

Perception-based Asymmetries in Place Assimilation and Lenition*

Jongho Jun

1. Introduction

Lenition and place assimilation have commonalities in terms of their phonetic attributes and the functional mechanisms proposed for an analysis. Based on these commonalities, the present study proposes a unified account for the analysis of the asymmetrical patterns of lenition and place assimilation. Specifically, perception-based and effort-based approaches are compared. It will be shown that a perception-based approach, which has been adopted for the analysis of asymmetries of most other phonological processes, is in general superior in providing a consistent solution for the asymmetrical patterns of lenition and place assimilation.

Many phonological processes show asymmetries with respect to the target segment classes and positions. Suppose that a phonological pattern is described by a rule $A \rightarrow B / _C$. If some other segment class, say K, does not undergo the same change in the same environment, then A would be an asymmetrical target. If A does not change to B in a different environment, say “before D”, then the rule context “before C” is an asymmetrical target position. These target asymmetries can be illustrated by the following attested patterns:

- (1) Some attested target asymmetries
 - a. Laryngeal neutralization: Obstruents are more likely to be neutralized for the voice feature before an obstruent than before a vocoid. (Steriade 1999)
 - b. Place assimilation: Nasals are more likely to undergo place assimilation than stops. (Jun 2004)
 - c. Consonant Deletion: Consonants want to be adjacent to a vowel, and preferably followed by a vowel. (Côté 2000)

* This paper has benefited from the advice and comments from Donca Steriade, Adam Albright, Dan Silverman, Taehong Cho, Yoonjung Kang, and Donna Erickson. Earlier versions of this paper have been presented at the Twenty-Third Conference of The English Linguistic Society of Japan, Fukuoka, Japan (November 2005) and the Seoul Linguistic Forum 2005, Seoul, Korea (December 2005). I am grateful to the audiences of those conferences for their valuable comments. This research has been supported by grants from the Institute of Humanities of Seoul National University.

d. Contour tone distribution: If CVO can carry contour tones, then CVR and CVV can carry contour tones with equal or greater complexity. (Zhang 2004)

e. Lenition: All else being equal, lenition occurs more readily the greater the openness of the flanking segments. (Kirchner 2004)

In functional approaches to phonology, the source of these asymmetries lies in the difference in the perceptual and articulatory effects of different segment classes and positions. In particular, Phonetically-Based Optimality Theoretic (PBOT) approaches (Steriade 1993, 1995, 1997, 1999, 2000, 2001; Hayes 1999; Boersma 1998 and most papers in Hayes et al. 2004) employ either perceptibility or effort cost scales for an analysis of the asymmetries. In cases where the perceptual effect difference is considered as the source of the target asymmetries, perceptibility scales are called on. The scales, in which the less likely target of a given phonological process is more perceptible than the more likely target, have independent justifications. For instance, in explaining the pattern in (1a), Steriade proposes a perceptibility scale in (2) in which the obstruent voice distinction is more perceptible before a vowel (i.e., the less likely target position of laryngeal neutralisation) than before an obstruent (i.e., the more likely target position). The scale is based on the facts summarised in (3), which indicate that more perception cues of obstruent voicing are available before a vowel than before an obstruent.

(2) Perceptibility scale of obstruent voicing: __V(ocoid) > __O(bstruent)

(3) Perception cues for voice feature (O = present, X = absent)

Perception cues	V1's duration, V1's F0 & F1	Release burst, VOT	V2's F0 & F1
V1__V2	O	O	O
V1__O	O	X	X

In contrast, in cases where the articulatory effect difference is the source for the target asymmetries, effort cost scales are called on. In the scales, the effort cost is higher for the more likely target than the less likely target. For instance, to explain the pattern in (1e), Kirchner (2004) proposes an effort cost scale, shown in (4), in which the effort cost increases when a consonant occurs between vowels (the more likely target position of lenition), compared to when it occurs adjacent to a consonant (the less likely target position). This is based on the assumption that the more open the flanking segments, the greater the effort cost. The tongue and jaw positions for consonants are higher than that for vowels. So, if a consonant occurs between vowels, the articulators such as tongue and jaw must travel a long distance, compared to when it occurs adjacent to a consonant.

(4) Effort cost scale of flanking segments: V__V > V__C > C__C

These scales, perceptibility or effort cost, project parameterized phonetically-based

constraints and determine their internal rankings. For instance, as shown in (5a), Markedness constraints prohibiting voice feature distinction are parameterized and ranked relative to each other, based on the perceptibility scale in (2). These universally-ranked Markedness constraints may explain the pattern in (1a), interacting with Faithfulness constraints for voice feature. Similarly, asymmetrical patterns in (1b-d) have been analyzed by the constraints shown in (5b-d), whose internal rankings are determined according to the relevant perceptibility scales.

(5) Universally-ranked parameterized constraints in PBOT

- a. $*\alpha_{\text{voice}}/R_O \gg * \alpha_{\text{voice}}/R_R$ (R = resonant)
- b. $\text{PRES}(\text{place}(\frac{\quad}{[\text{stop}]} C)) \gg \text{PRES}(\text{place}(\frac{\quad}{[\text{nasal}]} C))$
- c. $\text{MAX-C}/_V \gg \text{MAX-C}/V_ \gg \text{MAX-C}/C_C$
- d. $*\text{CONTOUR}(35)\text{-}C_{\text{CONTOUR}}(\mathbf{VO}) \gg * \text{CONTOUR}(35)\text{-}C_{\text{CONTOUR}}(\mathbf{VR})$
- e. $\text{LAZY}(C, \mathbf{V_V}, R) \gg \text{LAZY}(C, \mathbf{C_V}, R)$

In contrast, for the analysis of the lenition pattern in (1e), the effort cost scale in (4) projects and ranks parameterized Markedness constraints, termed as LAZY in Kirchner (1998, 2004), prohibiting the occurrence of consonantal constriction, as shown in (5e).

With regard to the use of perceptibility and effort cost scales in PBOT analyses of phonological asymmetries, the following questions arise. First, for a certain phonological process, how do we know which scale should be used in an analysis of its asymmetrical patterns? Second, it seems that the previous literature is biased toward the use of perceptibility scales, as indicated by the above discussion: why is the effort-based approach employing effort cost scales rarely adopted in the analysis of phonological asymmetries, compared to perception-based approach employing perceptibility scales? It seems that Kirchner's analysis of lenition is the only PBOT approach in employing effort cost scales as the major functional source of the explanation. This bias is even more surprising when we consider the phonetic similarities between place assimilation and lenition, discussed below. Why are the asymmetries of such similar processes subject to different treatments?

To answer these questions, I will attempt to analyse lenition asymmetries within the framework of perception-based approach, while comparing it to an effort-based analysis. The present study may be viewed as part of a larger project exploring the possibility that the source of all phonological asymmetries lies in the difference in perceptual, but not articulatory, effects of the potential target segments and contexts involved.

Some words of caution are in order. I believe that articulatory and perceptual factors

are responsible for various aspects of most, if not all, phonological processes, including the occurrence and absence of each process. Among the various aspects, the main focus of the present study is on the target asymmetries of the type mentioned above. Thus, effort-based and perception-based approaches are compared in terms of their effectiveness only in explaining the target asymmetries, not any other aspects of phonological processes. Accordingly, although our discussion of an effort-based approach is mainly based on Kirchner (1998, 2004) as he emphasises the importance of effort-cost scales, only the parts of his work concerning the target asymmetries of lenition and the use of effort cost scales are relevant to the present study. It will be concluded that the perception-based approach provides, in general, a more adequate account for the target asymmetries of lenition than the effort-based approach, but this should not be understood as affecting any other aspects of lenition and any other parts of Kirchner's analysis.

This paper is organized as follows. In the following section, it will be shown that lenition and place assimilation are very similar in phonetics and PBOT analyses of their basic patterns. I will first discuss the phonetic characterisation of each process, and then the basic PBOT mechanisms which have been proposed for the analysis of the occurrence and absence of the processes. Section 3 introduces a perception-based analysis of place assimilation asymmetries proposed by Jun (1995, 2004). In section 4, I will provide a perception-based analysis of lenition asymmetries while comparing it to the effort-based analysis. The final section summarises the conclusions of the present study.

2. Commonalities Between Lenition and Place Assimilation

I will first discuss what phonetic process characterizes lenition and place assimilation. This is followed by a discussion of how their basic occurrence patterns have been analysed within the framework of Phonetically-Based Optimality Theory.

2.1 Lenition

Lenition may refer to a variety of different phonological processes, listed below.

- (6) Lenition (from Kirchner 1998: 1)
 - a. Spirantisation (from a stop or affricate to a fricative or approximant continuant)
 - b. Reduction from other consonants to approximants
 - c. Flapping (from a stop to a flap)
 - d. Degemination
 - e. Debuccalization
 - f. Complete elision

g. Voicing.

According to Kirchner, all these processes are commonly characterised by some reduction in constriction degree or duration of an articulatory gesture involved. To illustrate this point, I will focus on spirantisation and flapping as these two processes are directly relevant to the discussion of place assimilation, presented below.¹

Spirantisation refers to the change from a stop to a non-strident fricative or an approximant. Some examples from Florentine Italian are shown below.

(7) Florentine Italian (from Kirchner 2004: 317)

- a. pentola/ la ϕ entola '(the) pot'
- b. kasa/ la xasa '(the) house'
- c. tavola/ la θ avola '(the) table'

As schematized in Figure 1, the articulatory gesture for a stop at a certain place of articulation is greater in magnitude than that for a non-strident fricative at the same place of articulation, given that the vocalic nucleus is the same and the prosodic conditions are the same. Thus, the comparison between the two representations in Figure 1 indicates that gestural reduction occurs during spirantisation.

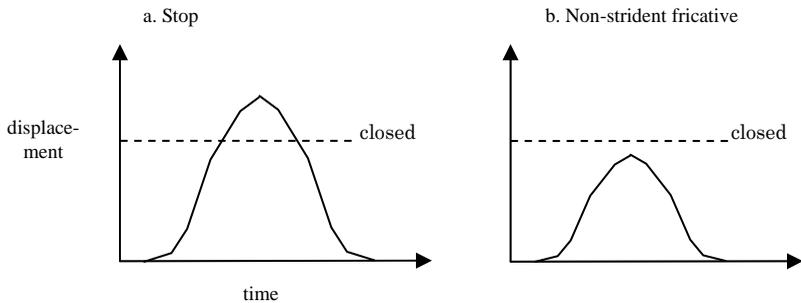


Figure 1. Schematic displacement vs. time graphs for a stop and nonstrident fricative (based on Kirchner 1998: Figure 4-1)²

An approximant would be characterized by even less displacement in a comparable schematic representation for an articulatory movement than a fricative. Thus, it may be safely assumed that a higher degree of gestural reduction occurs during spirantisation from a

¹ Also, spirantisation is the most common process at least in Kirchner's corpus, as mentioned by Gurevich (2004).

² The part above the "closed" line represents closure with compression.

stop to an approximant, compared to from spirantisation to a fricative.

Flapping refers to the change from a stop to a flap, and some examples from American English are shown below.

(8) Flapping in American English

- a. /bʌtər/ [bʌɾər] ‘butter’
- b. /sɪti/ [sɪɾi] ‘city’

A crucial difference in articulation between a stop and a flap is in the duration of closure phase (Ladefoged 2006: 170). A flap is typically made with a very short closure, as can be schematized in Figure 2. Flapping can then be described as the change from a full closure as schematized in Figure 1a to a short and reduced closure in Figure 2, that is, the reduction in duration and magnitude of an articulatory gesture involved.

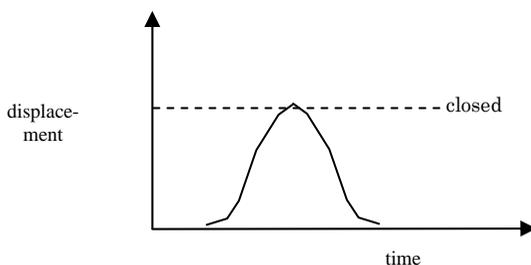


Figure 2. Schematic displacement vs. time graphs for a flap

In summary, gestural reduction is the main articulatory process responsible for the occurrence of lenition, and different types of lenition including spirantisation and flapping differ crucially in the degrees of reduction in the magnitude or/and duration of an articulatory gesture involved.

2.2 Place Assimilation

In place assimilation, one member of a consonant cluster takes on the place of articulation of the other member, as can be seen in the following examples:

(9) Place assimilation

a. English

- (i) /gri:n peɪnt/ [gri:m peɪnt] ‘green paint’
- (ii) /red kɑː/ [reg kɑː] ‘red car’

(iii) /bæd θɔ:ts/ [bæd̥ θɔ:ts] ‘bad thoughts’ (Nolan 1992: 262)

b. Korean

(i) /cinan + pam/ [cinampam] ‘last night’

(ii) /mit + ko/ [mikko] ‘believe + and’

(iii) /ip + ko/ [ikko] ‘wear + and’ (Jun 1996)

The phonetic transcriptions given above suggest that place assimilation is categorical, and it may be described as phoneme substitution. However, many experimental studies on casual speech place assimilation (Browman and Goldstein 1990, Barry 1985, Nolan 1992, Byrd 1994, Jun 1996 and others) show that the target gesture often remains, and assimilation is in fact gradient, not categorical. Previous studies diverge in the choice of the source of (perceptual) assimilation between gestural overlap and gestural reduction. Ohala (1990) and Browman and Goldstein (1990) claim that loss of gestures do not occur in assimilation, and that the target segment is simply not heard under much overlap with the trigger segment. However, an aerodynamic study on casual speech place assimilation by Jun (1996) suggests otherwise. Intraoral pressure was measured during the production of English and Korean labial-velar sequences, e.g., (9biii), and the results show that mere gestural overlap does not yield perceptual place assimilation, and gestural reduction, partial or complete, of the target segment is necessary for the occurrence of perceptual place assimilation. Nolan’s (1992) electropalatographic study of English place assimilation reports similar results. Thus, the articulatory process responsible for perceptual loss of the target in place assimilation appears to be gestural reduction of the target segment, which is always accompanied by temporal extension of the trigger segment. Under this assumption, the articulatory movements during place assimilation may be schematized as below.

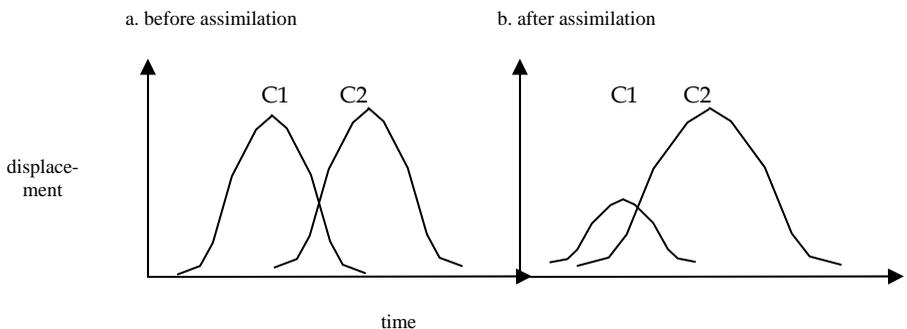


Figure 3. Schematic displacement vs. time graphs for a consonant cluster C1C2 before

and after assimilation

These schematic representations show that an articulatory gesture encoding the place of articulation of the target segment, C1 here, reduces whereas the gesture for the trigger segment, C2 here, lengthens. Putting aside the articulatory movement for C2, the reduced C1 gesture can be compared with the reduced gestures in lenition, shown in Figures 1-2. Previous experimental studies on casual speech place assimilation suggest that reduced target gestures in place assimilation are not significantly different from those of lenition.

The previous electropalatographic studies on English casual speech place assimilation (Barry 1985, Nolan 1992, Byrd 1994 and others) show that the target alveolar gesture often remains, and, in fact, “a continuum of degrees of realization exists for an alveolar in a place-assimilation context” (Nolan 1992: 267). Among alveolar tokens displaying a variety of different contact patterns, those with a short closure can be classified as flaps, as schematised in Figure 2. For these tokens, the alveolar target C1 reduces just as in flapping. In addition, some alveolar tokens lack “medial closure at the top of the display, but show contact along the sides of the palate a minimum of one row further forward than in the control non-alveolar token for the same rate by the same speaker” (Nolan 1992: 267). For these tokens, an articulatory gesture for the target segment was made, but its magnitude was not sufficient to achieve complete closure. Since these residual-alveolar tokens lack complete closure, they can be classified as a fricative (or an approximant), as schematized in Figure 1b, and thus the gestural reduction involved would be considered as a type of spirantisation. In summary, in English place assimilation, the alveolar target gesture reduces like the target in lenition does.

Jun’s (1996) aerodynamic experiment on the Korean labial-velar stop sequence shows similar results. Some tokens display very small changes in oral pressure, suggesting that the labial target gesture is partially reduced, seemingly giving approximation. Since the labial stop closure is incomplete, these tokens can be classified as a non-strident labial fricative, transcribable as [ɸ]. Thus the observed gestural reduction here would be comparable to the one schematized in Figure 1b.

In conclusion, previous experimental studies on place assimilation report cases of partial reduction of the target gesture which are not significantly different from lenition processes like spirantisation and flapping. Thus, I assume that place assimilation is a type of lenition which is always accompanied by the gestural extension of the trigger segment.

2.3 PBOT Analyses

The phonetic similarity between place assimilation and lenition, just discussed, is in fact reflected in the previous analyses of lenition and place assimilation within the framework of Phonetically-Based Optimality Theory. The basic mechanisms that Kirchner (1998, 2004) and Jun (1995, 2004) adopt for the analysis of lenition and place assimilation, respectively, are almost identical. Here is a brief introduction to their analyses.

Kirchner argues that lenition patterns arise directly from the interaction between the effort minimization constraint, termed as LAZY, and Faithfulness constraint, termed as PRESERVATION. Violations of LAZY are assessed based on the effort cost (i.e., ‘a mental estimate of the biomechanical energy’) required for the articulation of each candidate. Under the assumption that effort cost is higher for the production of stops, compared to continuants, an analysis of the occurrence and absence of spirantisation is as shown below:

(10) Occurrence and absence of lenition (from Kirchner 2004: 314 (1))

a.	/d/	LAZY	PRES(cont)
	d	**!	
	ð	*	*

b.	/d/	PRES(cont)	LAZY
	d		**
	ð	*!	*

In (10a), LAZY outranks PRES(cont) requiring preservation of an input [-continuant], and thus the fricative candidate, whose effort cost is lower than the stop, is chosen as an optimal output. Under the opposite ranking in (10b), the stop candidate is chosen as optimal, blocking spirantisation.

A similar analysis has been provided for the occurrence and absence of place assimilation, as shown below.

(11) Occurrence and absence of place assimilation (adapted from Jun 2004: 71 (15))

a.	/tk/	WEAKENING	PRES(place)
	i. tk	**!	
	ii. kk	*	*

b.	/tk/	PRES(place)	WEAKENING
	i. tk		**
	ii. kk	*!	*

WEAKENING is Markedness constraint requiring effort minimization, and it is no different from LAZY. For heterorganic consonant clusters, two separate articulatory gestures are made to encode the place of articulation whereas a single gesture is made for homorganic clusters. Under the assumption that making two separate gestures in a row requires more effort than making a single gesture, the heterorganic cluster candidate in (11i) incurs more violations of

WEAKENING than the homorganic cluster in (11ii). In (11a), WEAKENING outranks PRES(place) requiring preservation of an input place feature, and thus the homorganic cluster candidate is selected as an optimal output. Under the opposite ranking in (11b), the heterorganic cluster candidate is chosen as optimal, blocking place assimilation. In summary, Kirchner and Jun adopt exactly the same constraints and constraint interactions in explaining the occurrence and absence of lenition and place assimilation.

From the facts that similar articulatory processes characterise lenition and place assimilation and that an almost identical PBOT mechanism is adopted for analysis, it is expected that similar (asymmetrical) patterns would have been observed for the two processes, and the same mechanism would have been proposed for the analysis of the patterns. However, it seems that Kirchner and Jun take different directions in explaining the asymmetrical patterns. Specifically, Kirchner parameterises LAZY, relying on effort cost scales whereas Jun parameterises PRESERVATION, relying on perceptibility scales. In the remainder of this paper, I will attempt to solve this puzzling divergence by analysing the target asymmetries of lenition based on the perception-based mechanism which has been proposed for the analysis of place assimilation asymmetries.

3. Place Assimilation Asymmetries

To illustrate the perception-based analyses of place assimilation patterns provided by Jun (1995, 2004), let us consider the following cross-linguistic patterns of place assimilation which can have implicational relations.

- (12) Some asymmetrical patterns of place assimilation ($x > y$ means ‘x is a more likely target than y’)
- a. Target manner: nasal > stop > (continuants)
 - b. Target place: coronal > labial > dorsal
 - c. Position of target: V_C > (C_V)

Based on the idea that the source of these asymmetries lies in the difference in perceptibility of the place of articulation information among different segments and different contexts, Jun first proposes perceptibility scales shown in (13i). As discussed earlier, each perceptibility scale is proposed based on the perceptibility comparison among different segment types in a given context. For instance, the scale in (13ai) is based on the following arguments. In a pre-consonantal position, prominent perception cues for the place of articulation of a stop and a nasal, i.e., the release and C-to-V formant transitions, are normally lost, and thus the perceptibility of place information is quite low for stops and nasals. In contrast, a continuant like a fricative may maintain prominent place cues during consonantal constriction even

under the overlap with the following consonant, and thus its perceptibility is high. Stops and nasals differ with respect to perceptibility of place information. In a pre-consonantal position, V-to-C transitions are almost the only available source of place cues for stops and nasals. Since vowels preceding a nasal are typically nasalised, thus less distinct relative to non-nasalised vowels, nasals have less prominent place cues in the V-to-C transitions than stops. As a result, continuants have more prominent place cues than stops, which in turn have more prominent cues than nasals, as suggested by the scale in (13ai). Other scales in (13i) have comparable justifications. These perceptibility scales project sets of PRESERVATION constraints in (13ii), and determine their internal rankings.

(13) Perceptibility scales and internally-ranked Preservation constraints (Jun 2004)

	<i>(i) Perceptibility of place cues</i>	<i>(ii) ranked PRESERVATION constraints</i>
a. Target manner	[+cont]/_C > [stop]/_C > [nasal]/_C	<p>PRES(pl(____ C)) >> [+cont]</p> <p>PRES(pl(____ C)) >> [stop]</p> <p>PRES(pl(____ C)) [nasal]</p>
b. Target place	unreleased dorsal > unreleased labial > unreleased coronal	<p>PRES(pl(dorsal')) >> PRES(pl(labial')) >> PRES(pl(coronal'))</p>
c. Target position	__V > __C	<p>PRES(pl(__V)) >> PRES(pl(__C))</p>

The rankings in (13ii) indicate that place cues of a more perceptible segment or position must be preserved in preference to those of a less perceptible one. Language-particular assimilation patterns are produced depending on the ranking of these universally ranked PRESERVATION constraints relative to WEAKENING. Obviously, WEAKENING is more likely to outrank the relatively low-ranked PRESERVATION constraint for the less perceptible segment/position, and thus the less perceptible one would be a more likely target in place assimilation, mirroring the statements in (12).

To summarise, the asymmetrical patterns of place assimilation are the result of the interaction between WEAKENING and sets of parameterised PRESERVATION constraints whose internal rankings are established based on the perceptibility scales of the place information.

4. Lenition Asymmetries

Let us first consider what target asymmetries can fall out from the typology of lenition. We may begin with the typological generalisations provided in Kirchner (2004):

- (14) Typological generalizations of lenition (Kirchner 2004: 316)
 - a. All else being equal, lenition occurs more readily the greater the openness of the flanking segments (the widely attested pattern of intervocalic lenition being a special case).
 - b. All else being equal, lenition occurs more readily the faster or more casual the speech.
 - c. Unaffricated stops never synchronically spirantise to strident (sibilant or labiodental) fricatives.
 - d. Geminate stops never undergo voicing or reduction of oral constriction unless they concomitantly degeminate.

Among these, two generalizations in (14a, b) directly display the target asymmetry of the type discussed thus far, and they may be rephrased as follows:

- (15) Asymmetrical lenition patterns ($x > y$: x is a more likely target than y)
 - a. Flanking segments: more open $>$ less open, thus $V_V > C_V$ or V_C
 - b. Speech rate: fast speech form $>$ slow speech form

An additional asymmetry between two segment types may be derived, somewhat indirectly, from the generalisation in (14d): singleton stops are a more likely target in lenition, compared to geminate stops. The final generalisation involving stops and strident fricatives in (14c) also gives some indication of a target asymmetry in lenition. A stop is a common target of lenition like spirantisation, but, according to (14c), it does not lenite to the corresponding strident fricative. Moreover, it seems true that strident fricatives are not only the rare output of lenition, but also the rare target, compared to stops. The target asymmetry between strident fricatives and stops can be confirmed by the languages, discussed in Kirchner (1998), like Tümpisa Shoshone in which stops spirantise but strident fricatives do not lenite to the corresponding approximants, and Florentine Italian in which stops undergo lenition obligatorily whereas strident fricatives lenite to approximants only in fast and careless speech.

In summary, the following list shows the target asymmetries of lenition which can be derived, directly or indirectly, from the typological generalisations in (14).

- (16) Asymmetrical lenition patterns ($x > y$: x is a more likely target than y)
 - a. Flanking segments: more open $>$ less open, thus $V_V > C_V$ or V_C
 - b. Speech rate: fast speech form $>$ slow speech form

c. Stops > strident fricatives

d. Singleton stops > Geminate stops

In the remainder of this section, I will consider how to analyse each of these patterns while comparing perception-based and effort-based approaches.

4.1 Fast vs. Slow Speech Forms

In faster speech, adjacent segments overlap more significantly, and thus their perceptibility decreases, as shown in (17a). Based on this perceptibility difference, we may propose the ranking of Faithfulness constraints in (17b) where Faithfulness constraint for slow speech forms outranks that for fast speech forms. This ranking produces a correct prediction: fast speech forms are more likely to change, thus more likely to be targeted in lenition, than slow speech forms.

(17) Perception-based approach

a. Perceptibility scale: slow > fast

b. Constraint ranking: PRES(slow) >> PRES(fast)

c. Predicted pattern: fast speech forms are a more likely target than slow speech forms.

(Correct)

If we compare the two speech forms with respect to the effort cost required, fast speech forms are more effortful than slow speech forms, as shown in (18a), because in faster speech articulators must move faster to get to the articulatory target and thus extra effort is required, assuming the articulators achieve the same target they would achieve in slow careful speech. This effort cost difference leads to the ranking of Markedness constraints in (18b) where LAZY constraints prohibiting fast forms outrank that for slow speech forms.

(18) Effort-based approach

a. Effort cost scale: fast > slow

b. Constraint ranking: LAZY(fast) >> LAZY(slow)

c. Predicted pattern: fast speech forms are a more likely target than slow speech forms. (Correct)

From the ranking in (18b), it falls out that fast speech forms are more likely to be avoided, and thus more likely to be targeted in lenition, compared to slow speech forms. In conclusion, the two approaches, perception and effort-based, tie for the current asymmetry, both making correct predictions.

4.2 Singleton vs. Geminate

Let us consider the following target asymmetry: singleton stops are more likely to undergo

lenition such as spirantisation than geminate stops. As shown in (19a), geminate stops have higher perceptibility than singleton counterparts because the former has longer closure duration, thus longer manner cues, than the latter. This perceptibility difference leads to the universal ranking of Faithfulness constraints in (19b), from which it is predicted that a singleton stop is more likely to undergo lenition than its geminate counterpart, which is correct.

(19) Perception-based approach

- a. Perceptibility scale: geminate stop > singleton stop
- b. Constraint ranking: PRES(geminate) >> PRES(singleton)
- c. Predicted pattern: A singleton stop is a more likely target than a geminate.

(Correct)

In the simple effort cost comparison, geminates would be considered as more effortful than singleton counterparts, as shown in (20a): other things being equal, making a longer articulatory gesture for a geminate stop requires more effort than making a shorter gesture for the singleton counterpart. This effort cost difference would lead to the ranking of Markedness constraints in (20b) in which LAZY prohibiting a geminate stop must outrank that for a singleton stop. The resulting prediction is that a geminate stop is more likely to undergo lenition, which is incorrect, as stated in (20c).

(20) Effort-based approach

- a. Effort cost scale: geminate stop > singleton stop
- b. Constraint ranking: LAZY(geminate) >> LAZY(singleton) (simplified from Kirchner 2004: 325, (17))
- c. Predicted pattern: geminate stops are more likely targets than singleton stops.

(Incorrect)

However, in the effort-based approach, there are additional factors which must be considered. Spirantisation from a geminate stop to the corresponding geminate fricative does not meet the effort minimization requirement since, as Kirchner claims, long fricatives require more effort than short fricatives or long stops. Unlike a singleton fricative which can be characterised with brief constriction as shown in Figure 4a, geminate fricatives would be produced with a long steady-state constriction, as shown in Figure 4b.

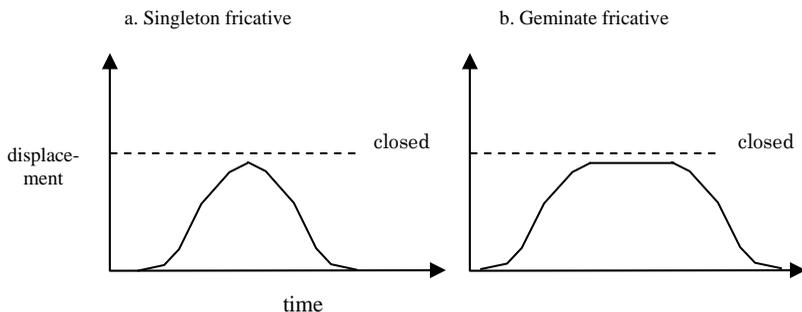


Figure 4. Schematic displacement vs. time graphs for singleton and geminate fricatives (based on Kirchner 1998: Figure 5-3)

According to Kirchner (2004: 326), such a long steady-state constriction requires “the additional antagonist muscle activation”, which is not needed for articulation of a stop and a non-strident fricative. Thus, the effort cost for a geminate fricative is greater than that for the corresponding long stop. Then the relevant effort cost scale would be the one in (21a). This scale leads to the ranking of LAZY constraints in (21b).

(21) Effort-based approach

- a. Effort cost scale: geminate fricative > geminate stop > singleton stop > singleton fricative
- b. Constraint ranking: LAZY(geminate fricative) >> LAZY(geminate stop) >> LAZY(singleton stop) >> LAZY(singleton fricative)

According to this ranking, even when a singleton stop is spirantised into the corresponding fricative, spirantisation is blocked for a geminate stop since the resulting fricative would incur a violation of the high-ranked LAZY(geminate fricative), as illustrated in the following tableau:

(22) a. Spirantisation of a singleton stop

	/p/	LAZY(gem fric)	LAZY(gem stop)	LAZY(sg stop)	PRES(cont)	LAZY(sg fric)
	p			*!		
☞	ɸ				*	*

b. Spirantisation of a geminate stop blocked

	/pp/	LAZY(gem fric)	LAZY(gem stop)	LAZY(sg stop)	PRES(cont)	LAZY(sg fric)
	pp		*			
☞	ɸɸ	*!			*	

As a result, the effort-based approach makes a correct prediction, i.e., that a singleton stop is

more likely to undergo lenition than a geminate stop. In conclusion, as with the target asymmetry between fast and slow speech forms, the two approaches, perception and effort-based, are in a tie for the asymmetry between geminate and singleton stops.

4.3 Stop vs. strident fricative

Strident fricatives have very prominent perception cues, whether place or manner, during the frication noise (Wright 2004), and thus strident fricatives have higher perceptibility, compared to stops, as stated in (23a). Based on this perceptibility difference, PRES(strident) is ranked above PRES(stop) as in (23b), which can correctly explain the asymmetrical fact that a stop is a more likely target than a strident fricative, as stated in (23c).

(23) Perception-based approach

- a. Perceptibility scale: strident > stop
- b. Constraint ranking: PRES(strident) >> PRES(stop)
- c. Predicted pattern: A stop is a more likely target than a strident. (Correct)

In contrast, as discussed by Kirchner (2004: 326), a strident fricative is made with “a sustained interval of precise, close, constriction” and thus its effort cost is greater than that required for a stop, as stated in (24a). According to this effort cost difference, LAZY constraint for a strident fricative should be ranked above that for a stop, as in (24b). An obvious prediction to make is that strident fricatives are more likely to undergo lenition than stops. This is counterfactual.

(24) Effort-based approach

- a. Effort cost scale: strident > stop
- b. Constraint ranking: LAZY(strident) >> LAZY(stop) (simplified from Kirchner 2004: 327, (20))
- c. Predicted pattern: Strident fricatives are a more likely target than stops. (Incorrect)

It seems that this asymmetry cannot be explained without positing the high-ranked Faithfulness constraint for strident fricatives, as shown in (23b). Thus, the dispreference for strident targets in lenition supports the perception-based approach.

To summarise, we have considered three target asymmetries of lenition, and each of them can be explained within the framework of the perception-based approach. Most importantly, the asymmetry between stops and strident fricatives allows the solution only within the perception-based, but not effort-based approach.

4.4 Flanking Segments

This section discusses the asymmetry between different flanking segments. Kirchner assumes that the effort cost required for the articulation of each sound is measured mainly according to the degree of displacement of articulators involved. For instance, an intervocalic position requires maximum displacement, as schematized in Figure 5a, thus maximum amount of effort cost. In contrast, a segment surrounded by consonants requires the least displacement, as in Figure 5b, thus least amount of effort cost.

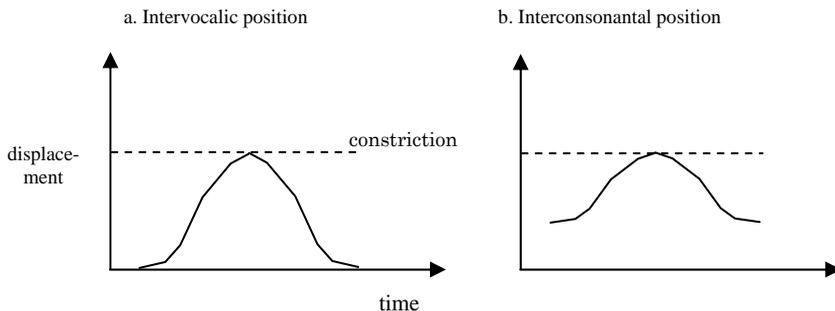


Figure 5. Displacement and openness of flanking segments (based on Kirchner 2004: 322 Figure 10.1)

This effort cost difference, summarized in (25a), leads to the ranking of LAZY constraints in (25b) in which LAZY constraint for an intervocalic stop outranks that for the one adjacent to a consonant. This ranking makes a correct prediction about attested lenition patterns, as stated in (25c).

(25) Effort-based approach

- a. Effort cost scale: $V_V > C_V > C_C$
- b. Constraint ranking: $LAZY(V_V) \gg LAZY(C_V) (\gg LAZY(C_C))$
(simplified from Kirchner 2004: 323, (14))
- c. Predicted pattern: A stop is more likely to undergo lenition in intervocalic position, compared to when it is adjacent to a consonant. (Correct)

However, the perception-based approach makes an opposite prediction. Crucial perception cues for identifying a consonant are often available during its adjacent vowels, and thus it is generally true that the greater the number of adjacent vowels the consonant has, the more perceptible it is. Then, the perceptibility scale should be the one in (26a) in which a stop is more perceptible in intervocalic position than when it is adjacent to a consonant. This scale may lead to the ranking of Faithfulness constraints in (26b) in which an

intervocalic stop must be preserved in preference to the one in other positions. From this ranking, it is predicted, as stated in (26c), that an intervocalic stop would be the least likely target in lenition. This is contradictory with a well-known and widely-accepted fact: an intervocalic position is a common target position of lenition.

(26) Perception-based approach

- a. Perceptibility scale: $V_V > C_V > C_C$
- b. Constraint ranking: $PRES(V_V) \gg PRES(C_V) \gg PRES(C_C)$
- c. Predicted pattern: An intervocalic stop is the least likely target in lenition.

(Incorrect)

Thus, the perception-based approach seems to be inadequate at least for the explanation of the asymmetry between flanking segments.

Before rejecting the perception-based approach for an analysis of the asymmetry between the flanking segments, let us consider whether the typological generalization about flanking segments in (14a) holds true for all lenition processes. Consonant deletion obviously involves gestural reduction and it is a case of maximal reduction. Thus, it should be considered as a special case of lenition. In fact, it is included in Kirchner’s (1998) list of lenition processes (as complete elision, see (6f) above), and it takes the end of the reduction continuum of variable lenition (for instance, see Kirchner 2004: 319, Table 10.1). Interestingly, typological generalizations of consonant deletion with respect to flanking segments, as discussed and analysed by Côté (2000), are not consistent with the corresponding generalisations of lenition. The two sets of generalisations are summarised below for easy comparison.

(27) Generalisations about flanking segments

	<u>Lenition</u> (e.g., spirantisation)	<u>Deletion</u>
V_V	most likely target	least likely target
V_C or C_V	intermediate	intermediate
C_C	least likely target	most likely target

The patterns are totally opposite. Deletion patterns are consistent with the prediction of perception-based approach shown in (26c). Thus, at least some lenition processes display the asymmetry between flanking segments, which can be explained within the perception-based, but not effort-based approach.

The perception-based approach still needs to answer the question of why real lenition processes, like spirantisation, are likely to occur in intervocalic position which is

perceptually very prominent. For now, I have only some speculative answers. From the assumption that lenition typically occurs in unstressed positions, it may be inferred that the perception cues for identifying a consonant in unstressed positions are quite weak even in intervocalic position. This low perceptibility would motivate lower-ranked Preservation constraints for intervocalic unstressed positions, which can explain the frequent intervocalic spirantisation.

An additional factor which might be involved is that partial reduction is probably more easily observed between vowels, compared to when it occurs between consonants. Most lenition processes like spirantisation involve partial reduction of an articulatory gesture whereas consonant deletion involves complete reduction. When a consonantal constriction reduces between vowels, the reduced gesture would maintain its acoustic effects throughout the constriction duration. But, when a consonant reduces adjacent to a consonant, much of the reduced gesture would be hidden under the overlap with the adjacent consonant. So, it would be difficult not only to notice the occurrence of partial reduction, but also to identify the segment type for the reduced gesture. Thus, my conjecture here is that a consonant probably lenites more often adjacent to a consonant, compared to when it does intervocalically, but it is less often noticed and reported. The verification of this speculation requires a careful investigation of phonetic details about the reported lenition contexts. I leave it to future research.

5. Conclusions

The present study is summarised as follows. First, I have pointed out that the conventional PBOT analyses of the target asymmetries of phonological processes are biased toward the use of perceptibility scales. Patterns of lenition have been somewhat exceptionally subject to the effort-based approach employing the effort cost scales.

Second, it is shown that a fundamentally identical phonetic process, i.e., gestural reduction, characterises lenition and place assimilation. Moreover, the basic occurrence patterns of the two processes have been subject to the same treatment within the framework of Phonetically-Based Optimality Theory. Nonetheless, to explain the target asymmetries of the two processes, previous PBOT works have focussed on different types of constraints, employing different types of scales: effort cost scales for lenition and perceptibility scales for place assimilation.

Third, I have provided a perception-based analysis for each of the target asymmetries of lenition while comparing them to the corresponding effort-based analyses. I have shown that at least the asymmetries between stops and strident fricatives can be analysed only

within the perception-based approach, requiring the use of perceptibility scales.

Finally, in the discussion of how to explain the target asymmetry between flanking segments, I have pointed out that the observed asymmetries of consonant deletion, a special case of lenition, are consistent only with the perception-based approach whereas those for other lenition processes like spirantisation are consistent only with the effort-based approach. Some speculative suggestions have been provided for the explanation of the latter asymmetries.

References

- Barry, Martin. 1985. A palatographic study of connected speech processes. *Cambridge Papers in Phonetic and Experimental Linguistics* 4: 1-16.
- Boersma, Paul. 1998. *Functional phonology: Formalizing the interactions between articulatory and perceptual drives* [LOT International Series 11]. Doctoral dissertation, University of Amsterdam. The Hague: Holland Academic Graphics.
- Browman, Catherine P., and Louis M. Goldstein. 1990. Tiers in Articulatory Phonology. In *Papers in laboratory phonology I: Between the grammar and physics of speech*, ed. John Kingston and Mary E. Beckman, 341-376. Cambridge: Cambridge University Press.
- Byrd, Dani. 1994. *Articulatory timing in English consonant sequences*. Doctoral dissertation, UCLA.
- Côté, Marie-Hélène. 2000. *Consonant cluster phonotactics: A perceptual approach*. Doctoral dissertation, MIT.
- Gurevich, Nomi. 2004. *Lenition and contrast: The functional consequences of certain phonetically conditioned sound changes*. Outstanding Dissertations in Linguistics. New York: Routledge.
- Hayes, Bruce. 1999. Phonetically-driven phonology: The role of Optimality Theory and inductive grounding. In *Functionalism and formalism in linguistics, volume I: general papers*, ed. Michael Darnell, Edith Moravcsik, Michael Noonan, Frederick Newmeyer, and Kathleen Wheatly, 243-85. Amsterdam: John Benjamins.
- Hayes, Bruce, Robert Kirchner and Donca Steriade. 2004. *Phonetically based phonology*. Cambridge: Cambridge University Press.
- Jun, Jongho. 1995. *Perceptual and articulatory factors in place assimilation: An optimality theoretic approach*. Doctoral dissertation, UCLA.
- Jun, Jongho. 1996. Place assimilation is not the result of gestural overlap: Evidence from Korean and English. *Phonology* 13: 377-407.
- Jun, Jongho. 2004. Place assimilation. In Bruce Hayes, Robert Kirchner and Donca Steriade eds. 58-86.
- Kirchner, Robert. 1998. *An effort-based approach to consonant lenition*. Doctoral dissertation, UCLA.
- Kirchner, Robert. 2004. Consonant lenition. In Bruce Hayes, Robert Kirchner and Donca Steriade eds.

313-345.

- Ladefoged, Peter. 2006. *A course in phonetics*. 5th edition. @: Thomson/Wadsworth.
- Nolan, Francis. 1992. The descriptive role of segments: Evidence from assimilation. In *Papers in laboratory phonology II: Gesture, Segment, Prosody*. ed. Gerard Docherty and D. Robert Ladd, 261-280. Cambridge: Cambridge University Press.
- Ohala, John J. 1990. The phonetics and phonology of aspects of assimilation. In *Papers in laboratory phonology I: Between the grammar and physics of speech*, ed. John Kingston and Mary E. Beckman, 258-275. Cambridge: Cambridge University Press.
- Steriade, Donca. 1993. Neutralisation and the expression of contrast. Paper presented at *NELS 24*.
- Steriade, Donca. 1995. Positional neutralization. Ms., UCLA.
- Steriade, Donca. 1997. Phonetics in phonology. Handout presented at SICOL 1997, Seoul, Korea.
- Steriade, Donca. 1999. Phonetics in phonology: The case of laryngeal neutralization. In *UCLA working papers in linguistics no. 2: Papers in phonology 3*, ed. Matthew K. Gordon, 25-146.
- Steriade, Donca. 2000. *The phonology of perceptibility effects: The P-map and its consequences for constraint organization*. Ms., UCLA.
- Steriade, Donca. 2001. Directional asymmetries in place assimilation: A perceptual account. In *The role of speech perception in phonology*, ed. Elizabeth Hume and Keith Johnson, 219-250. San Diego: Academic Press.
- Wright, Richard. 2004. A review of perceptual cues and cue robustness. In Bruce Hayes, Robert Kirchner and Donca Steriade eds. 34-57.
- Zhang, Jie. 2004. The role of contrast-specific and language-specific phonetics in contour tone distribution. In Bruce Hayes, Robert Kirchner and Donca Steriade eds. 157-190.