

Local Intrasyllabic Consonant Cluster Metathesis: Dynamical Aspects

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Park, Haeil. 2006. Local Intrasyllabic Consonant Cluster Metathesis: Dynamical Aspects. *Linguistic Research* 23.1, 97-124. This paper provides an analysis of metathesis in the local intrasyllabic consonant clusters using a dynamic coupling-structure, based on the Articulatory Phonology framework. It is hypothesized that the greater variability in gestural timing can result in more metathesis in the local CC within syllables. Consistent with the proposed hypothesis, the typological survey results show more metathetical phenomena found cross-linguistically in codas known to have relatively higher variability than in onsets. Also, an experimental German production study result exhibits that the variability difference between onsets and codas have a compatible pattern with the number of metathetical errors the subjects make. The fact that in Old English, there is a case of structure-violating local CC metathesis is consistent with the claim of this study. (Yonsei University)

Keywords metathesis, articulatory phonology, dynamic coupling, variability, consonant cluster, onset, coda

1. Introduction

Metathesis refers to an alteration in the sequence of two segments. It has occurred occasionally across languages in diachronic sound change or synchronic variation. Metathesis can be divided into two categories: long-distance and local metathesis, depending on whether the process occurs between the adjacent segments or not. This study focuses on the local CC metathesis within a syllable, and proposes a dynamic coupling structure-based account on it under the framework of Articulatory Phonology (e.g. Browman and Goldstein 1989, 1990a, 1990b, 1992).

The hypothesis of the present study is that greater variability in gestural timing results in more metathesis synchronically or diachronically. It is hypothesized that if a

consonant cluster exhibits greater variability in gestural timing, then metathesis can potentially occur between the two consonants.

The organization of this paper is as follows. In §2, I will present the proposed account of the present study on local within-syllable metathesis, based on the dynamic coupling structure in Articulatory Phonology. To support this hypothesis, typological evidence of my hypothesis will be discussed, along with two apparent onset cluster metathesis, and synchronic evidence through a production study on German /sk/ and /ks/ clusters will be offered, focusing on the effect of variability on the number of synchronic metathetical errors. Then a case of structure-violating metathesis will be presented. After that, order contrast facts will be described and discussed as one prediction of my hypothesis. Finally, Perceptual Optimization and Evolutionary Phonology approaches to metathesis will be discussed. §3 concludes this study.

2. Framework: Articulatory Phonology

In Articulatory Phonology (Browman and Goldstein, e.g. 1989, 1990a, 1990b, 1995), the basic units of speech are dynamically-defined articulatory action units, which are called gestures. These action units stand for events that take place within the speaker's vocal tract during speech production. They are not identical with either the segments or features of more conventional phonological representations. Because the actions are distributed across the various articulator sets of the vocal tract, an utterance is regarded as a constellation of a small number of potentially overlapping gestures.

Gestures are dynamically specified with respect to space and time (Browman and Goldstein 1992). First, the goals of gestures are to make a constriction in the vocal tract with one of the constriction organs including lips, tongue tip, tongue body, velum, and glottis. Each gesture is specified for a value of constriction degree and a value of constriction location. Second, a gesture is defined in terms of its temporal structure. Temporal aspect of a gesture is specified by the stiffness of the constriction and the phase relations of the constriction. Based on these, various points in the gesture can be coordinated with those in another gesture. These points consist of onset, target, release,

and C-center. Onset is the point at which articulators start to move to achieve constriction, and target is the point at which constriction is achieved. Release is the point where constriction is released, and C-center is the midpoint of target and release (Gafos 2002).

In Articulatory Phonology, coordination is achieved by phasing: some phase of motion of one member of the pair is specified to occur simultaneously with some phase of the other member. Browman and Goldstein (2000) suggest that every phase relation among gestures within a lexical unit is associated with a bonding strength which represents the degree of cohesion of the gestures. More bonding strength among gestures results in less variability in gestural coordination, while weak bonding strength leads to more variability in gestural coordination. Greater variability in gestural coordination means that a set of gestures exhibits less cohesion and more flexibility in their gestural coordination so that they can allow a change in the gestural sequence. Relating this to local CC metathesis, we can hypothesize that if a consonant cluster exhibits greater variability in gestural timing, then metathesis can occur between the two consonants, since their gestural cohesion and bonding strength is weak, following Yanagawa (2002) who offers an explanation of this kind for *hitpa'el* metathesis in Modern Hebrew¹.

2.1 Hypothesis

The hypothesis proposed here is that greater variability can be an influencing factor for more synchronic and /or diachronic metathesis. That is, provided that a consonant cluster exhibits greater variability in gestural timing, the cluster can undergo metathesis.

2.2 Dynamic Coupling Structure-Based Account

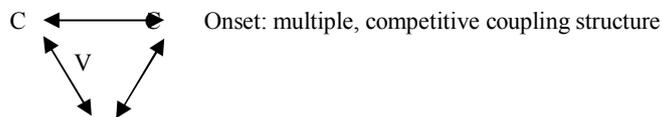
In this study, my hypothesis that greater variability in gestural timing gives rise to more metathesis is based on the coupling model that Browman and Goldstein (2002)

¹ Yanagawa convincingly proposed a gesture-based account for *hitpa'el* metathesis in the Articulatory Phonology framework, using the same assumption that greater variability in gestural coordination can allow a change in the gestural sequence.

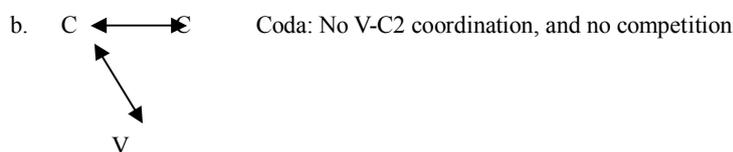
proposed to account for the greater stability in gestural timing of onset consonant sequences. The onset consonant sequences have been argued to be different from coda ones in two respects: firstly, the former exhibits greater stability in gestural timing (Byrd 1996)². Byrd indicated that consonant gestures exhibit less temporal overlap in an onset than in a coda. In an electro-palatographic study of stop-stop and sibilant-stop clusters. And she also demonstrated that a sibilant-stop sequence as an onset cluster is not only less overlapped, but also less variable in timing than the same sequence as a coda cluster.

Secondly, the onset CC clusters show the c-center effect (Browman and Goldstein 2000). Browman and Goldstein claimed that the c-center effect observed in onsets and asymmetries of relative coordination stability between onsets and codas could be accounted for by a coupling model where phonetic units are modeled as oscillators, and coordination is achieved by coupling. There, it is hypothesized that for onset clusters, each consonant gesture was phased identically to the vowel gesture (C-V phasing), and the consonant gestures are also directly phased to each other (C-C phasing), thereby making both of the phasing relations in competition. The consequences of this competition is the c-center effect, which means that adding additional consonants to an onset results in the change of the coordination of all consonant gestures with respect to the vowel in the way that preserves the overall timing of the center of the consonant sequence with respect to the vowel. In coda consonant clusters, however, they hypothesize that the first consonant is phased to the vowel (V-C phasing), and the consonants are phased to each other. Since there is no competition between the two phasings, there is expected to be no c-center effect. Such a coupling asymmetry in onset vs. coda is schematically illustrated as follows:

(1) a.



² In an electropalatographic study of stop-stop and s-stop clusters by Byrd (1996), she indicated that consonant gestures exhibit less temporal overlap in an onset than in a coda. And she also demonstrated that a sibilant-stop sequence as an onset cluster is not only less overlapped, but also less variable in timing than the same sequence as a coda cluster.



Browman and Goldstein (2000) also hypothesize that multiple coupling structures in onset can explain the greater stability in gestural overlap. Nam and Saltzman (2003) successfully tested this idea by extending the model of Saltzman and Byrd (2000) in which ‘a pair of gestural actions can be controlled by coupling the dynamical systems (oscillators) hypothesized to underlie the two actions’, to allow for multiple gestures and competitive couplings. They showed through simulation experiments that both the greater stability of onset consonant clusters and their c-center effect result from competitive couplings between C-V and C-C of onsets. In the next section, I will present typological and experimental evidence that pattern compatibly with the hypothesis of this study.

2.3 Typological Evidence

Under the proposed hypothesis, it is predicted that first, there will be more metathesis found in coda clusters than in onset clusters, and second, that the presence of any onset CC metathesis implies the presence of coda CC metathesis in a certain language. To test these predictions, a cross-linguistic survey was conducted, investigating intra-syllable CC cluster metathesis in 10 languages. The survey upholds the first prediction with 8 languages only showing intra-syllable CC metathesis in coda, and with two apparent counter-examples, Zoque and Hua.³ The second prediction is well supported by the fact that the English language argued to have an onset metathesis, for example, in /sp ge j/ ‘spaghetti’ → [ps ge j] has also coda CC metathesis as in /æsk/ → [æks]. And the Hua language which seems to have onset

³ Louis Goldstein (p.c.) mentioned that the basis for the metathetical asymmetry could be that there are more suffixes than prefixes in languages. Thus, comparisons between the numbers of prefixes and suffixes in those 10 language examined in this study should be made to test this hypothesis.

metathesis, does not have any codas, hence not being counterevidence for my proposal.

2.3.1 Languages with Intra-Syllable Coda CC Metathesis

First, let us take a look at Old English examples of consonant cluster metathesis. Some coda clusters with stop plus fricative sequence become fricative plus stop sequences by undergoing metathesis.⁴

- (2) tu[ks] → tu[sk] ‘grinder’
 wæps → wæ[sp] ‘wasp’
 do[ks] → do[sk] ‘dusk’
 wli[ps] → wli[sp] ‘lispings’

These data are of interest, since they does not fully uphold Steriade’s (2001) perceptual optimization account on coda fricative-stop cluster metathesis of the following examples.

- (3) a. wesp → weps : Dutch (dialects and children)
 b. wasp → waps : Southern American English
 ask → aks

Another instance of coda cluster metathesis can be found in Faroese. Where we would expect a postvocalic fricative followed by two stops, we find instead the fricative followed by the two stops. This can be seen in (4) where a velar stop metathesizes with an adjacent coronal fricative /s/, just in case it is followed by another stop consonant (Lockwood 1955; Jakobson & Matras 1961).

⁴ There are also some metatheses cases involving coda clusters in Old English (Hempl 1892).

a:[dl] → a:[ld] ‘disease’
 wor[sm] → wor[ms] ‘matter’
 ta:[kn] → ta:[ŋk] ‘token’

(4) <u>Fem. Sg.</u>		<u>Neut. Sg.</u>		
Baisk		baiks-t	*baiskt	‘bitter’
Fesk		feks-t	*feskt	‘fresh’
Rask		raks-t	*raskt	‘energy’
Dansk		danks-t	*dansk	‘Danish’
Fransk		franks-t	*franskt	‘French’

A third case of metathesis comes from Lithuanian that differs from Faroese in that any coronal fricative can undergo metathesis, as shown in (4). The pattern can be seen, for example, by taking a look at the infinitive and gerund forms. In the forms, the underlying order fricative+stop is reversed, giving stop+fricative (Kenstowicz 1972; Ambrazas 1997).

(5) /dresk-/ + -ti	→	dreksti	‘to tear’
/tisk-/ + -ti	→	tiksti	‘to splash’
/mezg-/ + -damas	→	megzdamas	‘while knitting’
/cirsk-/ + -lys	→	cirklys	‘chirper’

Fourth, according to Drachman (1969), in Twana, the Salishan language, a glottal stop metathesizes to a word-final position, changing the sequential ordering of a glottal stop and an adjacent consonant, as in (6).

(6) he ₁ d	→	hed ₁
sco ₁ b	→	scob ₁
d ca ₁ d	→	d cad ₁
ho ₁ o ₁ l	→	ho ₁ ol ₁
slo ₁ b	→	slob ₁
w ₁ d-wE'daw	→	wd ₁ -wE'daw

Fifth, we now turn to some data from Persian in which obstruent or nasal plus liquid came to undergo metathesis;

- (7) caxr(a) → carx 'wheel'
 vafr(a) → barf 'snow, ice'
 asr(u) → ars 'tear'
 *namr(a) → narm 'soft'

The loss of a word-final vowel creates the context for metathesis. The deleted vowel is included in the parentheses in the examples above. This phenomenon, however, seems to be explainable by the sonority contour principle⁵, as in Hock (1985); metathesis helps eliminate the clusters which is not in accord with the language's preferred syllable structure, i.e., sonority increases in the onset and decreases in the coda. However, this approach has several drawbacks. First, consider the cases of Faroese and Lithuanian metatheses in (4-5) and of Dutch and Southern American English metatheses in (3). In the languages, the metathesized coda sequence TS (Obstruent-Sibilant) clearly violates the sonority principle. Second, it fails to capture the cross-linguistic fact of metathetical asymmetry between onset and coda consonant clusters.

Sixth, there is another language with coda cluster metathesis, which is Kota, one of the Dravidian languages, in which the sequence VC + y surfaces as VyC (Emeneau 1967, 1970; Semilzoff-Zelasko 1973).

- (8) ku:p + y → ku:yp 'blow with breath'; 'y' is the past tense marker
 a:k + y → a:yk 'construct'
 u:t + y → u:yt 'fix into ground by pressure'
 tal + y → tayl 'push'

⁵ Ohala and Kawaskaki (1984) express considerable doubts about theories of the syllable that are based on the sonority hierarchy. They argue that its foundation, sonority hierarchy, is lacking in an independently established phonetic correlate. They then propose that an independent basis for some constraints on syllable organization can be found in terms of the 'empirically measurable properties of the sounds involved'. Such a phonetic approach to sonority is also consistent with the view held by Mattingly (1981), whose proposal is based on the notion of parallel transmission as an organizing principle for speech communication. Sonority is argued to be one way of achieving this goal of parallel transmission. In the similar line, Chitoran et al. (2002) also suggests that the sonority sequencing principle should be reinterpreted by the articulatory-based account in order to account for a good many instances of violating the principle.

In this language, VC plus a glide /y/ metathesizes into VyC, where 'y' is the past tense marker for one class of verbs. The sonority hierarchy principle can provide an explanation for this data, but the account has several crucial weaknesses, as mentioned above.

Seventh, in Udi, a Northeastern Caucasian language, a stop plus fricative sequence in onset clusters metathesizes to a fricative plus stop consonant sequence. This kind of metathesis is interesting, because it is quite contrary to what we saw in the Faroese and Lithuanian cases; reversing the order of the stop and fricative positions the weaker stop in a weaker context, i.e., inter-consonantal. If it were to avoid the marked sequence of stop + double sibilant, then how could the Lithuanian examples in (10) where the marked sequences are created by metathesis be explained in a principled manner, even though it is quickly eliminated by loss of one of the sibilants?

(9) $\text{mut}_{\text{U}}\text{sun} \rightarrow \text{mu}_{\text{U}}\text{t}_{\text{U}}\text{un}$

$\text{et}_{\text{U}}\text{sun} \rightarrow \text{e}_{\text{U}}\text{t}_{\text{U}}\text{un}$

(10) /mezg-/ + /syu/ → meks-syu → meksiu (future of 'knit')
 /reisk-/ + /syu/ → reiks-syu → reiksiu (future of 'tie')

Finally, another case of coda cluster metathesis is found in the development in Tübatulabal, which seems to convert a relatively unmarked structure with /h/ next to a vowel into a marked configuration with /h/ in postconsonantal and word-final position.

(11) Tübatulabal (cf. Voegelin 1935: 86-87)

$\text{ha}'_{\text{I}}\text{aya}'\text{hl} \rightarrow \text{ha}'_{\text{I}}\text{aya}'\text{lh}$ 'the trout'

$\text{tso:}'\text{hn} \rightarrow \text{tso:}'\text{nh}$ 'his gray fish'

In the next section, several cases of the apparent onset cluster metathesis will be

discussed, and are argued to be no real counterexamples.

2.3.2 Apparent Onset CC Metathesis

First, consider Hua, a Papuan language of the eastern highlands of New Guinea, where there seems to be cluster metathesis in coda, but not in onset. The examples from Haiman (1980) are shown as follows:

- | | | | | |
|------|-------|---|--------------------|--------------------------|
| (12) | pkai- | ~ | kpai- | ‘grow, nurture, develop’ |
| | kbeta | ~ | bketa ₁ | ‘a daisy-like flower’ |
| | mna | ~ | nma | ‘bird, flute; louse’ |

The form on the left is in each case more common. According to Haiman, schwa is always inserted between the two consonants of the onset clusters (coda clusters do not exist in this language). Thus the actual phonetic forms of the three words are [p kai], [k beta], and [m na]⁶. Thus, we can conclude that the examples above do not fall under the category of onset cluster metathesis.

The second more controversial case is found in Zoque, a Mexican language. In this language, a palatal glide + consonant sequences, due to morpheme concatenation, is pronounced with the glide following the consonant.

- | | | | | |
|------|---------|---|--------|---------------|
| (13) | y-pata | → | pyata | ‘his mat’ |
| | y-buro | → | byuro | ‘his burro’ |
| | y-faha | → | fyaha | ‘his belt’ |
| | y-mula | → | myula | ‘his mule’ |
| | y-wakas | → | wyakas | ‘his cow’ |
| | y-hayah | → | hyayah | ‘her husband’ |

⁶ However, it remains to be seen whether the schwa inserted between the two consonants is the true epenthetic vowel creating a new syllable or just a case of a vowel intrusion resulting from two consonant gestures being produced with a low degree of overlap, as argued in Gafos (2002).

When /y/ precedes an alveolar consonant /t/, /d/, /c/, /s/ or /n/, the alveolar consonant is palatalized (the palatal glide does not surface as a separated sound).

- (14) y-tatah → catah 'his father'
 y-duracehk → ne urac hku 'it is lasting'
 y-c hk- → t ahku 'he did it'
 y-s k → ek 'his beans'
 y-nanah → anah 'his mother'

When /y/ precedes in non-initial position, the cluster /yh/ remains unchanged.

- (15) kuy 'wood' + ham 'lime' → kuyham 'ashes'
 kay 'narrow' + hu ti 'thread' → kayhu ti 'fine thread'

When /y/ precedes /t/ in non-initial clusters, the /t/ is palatalized to /c/ but the glide is not deleted.

- (16) tey 'there' + -tih → teycih 'right there'
 kuy 'wood' + t m 'seed' → kuyc m 'avocado'

When /y/ precedes an alveopalatal consonant /t/ or /c/, /y/ deletes.

- (17) y- + t o ngoya 'rabbit' → t o ngoya 'his rabbit'
 y- + a pun 'soap' → a pun 'his soap'

Based on these data, Sagey (1986) argues that apparent glide/consonant metathesis in Zoque is not metathesis at all. Rather, palatalization is involved: the vocalic articulation of the glide is pronounced as a secondary palatal articulation on the following consonant. This argument is very convincing, because all the examples in (15-17) can be derived in a straightforward way if we postulate two palatalization rules to apply before deletion. Palatalization I is a phenomenon whereby a consonant is palatalized after the word-initial [y], whereas in palatalization II, [Coronal]

is any systematic difference of metathetical production errors in onset vs. coda. Specifically, the present study investigates the effects of positional (onset vs. coda) and segment ordering (/sk/ vs. /ks/) difference on the frequency of metathetical errors.

2.4.1.1 Material

Twenty-four German words were used as test stimuli (a list of test words is given in the appendix). Those include six words with onset /sk/, six words with onset /ks/, six with coda /sk/, and six with coda /ks/. 14 filler words without /sk/ or /ks/ in both positions were also included to extract more errors from the subjects. They were repeated once. All the 38 tokens were randomized.

2.4.1.2 Subjects

The subjects were 2 Male and 1 female native speakers of German who were graduates at Yale University with no known speech or hearing disorders. The subjects got paid for their participation.

2.4.1.3 Procedure

The experiment involved the task of pronouncing the words popping up at a regular interval of one second on the screen of a laptop computer. The DMDX program was used to run the experiment from a PC and record the subjects' oral responses. The speaker was instructed to read aloud what they saw. After a practice trial using a representative selection of stimuli and filler words to ensure the subjects' comprehension of the task, the subjects performed the task individually. To determine what types of production errors the subjects made, their recordings were transcribed auditorily and through the examination of spectrograms.

and in coda. This way, we can find out whether there arises the positional effect on metathetical errors.

2.4.1.4 Results and Discussion

Table 1 shows the number of metathetical errors for the 24 stimuli for the subjects (see appendix II for their specific words in which they produced metathesis errors).

Table1. The number and percentage of the production errors by 3 German subjects.

Position	Segment Order	Subject 1	Subject 2	Subject 3
Onset	/sk/	0	0	0
	/ks/	0	0	0
Coda	/sk/	2	2	2
	/ks/	1	2	1

Table 1 shows that the three subjects made no metathetical errors in onset, while they made significantly more metathesis errors in coda ($p < .01$) according to the one-way ANOVA test (one way analysis of variance). Among the errors in coda, the number of errors in /sk/ is not significantly different than that in /ks/ ($p > .05$). The interpretation of these results is as follows:

These results clearly show that there is a systematic difference between onset and coda position in the production of metathetical errors in that no metathetical errors did not appear in both of the onset clusters, and at the same time, metathesis took place in both of the coda clusters, even though there was a slightly more errors in the coda /sk/. The fact that the production of metathetical errors has something to do with the positional distinction between onset and coda indicates that synchronic variation can be constrained by some difference between mechanisms underlying each position, which this paper proposes is the difference in gestural timing variability between onset and coda consonant clusters. This was tested via measuring the actual variability in both coda and onset clusters, which will be discussed in the next section.

2.4.2 Variability Measurement

The variability for two of the three production experiment subjects, AV and OK, was measured. Only /sk/ clusters were included for the analysis, since the variability of the /ks/ clusters were impossible to measure by the present acoustic analysis. Thus

the total 12 words were used as test words, with 6 words in each position. The recorded data were analyzed using Praat. Two kinds of measurements were made for each token: first, onset-onset lag, and second, absolute deviation in onset-onset lag from the group mean. Onset-onset lag represents the lag between the C1 onset of frication and the C2 onset of closure. Wide-band spectrogram was used to determine the two onset points. Variability in onset-onset lag exhibits variability of gestural timing between the two consonants. The variability value in gestural timing was calculated as the absolute deviation of each token in onset-onset lag from the group mean. Effects of position within a syllable and subjects on variability were tested in a 2-way ANOVA.

2.4.2.1 Results

The following figure shows the average onset-onset lag for the onset and coda /sk/ of two subjects.

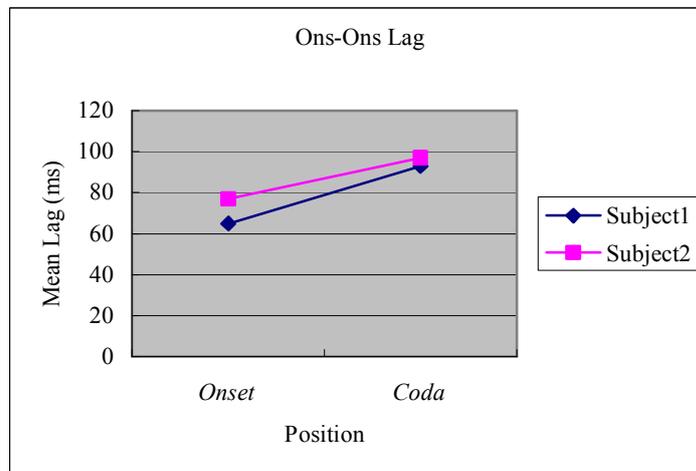


Figure 1. Average onset-onset lag

It is shown from Fig. 1 that average onset-onset lag is longer in coda than in onset for /sk/ clusters of both subjects. The effects of position and subject were analyzed by

two-way ANOVA. The effect of position was significant ($F = 24.28$; $p < 0.0001$), while the effect of subject was not ($F = 2.374$; $p = 0.1390$). The interaction effect was not significant, either ($F = 0.4820$; $p = 0.4955$).

The following figure shows the average variability in gestural timing – the average absolute deviation in onset-onset lag – for the two subjects and the two positions.

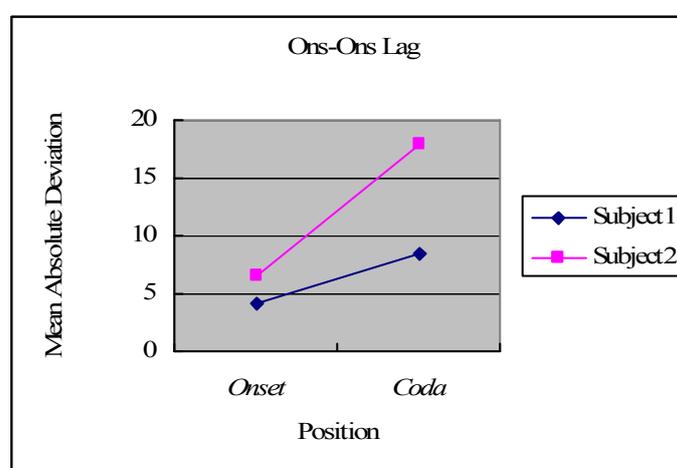


Figure 2. Average variability in onset-onset lag

Figure 2 exhibits that coda clusters are more variable than onset clusters, and subject 2 shows more variability than subject 1 in both onset and coda. Two-way ANOVA was executed to investigate the effects of position and subject. Both the effects of position ($F = 9.724$; $p = 0.0054$) and subject ($F = 5.008$; $p = 0.0368$) were significant. The interaction effect, however, was not significant ($F = 1.466$; $p = 0.2401$).

2.4.2.2 Discussion

The findings showed that coda clusters exhibited significantly greater variability in gestural timing than onset clusters. This supports Byrd's (1996) experiment result on American English clusters. The result of the present experiment is compatible with the

hypothesis of this study that more variability can result in more metathetical errors.

Naturally, a question then arises: why can this production experiment result be relevant to the diachronic sound change regarding metathesis. An answer to this question can be found from Ohala (2003): ‘A great deal of phonetic variation parallels sound change, that is, synchronic variation, including that which we find in present-day speech, resembles diachronic variation. The synchronic variation can be found both in speech production and in speech perception.’ Variations in production can create ambiguity in the speech signal which the listener is unable to figure out, and in such cases a new pronunciation does develop and a sound change occurs. He has referred to such cases as “mini-sound changes” – “mini” because in the beginning such sound changes are limited to a given listener. Thus, under the assumption that production errors are a kind of variations in production⁹, the possibility of the subjects’ metathetical errors becoming a mini-sound change would be fairly high, even though such a mini-sound change influences the rest of the population and becomes “maxi-sound changes” at a very low rate.

However, perceptual optimization can not account for why onset /ks/ does not produce metathetical errors, and why coda /ks/ is also vulnerable to metathesis. According to their hypothesis, stop consonants prefer to switch to postvocalic position with its transitional cue in order to maximize their perceptual cues, because a stop that is word final may be unreleased, resulting in lack of evidence for it following the fricative. This may increase its chance of being ordered before the fricative ([VTS{C,#}], instead of after ([VST {C,#}]) (Seo and Hume 2001). Also, the evolutionary phonology account by Blevins and Garrett (2004) does not have any relevant explanation as to why metathesis errors did not occur in onsets in this experiment. According to their account, there is a tendency to auditorily segregate sibilant noise from the rest of the speech stream, and this segregation can lead to dramatic misperceptions, and potentially metathesis. Thus, the current asymmetry in production errors finds no interpretation from their auditory-stream segregation-based account of the diachronic sibilant-stop or stop-sibilant metathesis

The production experiment result also raises the question of to what extent lexical

⁹ The assumption is possible, since their error rate is quite high, ranging from 17 to 33 percent.

frequency effect may be an influencing factor to the ordering of the segments, since this effect has been shown to affect perception (Luce 1985, Vitevitch and Luce 1999) and metathesis (Makashay 2001). If this is the case, the lexically infrequent words should trigger more errors including metathesis. Thus, through the Google search of pages written in German, summing the frequencies of occurrence of German words with the clusters of interest, i.e., the dataset that I used in the experiment, and dividing them by six yield the results shown in Figure 3 for written frequencies. It is observed that patterns of frequencies of occurrence, and counts of metathetical errors are at odds with each other. For example, coda /sk/ brings about the most production errors, even when coda /sk/ is the most frequent. Also, words with onset /sk/ do not trigger any errors, even though they are more frequent than those with coda /ks/. Thus, it can be concluded that lexical frequencies did not give a boost to subjects' performance of correct pronunciation.

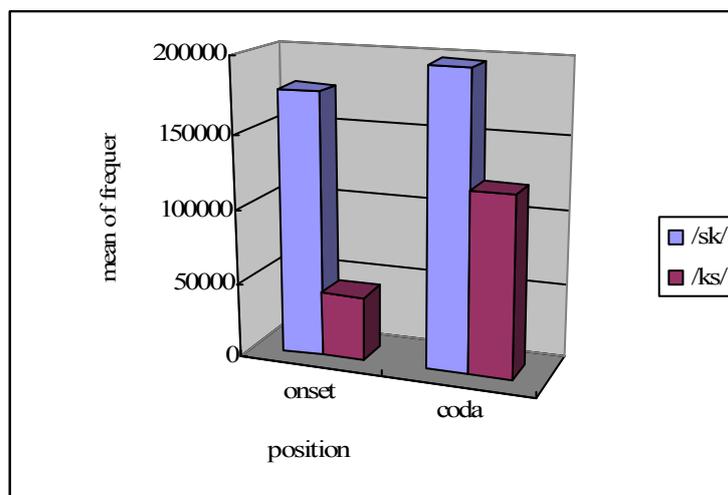


Figure 3. Average written frequencies of the dataset of this experiment

2.5 Structure-Violating Metathesis Evidence

If the present hypothesis is right, then it is predicted that as a consequence of

metathesis, a consonant sequence can be created historically which were not present, since the dynamic structure is operative independently of the phonotactics of a given language. Juliette Blevins (personal communication) stated that synchronically, metathesis is not structure preserving, as shown by the fact that ‘closed syllables in the incomplete forms are not attested in complete forms in Rotuman’. She added with respect to diachronic metathesis that in languages like Rotuman and the mirror image in Ngkoth, VV sequences were created historically which did not exist, even though Blevins (2003) argued that the majority of perceptual metatheses are structure preserving in the broadest phonotactic sense.

However, to the best of my knowledge, no literature has focused on whether there is any language with any CC coda or onset sequence that was created by metathesis. This study will argue that Old English has created a new coda consonant sequence via metathesis. As I have shown in the earlier section, /worm/ ‘matter’ becomes [worms] (Hemphill 1892). A closer look at the Old English dictionary (Sweet 1953) has shown that there is no word with a coda /ms/ sequence found in it¹⁰, indicating that Old English local CC metathesis in coda might be dynamically motivated by greater variability in gestural timing under the assumption that coda sequences are more variable than onset clusters in OE. Thus, the prediction of the hypothesis of this study is proven to be true. Future work, however, is necessary to investigate whether or not there are any other languages of the same type as OE to determine if this phenomenon is just limited to this language.

2.6 Order Contrast Facts

Given the hypothesis of this study, it is arguably predicted that the order contrast in codas should be more difficult to maintain than in onsets, since its gestural timing is more variable than coda’s. To test this prediction, I investigated many languages with metathesis and without. These languages are classified into four groups: The first group is the languages with order contrast only in onset. Its most typical examples are

¹⁰ Notice that OE does not have /s/ as the plural marker for nouns or as the third person singular marker for verbs, differently from Modern English.

Hungarian and Georgian. In those languages, it is reported that order contrast exists only in onset, as shown in (20-22).

(20) Hungarian (Kenesei 1998)

/sp-/ vs. /ps-/
 /sk/ vs. /ks-/
 /gn-/ vs. /ng-/

(21) Georgian (Butskhrikidze 2002)

/sv-/ vs. /vs-/	/xl-/ vs. /lx-/
/rxʰ-/ vs. /xʰr-/	/lb-/ vs. /bl-/
/tʰl-/ vs. /ltʰ-/	/rb-/ vs. /br-/
/dn-/ vs. /nd-/	/rtʰ-/ vs. /tʰr-/
/gr-/ vs. /rg-/	/vs-/ vs. /sv-/
/p _U -/ vs. / _U p-/	/ _U x-/ vs. /x _U -/

Second, there are a group of languages where a similar number of contrasts exist both in onset and coda. In this group are included French and German. Third, a certain languages do not have order contrast in either onset or coda. Lithuanian and Faroese, for example, fall under this type. And, finally, there is a language with order contrast only in coda CC clusters. English is the only language of this type that I was able to find. However, to block the impact of the loan words from Latin or Greek on the existence of order contrast, we need to examine the onset or coda clusters of the native words of Old English. I still found four cases of order contrast only in codas.

(22) a. /-sp/ vs. /-ps/ b. /-sk/ vs. /-ks/
 c. /-dl/ vs. /-ld/ d. /-kn/ vs. /-nk/

The first type obviously upholds the hypothesis of this study, because order contrast is clearly dispreferred in coda. And the second and the third type of languages provide no evidence for it due to the lack of order contrast preference in either onsets

or codas. However, the final type interestingly constitutes counter-evidence for it, since it seems that order contrast is harder to maintain in onsets than in codas in English. Thus, this language should be investigated to determine which factors might have influenced the development of coda order contrast. To sum up, although this order contrast argument is not conclusive, given that the number of the languages examined is too small, this argument is suggestive to the extent that there is more preference of order contrast in onsets found in more languages.

2.7 Possible Perceptual Optimization and Evolutionary Approaches

2.7.1 Perceptual Optimization: Hume (1997) and Steriade (2001)

Because of its notorious irregular nature, metathesis was exempted by the neogrammarians from their regularity hypothesis. Hoenigswald (1964) and Hock (1985) argue that some of the changes wrongfully regarded as ‘sporadic’ fall under the category of regular sound change. In line with them, Hume (1997) and Steriade (2001) provide a perceptual optimization account for why some regular metathesis takes place.

According to Hume (1997), metathesis shifts a perceptibly vulnerable consonant to a context in which the acoustic/auditory cues to the identification of the sequences are more robust, thus increasing the consonant’s perceptual prominence. A perceptually weak consonant, generally a stop or a nasal, is a segment with relatively weak internal cue to place or manner articulation. Among the perceptually vulnerable consonants, stops are argued to depend on cues such as release bursts and formant transitions. Thus, from a perceptibility perspective, the occurrence of stops in contexts in which these cues are present is to be preferred over the one in which the cues are absent or partially masked, e.g., first, postvocalic position is preferred for a stop over postconsonantal or interconsonantal position, since it can have a VC transition, and second, prevocalic is preferred for a stop over postvocalic, preconsonantal position, in that it can have its burst, and that CV transitions provide better cues than VC transitions (Fujimura, Macchi, and Streeter 1979). Faroese metathesis exhibits the first

kind of metathesis, since the metathesized /k/ lands at a postvocalic position, as in (23) (Seo & Hume 2001). Metathesis of the second kind is found in rural Latin, as in (24) (Steriade 2001).

- (23) /baisk+t/ → [baikst] *baiskt 'bitter, neut.sg.'
 (24) /ipse/ → [ispe] *ipse 'he, she, it'

In their account, the Faroese metathesis occurs because a stop shifts from interconsonantal position to postvocalic position to maximize its perceptual prominence by getting VC transitional cues at the expense of the fricative /s/, a sound with stronger internal cues to both place and manner, while the rural Latin undergoes metathesis because a stop changes positions from postvocalic to prevocalic position to gain a good burst and CV transition cues better than VC ones.

Even though this approach can obviously account for the cross-linguistic tendency of sibilant-stop metathesis, it has several weaknesses: First, some data clearly go against this account, since the opposite results have occurred historically across languages, as Makashay (2001) has noted. For instance, Nakao (1986) has the counterexamples to the cases of (20) (postvocalic TS → ST metathesis) from OE, which will be further discussed in the next section, and Silva (1973) notes a case of intervocalic ST → TS metathesis contrary to that in (24) in the development of Lappish into Mordvin: *boaske* 'the small of the leg' → *pukso* 'the thick flesh'.

Another weakness in the perceptual optimization account is that the account does not capture the cross-linguistic fact that metathesis rarely occurs in the onset consonant clusters, while it frequently occurs in the coda. From the viewpoint of Articulatory Phonology, however, the present paper proposes that the stability or cohesion of consonant gestures is weak in coda, since the second consonant is not phased to the vowel, which is why there occurs this kind of cross-linguistic asymmetry in metathesis.

Given that my proposal can not properly account for why some particular clusters like fricative-stop sequence metathesize, when lots of others do not in the world's languages, and that the Perceptual Optimization can not provide an adequate

explanation for the synchronic and diachronic asymmetry in metathesis between onset and coda clusters as well as the structure-preserving case of metathesis in Old English, these two approaches combined could solve the puzzles. That is, the PO provides some suggestions as to why particular situations should give rise to metathesis, and the dynamical variability-related factors proposed here could be influencing the development of more metathesis in codas both synchronically and diachronically, let alone the emergence of structure-violating metathesis.

2.7.2 Evolutionary Phonology: Blevins and Garrett (2004)

Hypothesizing that certain sound patterns are crosslinguistically frequent as a consequence of convergent evolution: the intrinsic properties of speech perception and production result in certain frequent sound changes, which in turn yield sound patterns, Blevins and Garrett (2004) explains metathesis, a common sound pattern as the result of convergent evolution. In doing so, they identify four main types of metathesis, with specific phonetic features, as listed in Table 2.

Table 2. Four types of metathesis

Metathesis type	Phonetic feature
a. Perceptual metathesis	Elongated phonetic cues
b. Compensatory metathesis	Stress-induced temporal shifts
c. Coarticulatory metathesis	CC coarticulation
d. Auditory metathesis	Auditory stream decoupling

The first type concerns features with intrinsically long duration (e.g., laryngealization or pharyngealization); such features are spread over the long domain, allowing them to land in non-historical positions. It is worth noting that an Evolutionary approach have two interesting predictions concerning this type of metathesis. First of all, it is correctly predicted that when there is a blocker, no metathesis should occur. And, another prediction is related with directionality effects. A segment or feature moves into a relatively prominent position. This observation is convincingly explained via the misperception of the linear origin of a segment with

extended cues. The second type is prosodically conditioned, i.e. features in a weak syllable within a foot shift their positions into the strong syllable. The third type of metathesis emerges in consonant clusters with the same manner of articulation but the different place of articulation, and results from coarticulation facilitated by shared articulatory gestures, since coarticulation can have different acoustic effects depending on how much the gestures involved overlap, as demonstrated by Browman and Goldstein (1990b). The categorization of coarticulatory metathesis is upheld via the unidirectionality of several languages, PK > KP and not vice versa. The fourth type involving sibilants results from auditory-stream decoupling to the extent that sibilant noise tends to be decoupled from the rest of the speech stream, thereby this decoupling resulting in noticeable misperceptions.

Problematically, however, it still can not account for the metathesis asymmetry, i.e. why cluster metathesis occur rarely in onsets, but frequently in codas across languages, even though this evolutionary phonology approach can correctly predict the direction of change in some particular onset and coda clusters.

3. Conclusion

This study has proposed that the greater variability in gestural timing can result in more synchronic or diachronic metathesis, specifically the intra-syllabic local CC metathesis along the lines of the coupling model that Browman and Goldstein (2002) proposed to explain the greater stability in gestural timing of onset consonant sequences discovered by Byrd (1996). To support my hypothesis, typological evidence was provided, focusing on the two predictions of the present hypothesis. To the best of my knowledge, the typological survey results were the first to find that there is a cross-linguistic asymmetry in the number of metathesis between onset vs. coda. As another piece of supporting evidence, a production study on German was presented, showing that the variability difference between onsets and codas patterns compatibly with the number of metathetical errors, and that this synchronic metathesis can be associated with diachronic metathesis under the assumption from Ohala (2003) that synchronic variation parallels or resembles diachronic variation. Thirdly, by

showing that Old English has a case of structure-violating local CC metathesis, I have provided an additional piece of supporting evidence of the claim of this study. Finally, I have presented and discussed order contrast facts, stating that even though the facts do not fully uphold my proposal, it is somewhat suggestive of its validity in spite of requiring more future research on it.

Finally, I have noted that even if the possible perceptual optimization have some abilities to have an explanation for the direction of a change in some particular onsets and codas, they do not correctly predict this metathetical asymmetry to be found cross-linguistically in diachronic or synchronic change, suggesting that this variability-based approach can parallel or complement this PO approach.

Also, there are other types of local metathesis that would need to be examined in order to determine if these dynamical bases of metathesis still hold true of all the local metathesis. For example, this study did not investigate local CV metathesis and inter-syllabic CC metathesis. Future research will investigate these two types of local metathesis.

APPENDIX I: LIST OF TEST WORDS AND ERRORS

Onset-/sk/	Onset-/ks/	Coda-/sk/	Coda-/ks/
Skepsis	Xenia	brusk	Fuks
Skat	Xaver	Kafkaesk	perplex
Skonto	Xilophon	burlesk	Kleks
Skizze	Xanthen	grotesk	Konvex
Skalpell	Xylography	Kiosk	Lux
skala	Xanthippe	Obelisk	Fax

APPENDIX II: LIST OF METATHESIS ERRORS EACH SUBJECT MAKES

	Subject 1	Subject 2	Subject 3
Coda-/sk/	Obelisk	Obelisk	Kiosk
	Kiosk	brusk	grotesk
Coda-/ks/	Fuks	Fuks	Kleks
		Faks	

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