual constraints and Output-Output-Faithfulness. The empirical evidence comes from the systematic patterns of variation among speakers. This is our main result. We have also identified two additional patterns of opacity: Vowel Epenthesis is opacified by Metathesis (Mohanan 1992), and Metathesis is opacified by Fricativization. The former pattern can be captured in terms of Comparative Markedness (McCarthy 2003), the latter in terms of Stratal Optimality Theory (e.g. Kiparsky 2003, to appear).

The emerging picture is somewhat heterogeneous. We have made descriptive use of three different theories of phonological opacity to account for Singapore English variation data: Output-Output-Faithfulness, Comparative Markedness, and Stratal Optimality Theory. Each theory captures one aspect of the triple opacity in Singapore English, but none captures them all. We conclude that Singapore English consonant cluster processes remain a theoretical challenge for Optimality Theory. Alternatively, it is of course entirely possible that opacity is not a unitary phenomenon after all and the failure of Optimality Theory to unify the three kinds of opacity is a positive result.

Appendix

An extract from the tagged corpus. Key: U = underlying form; T = target cluster; M = morphophonological environment; S = speaker/utterance identifier; P = pause vs. no pause before *my/again*; F = faithful vs. unfaithful output; A = alternation type (F = Faithful, M = Metathesis, C = Copy); H = what the transcribers heard.

U:/lisping my/ T:sp M:#V S:38-1 P:0 F:0 A:F H:lisping my
U:/lisp again/ T:sp M:##V S:38-1 P:0 F:1 A:M H:lips again
U:/lisped my/ T:sp M:#C##C S:38-1 P:0 F:1 A:M H:lipsst my
U:/lisping again/ T:sp M:#V S:38-1 P:1 F:0 A:F H:lisping again
U:/lisps my/ T:sp M:#C##C S:38-1 P:0 F:1 A:M H:lips my
U:/lisp my/ T:sp M:##C S:38-1 P:0 F:1 A:M H:lips my

U:/lisps again/ T:sp M:#C##V S:38-1 P:0 F:1 A:M H:lips again
U:/lisped again/ T:sp M:#C##V S:38-1 P:0 F:1 A:M H:lipst again
U:/lisping my/ T:sp M:#V S:38-2 P:0 F:1 A:C H:lipsfing my
U:/lisp again/ T:sp M:##V S:38-2 P:0 F:1 A:M H:lips again
U:/lisped my/ T:sp M:#C##C S:38-2 P:0 F:1 A:M+Dp H:lits my
U:/lisping again/ T:sp M:#V S:38-2 P:0 F:1 A:C H:lipsping again
U:/lisps my/ T:sp M:#C##C S:38-2 P:0 F:1 A:M H:lips my
U:/lisp my/ T:sp M:##C S:38-2 P:0 F:1 A:M H:lits my
U:/lisps again/ T:sp M:#C##V S:38-2 P:0 F:1 A:M H:lips again
U:/lisped again/ T:sp M:#C##V S:38-2 P:0 F:1 A:M H:lipst again

References

Anttila, A. 2002. Variation and phonological theory. In Handbook of Language Variation and Change, eds. J. Chambers, P. Trudgill, and N. Schilling-Estes, 206-243. Malden, Mass., and Oxford, U.K.: Blackwell.

Bao, Z. 1998. The sounds of Singapore English. In English in New Cultural Contexts: Reflections from Singapore, eds. J.A. Foley, T. Kandiah, Z. Bao, A.F. Gupta, L. Alsagoff, C.L. Ho, L. Wee, I.S. Talib, and W. Bokhorst-Heng, 127-151. Singapore: Oxford University Press.

Benua, L. 1995. Identity effects in morphological truncation. In Papers in Optimality Theory, eds. J.N. Beckman, L.W. Dickey, and S. Urbanczyk, 77-136. University of Massachusetts, Amherst.

Bermúdez-Otero, R. 1999. *Constraint Interaction in Language Change: Quantity in English and Germanic*. Doctoral dissertation, University of Manchester.

Blevins, J. 1995. The syllable in phonological theory. In The Handbook of Phonological Theory, ed. J. A. Goldsmith, 206-244. Cambridge, Mass. and Oxford, U.K.: Blackwell.

Boersma, P. and D. Weenink. 1996. PRAAT, a system for doing phonetics by computer. Institute of Phonetic Sciences of the University of Amsterdam, Report 132. An updated copy of this manual is available at www.praat.org.

Borowsky, T. 1986. Topics in the Lexical Phonology of English. Doctoral dissertation, University of Massachusetts, Amherst.

Côté, M.-H. 2000. Consonant cluster phonotactics: A perceptual approach. Doctoral dissertation, Massachusetts Institute of Technology.

Hayes, B., B. Tesar, and K. Zuraw. 2003. OTSoft 2.1, software package. [Available free of charge at http://www.linguistics.ucla.edu/people/hayes/otsoft/.]

Hume, E. 1998. The Role of Perceptibility in Consonant/Consonant Metathesis. In Proceedings of West Coast Conference on Formal Linguistics 17, eds. S. Blake, E.-S. Kim, and K. Shahin, 293-307. Stanford: CSLI Publications.

Itô, J. 1988. Syllable Theory in Prosodic Phonology. New York: Garland Publishing.

Itô, J. and A. Mester. 2002. On the sources of opacity in OT: Coda processes in German. In The Syllable in Optimality Theory, eds. C. Féry and R. van de Vijver, 271-303. Cambridge: Cambridge University Press. Also available as ROA-347-0999.

Kiparsky, P. to appear. Paradigms and Opacity. Stanford: CSLI Publications.

Kiparsky, P. 2003. Finnish Noun Inflection. In Generative Approaches to Finnic and Saami Linguistics, eds. S. Manninen and D. Nelson, 109-161. Stanford: CSLI Publications.

Kiparsky, P. 2000. Opacity and cyclicity. The Linguistic Review 17:351-367.

Kiparsky, P. 1993. Variable rules. Handout from Rutgers Optimality Workshop 1.

Labov, W. 1997. Resyllabification. In Variation, Change and Phonological Theory, eds. F. Hinskens, R. van Hout and L. Wetzels, 145-179. Amsterdam/Philadelphia: John Benjamins.

McCarthy, J. J. 2003. Comparative Markedness. Theoretical Linguistics: 29(1-2): 1-51. Also available at http://roa.rutgers.edu/, ROA-489.

McCarthy, J. J. and A. Prince. 1993. Prosodic Morphology I: Constraint Interaction and Satisfaction. Report no. RuCCS-TR-3. New Brunswick, NJ: Rutgers University Center for Cognitive Science.

Mohanan, K.P. 1992. Describing the phonology of non-native varieties of a language. World Englishes 11:111-128.

Poedjoesoedarmo, G. 2000. A description of the English pronunciation of young educated Singaporeans: A study in multidimensional variation. In The English Language in Singapore: Research on Pronunciation, eds. A. Brown, D. Deterding, and E. Low, 65-75. Singapore: Singapore Association for Applied Linguistics.

Prince, A. and P. Smolensky. 1993. Optimality Theory: Constraint Interaction in Generative Grammar. Report no. RuCCS-TR-2. New Brunswick, NJ: Rutgers University Center for Cognitive Science.

Rubach, J. 2000. Backness switch in Russian. Phonology 17:39-64.

Steriade, D. 2001. Directional asymmetries in place assimilation: a perceptual account. In Perception in phonology, eds. E. Hume and K. Johnson, 219-250. San Diego: Academic Press.

Steriade, D. 1982. Greek Prosodies and the Nature of Syllabification. Doctoral dissertation, Massachusetts Institute of Technology.

Tay, M. 1982. The uses, users and features of English in Singapore. In New Englishes, ed. J.B. Pride, 51-70. Rowley, MA: Newbury House.

Department of Linguistics
New York University
719 Broadway, 4th floor
New York, NY 10003

arto.anttila@nyu.edu (Anttila)
vivienne.fong@nyu.edu (Fong)
sb513@nyu.edu (Benus)
jrn218@nyu.edu (Nycz)