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Phonetic Nature in English Phonology1)

Jae-Young Lee

1. Introduction

The goal of this paper is to present a principled account of consonant alternations in English nasal clusters, as exemplified in such alternations as [ŋø] ~ [ŋg] (*singer* ~ *longer*), [mø] ~ [mb] (*bomber* ~ *bombard*), [mø] ~ [mn] (*condemning* ~ *condemnation*), and [øn] ~ [gn] (*designer* ~ *designation*).[2] I argue that all such alternations are explained in a unified way within the framework of Optimality Theory (Prince and Smolensky 1993, McCarthy and Prince 1995) by appealing to phonetically motivated principles. This paper focuses on exploring the motivating forces of such alternations.

The questions that a unified, principled account of English NC phonology must answer are (i) why deletion takes place; (ii) why oral stops are deleted instead of nasal stops; and (iii) why the coronal /n/ is deleted instead of the labial /m/ in *mn* cluster. I argue that the answers to these questions can be found in two functional principles which are at the heart of all phonological phenomena: Perceptibility and Ease of Articulation (Cole and Kisseberth 1994). These two principles require that speech be perceptible, and that speech production impose a minimal articulatory burden, requirements which in most situations are in direct conflict.

Previous analyses of English NC phonology in Halle and Mohanan (1985) and Borowsky (1986) treat these phenomena through three unrelated rules of consonant deletion: *g/b* deletion, *n*-deletion, and prenasal *g*-deletion. Since the structural conditions of the three rules vary considerably, there is no natural means of collapsing them.

I assume that the prosodic word (PrWd) is a phonological constituent and a domain in which phonological phenomena take place. I demonstrate the difference in the PrWd structures between class 1 and class 2 suffixed forms.[3] Class 1

1) This article is excerpted from the author's doctoral dissertation (1996).

2) I will use the term NC cluster for the consonant-nasal cluster *gn* as well as for the nasal-consonant cluster.

3) It has generally been claimed that English has two classes of suffixes (e.g., Chomsky and Halle (1968, SPE hereafter, Halle and Mohanan (1985), Borowsky (1986), Fabb (1988), Inkelas (1989) and Goldsmith (1990)). The two suffix classes have been variably termed in the literature. I use the terms class 1 and class 2 suffix. Class 1 suffix class includes *-an*, *-ance*, *-al* (adjectival), *-ation*,

suffixed forms (e.g. *longer, bombard, condemnation,* and *designation*) constitute a single PrWd, while class 2 suffixed forms (e.g. *singer, bomber, condemner,* and *designer*) involve recursive PrWds, where a stem constitutes an inner PrWd. The difference in the PrWd structures plays a crucial role in accounting for the difference in the phonological alternations between class 1 and class 2 suffixed forms.

In section 2, I will first lay out the phonological alternations in English NC clusters. Section 3 is devoted to a brief discussion of previous analyses of the alternations. I then present some arguments for the proposed PrWd structures for class 1 and class 2 suffixed forms in section 4. I propose an analysis within the "principled" OT framework in section 5. The principled OT approach refers to the approach that provides an explicit role for functional principles in phonological analysis. Section 6 contains a summary and conclusion of this paper.

2 Consonant alternations in NC clusters

There are four kinds of alternations regarding NC clusters. First, let us consider the alternation [ŋø] ~ [ŋg].

The voiced velar stop *g* in *ŋg* cluster is not pronounced in word final position of monomorphemic words, while it is pronounced in word medial position of the derived words consisting of a stem and a class 1 suffix, as illustrated in (1).

(1) a. Monomorphemic word: long, strong, young
  b. Stem-Class 1: longer, stronger, younger

Put in terms of syllable structure, the *g* in *ŋg* is not permitted in the coda position of monomorphemic words, while it is licensed as an onset of the vowel initial suffix in class 1 suffixed forms.

Class 2 suffixed forms behave differently from class 1 suffixed forms with respect to the [ŋø] ~ [ŋg] alternation. Although the final *g* could form an onset of the vowel initial suffix, it does not, as seen in (2b): the *g* is deleted.

(2) a. Monomorphemic word: sing, bang
  b. Stem-Class 2: singer, banger

-itive, -ify, -ic, -ity, and so forth. Class 2 suffix class contains *-age, -al* (nominal), *-ed, -ful, -ing* (verb-), *-ist, -ize, -ment, -ness,* and so on.

The only difference between the derived words showing *g* deletion in (2b) and the derived words without *g* deletion in (1b) lies in word structures. The former consists of a stem and a class 1 suffix but the latter a stem and a class 2 suffix.

Second, as for [mø] ~ [mb], the data in (3a) show that the voiced bilabial stop *b* in *mb* cluster is deleted in the coda position of monomorphemic words in the same way as the voiced velar *g* in the *ŋg* cluster in (1a, 2a). The *b* in *mb*, however, is not deleted in class 1 suffixed forms since it is licensed as an onset for the vowel initial suffix, like the *g* in *ŋg* in (1b), as seen in (3b).

(3) a. Monomorphemic word: bomb, crumb
b. Stem-Class 1: bombard; bombastic, crumble

On the other hand, although the syllable structures of the words in (4) below seem to be the same as those of the words in (3b), the *b* in *mb* is not pronounced in the words in (4), whose morphological structures consist of a stem and a class 2 suffix.

(4) Stem-Class 2: bomber, bombing, crumby

The third type of consonant alternation in NC cluster is the [mø] ~ [mn] alternation. The *n* in *mn* is deleted in monomorphemic words, while it is not deleted in the derived words consisting of a stem and a class 1 suffix, as seen in (5a) and (5b), respectively. The *n* in *mn* appears in coda position in (5a), while it occurs as an onset in (5b).

(5) a. Monomorphemic word: condemn, damn, solemn
b. Stem-Class 1: condemnation, damnation, solemnity

In the class 2 suffixed words in (6), the *n* in *mn* might be syllabified as an onset of the vowel initial suffix like that in (5b) because the apparent structure of the words in (6) is similar to that of the words in (5b) in that stems are followed by vowel initial suffixes.

(6) Stem-Class 2: condemner, damning, limning

Thus, it might be predicted that the *n* is also pronounced in the class 2 suffixed forms in (6). However, the fact is that the *n* in (6) is not pronounced, like the *n* in (5a), where it is in coda position.

Fourth, the [øn] ~ [gn] alternation is exemplified in (7). The *g* in *gn* is deleted if the cluster appears in coda position, while the obstruent g is not deleted if it is syllabified as a coda followed by *n* in the onset of the following syllable. The words in (7a) are monomorphemic, whereas those in (7b) are polymorphemic, consisting of a stem and a class 1 suffix.

(7) a. Monomorphemic word: sign, resign, design
b. Stem-Class 1: signature, resignation, designation

The class 2 suffixed forms in (8) show that the *g* in *gn* is preceded by a vowel and the *n* is followed by a vowel. The *g* might be in the coda of the preceding syllable and the *n* may be associated to the onset of the following syllable because the environment for syllabification of the words seems to be the same as that in (7b).

(8) Stem-Class 2: signer, designer

Thus, it is predicted that the *g* in (8) should be pronounced like that in (7b). This prediction, however, does not hold of the class 2 suffixed forms: the *g* is not pronounced in (8).

In this section, I have addressed the phonological alternations in English NC clusters. And I have demonstrated the parallelism of class 2 suffixed forms to unsuffixed forms on the one hand, and the difference of class 2 suffixed forms from class 1 suffixed forms on the other.

In the next section, I will discuss some previous derivational analyses of the phonological alternations.

3. Previous analyses

Halle and Mohanan (1985) introduce three different rules for the [ŋg] ~ [ŋø], [mb] ~ [mø], [mn] ~ [mø], and [gn] ~ [øn] alternations, as shown in (9) below. The [ŋg] ~ [ŋø] and [mb] ~ [mø] alternations are accounted for by a single rule in (9a) stating that a non-coronal, voiced obstruent is deleted at stratum 2 when flanked by a nasal and a morphological bracket. Morphemes are enclosed by brackets. The [mn] ~ [mø] alternation is explained by *n*-Deletion in (9b) saying that a coronal nasal *n* is deleted at stratum 2 when flanked by a nasal and a morphological bracket. Prenasal *g*-Deletion in (9c) shows that the *g* is deleted at stratum 2 when followed by a nasal *n* which is in turn followed by a bracket, resulting in the compensatory lengthening of a preceding vowel.

(9) a. Non-coronal Deletion (Halle and Mohanan 1985: 96)

$$\begin{bmatrix} -\text{son} \\ +\text{voice} \\ -\text{cor} \end{bmatrix} \text{--->} \; ø \; / \; [+\text{nasal}] \_\_ \;] \quad (\text{domain: stratum 2})$$

b. n-Deletion (Halle and Mohanan 1985: 96)

n ---> ø / [+nasal]___] (domain: stratum 2)

c. Prenasal g-Deletion (Halle and Mohanan 1985: 96)

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V     g             V   g / ___ n ] (domain: stratum 2)
|     |            / \          |
X     X   --->    X   X         X
 \   /             \ /
   R                R
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Thus, in the monomorphemic words in (10), the *g* and *b* in *sing* and *bomb*, the *n* in *condemn*, and the *g* in *sign* are deleted at stratum 2 because they satisfy the SDs of the rules in (9a, b, c), respectively. The morphological brackets given to the monomorphemic words at stratum 1 remain intact at stratum 2.

(10) a. [sing], [bomb] (stratum 2)
b. [condemn] (stratum 2)
c. [sign] (stratum 2)

Class 2 suffixed forms like those in (11) below also undergo consonant deletion at stratum 2. The *g* and *b* in *singer* and *bomber*, the *n* in *condemner*, and the *g* in *signer* are deleted at stratum 2 because they satisfy the SDs of the rules in (9): *g*, *b*, and *n* are flanked by a nasal and a morphological bracket in (11a, b), respectively; *g*, in (11c), is followed by a nasal *n* preceding a morphological bracket. The class 2 suffix *-er* (nominalizing) is attached to a stem at stratum 2.

(11) a. [[sing] [er]] [[bomb] [er]] (stratum 2)
b. [[condemn] [er]] (stratum 2)
c. [[sign] [er]] (stratum 2)

Class 1 suffixed forms, on the other hand, do not undergo consonant deletion because they do not satisfy the environments for the rules in (9). For example, the class 1 suffixed forms like *longer*, *bombard*, *condemnation*, and *signature* have the structures [longer], [bombard], [condemnation], and [signature], respectively, at stratum 2, as seen in (12). The *-er* (comparative), *-ard*, *-ation*, and *-ature* suffixes are all class 1 suffixes, which means that they are attached at stratum 1. The inner brackets introduced at stratum 1 are deleted at stratum 2 by Bracket Erasure Convention (BEC), which states that "the brackets between the morphemes are deleted after the application of all rules at a given stratum" (Halle and Mohanan 1985: 61).

(12) a. [[long][er]] (stratum 1) ---> [longer] (stratum 2)
b. [[bomb][ard]](stratum 1) ---> [bombard] (stratum 2)
c. [[condemn][ation]] (stratum 1) ---> [condemnation](stratum 2)
d. [[sign] [ature]] (stratum 1) ---> [signature] (stratum 2)

Halle and Mohanan, as shown above, deal with consonant deletion in NC clusters as three different phenomena, by introducing three distinct rules. The rules are sensitive to segmental and morphological environments. And, in their analysis, monomorphemic words have the same structures at stratum 1 and 2. However, they have to wait for the rules at stratum 2 in order not to violate the Strict Cyclicity Condition (SCC). The SCC requires that "rules applying in a cyclic stratum cannot change structure in environments not derived in their cycle" (Halle and Mohanan 1995: 97). A derived environment is "the environment created by the concatenation of two morphemes, or by the application of an earlier rule in the same cycle" (Halle and Mohanan 1985: 94). According to Halle and Mohanan, stratum 1 is cyclic, while stratum 2 is non-cyclic. Thus, consonant deletion rules cannot apply to monomorphemic words - non-derived structures at stratum 1. However, stratum 2, which is non-cyclic, is not subject to the SCC and thus the rules apply at stratum 2.

Borowsky (1986) also presents three independent rules for the consonant alternations in English NC clusters, as seen in (13).

(13) a. Voiced Obstruent deletion (Borowsky 1886: 234)

$$\begin{bmatrix} -\text{son} \\ +\text{voice} \end{bmatrix} \text{ ---> } \emptyset \ / \ [+\text{nasal}] \underline{\quad} \sigma]$$

b. n deletion (Borowsky 1986: 233)
n ---> ø / m ___]

c. g deletion (Borowsky, 1986: 234)
g ---> ø / ____ [+nasal]]

The ŋg ~ ŋø and mb ~ mø alternations are explained by a single rule in (13a) stating that a voiced obstruent is deleted in syllable final position when preceded by a nasal. The *n* deletion rule in (13b) indicates that a coronal nasal *n* is deleted after *m* in a 'word' cycle enclosed by brackets. The *g* deletion rule in (13c) states that the *g* is deleted before a nasal *n* followed by a morphological bracket assigned to a word, resulting in the compensatory lengthening of a preceding vowel.

There are two major differences between the rules introduced by Borowsky and the rules by Halle and Mohanan, in that (i) Borowsky does not specify the level (stratum) in which the rules apply and (ii) she imposes the syllable condition on deletion, as seen in (13a) above. Borowsky invokes the notion of extrametricality, which excludes a morpheme final consonant on the first cycle of level 1, and makes use of the SCC, which blocks the application of structure-changing rules in non-derived environments. The syllable condition on deletion is illustrated by the words in (14). The *ŋg* and *mb* in the left-hand column in (14a,b) are in the syllable coda position, resulting in *g* and *b* deletion, while they are split by a syllable boundary in the right-hand column, thus immune to the deletion. The data in (14) are taken from Borowsky (1986: 240).

(14) a. angma anger
angstrom England
b. lambkin crumble

According to Borowsky's account, monomorphemic words undergo consonant deletion at level 2 because they meet the SDs of the rules in (13), as illustrated in (15) below. The target consonants are not deleted at level 1 because they are extrametrical at that level, and the SCC blocks the application of consonant deletion rules. The extrametrical segment is enclosed in parentheses. Extrametricality does not work at level 2. Although Borowsky invokes both extrametricality and the SCC to prevent the deletion rules from operating at level 1, the SCC alone is sufficient to block the application of the deletion rules at level 1 because the rules are structure-changing. On the other hand, the target consonants are deleted at level 2 since they satisfy the environments of the concerned rules. A word cycle is assigned at level 2, which gives the structure [[ ]]$_w$; for example, [[long]]$_w$ and [[bomb]]$_w$. This structure leads to a derived environment. Thus, the SCC cannot block the application of the deletion rules at this cyclic level. Borowsky claims that level 2 is cyclic as well as level 1, as opposed to the claim by Halle and Mohanan that stratum (level) 2 is non-cyclic.

(15) a. **g/b deletion**

Level 1				
	Cycle 1		loN(g)	bom(b)
		g/b deletion	blocked by SCC or extrametricality	
Level 2				
	Cycle 1		[[loŋg]]	[[bomb]]
		g/b deletion	g --> ø	b --> ø

b. **n deletion**

Level 1			
	Cycle 1		condem(n)
		n-deletion	blocked by SCC or extrametricality
Level 2			
	Cycle 1		[[condemn]]
		n- deletion	n --> ø

c. **Prenasal g deletion**

Level 1			
	Cycle 1		sig(n)
		g-deletion	blocked by SCC or extrametricality
Level 2			
	Cycle 1		[[sign]]
		g- deletion	g --> ø

Likewise, class 2 suffixed forms like *singer*, *bomber*, *condemner*, and *signer* also undergo consonant deletion at level 2, as shown in (16) below. The class 2 suffix *-er* is attached after a word cycle is assigned in the first cycle of level 2, where the target consonants meet the SDs of rules in (13) above.

(16) a. **g/b deletion**

Level 1				
	Cycle 1		siN(g)	bom(b)
		g/b deletion	blocked by SCC or extrametricality	

Level 2

Cycle 1		[[siŋg]]	[[bomb]]
	g/b deletion	g --> ø	b --> ø
Cycle 2		[[[siŋø]] er]	[[[bomø]] er]

b. **n deletion**

Level 1

Cycle 1		condemn(n)
	n- deletion	blocked by SCC or extrametricality

Level 2

Cycle 1		[[condemn]]
	n- deletion	n --> ø
Cycle 2		[[[condemø]] er]

c. **Prenasal g deletion**

Level 1

Cycle 1		sig(n)
	g- deletion	blocked by SCC or extrametricality

Level 2

Cycle 1		[[sign]]
	g- deletion	g --> ø
Cycle 2		[[siøn] er]

On the other hand, class 1 suffixed forms like *longer*, *bombard*, *condemnation*, and *signature* do not undergo consonant deletion since they do not satisfy the environments for the deletion rules, as seen in (17), where the period indicates a syllable boundary. The *g*, *b*, and *n* in *longer*, *bombard*, and *condemnation* are no more extrametrical in the cycle 2 of level 1 and are thus syllabified as the onset of the vowel initial suffix. The *g* in *signature* is licensed as a coda of the preceding syllable and the *n* is syllabified as an onset of the following syllable when the suffix *-ature* is attached in the second cycle of level 1.

(17) a. **g/b deletion**

Level 1

Cycle 1		lon(g)	bom(b)
	g/b deletion	blocked by SCC or extrametricality	
Cycle 2		lon.ger	bom.bard
	g/b deletion	d.n.a.	d.n.a.

Level 2

Cycle 1		[[long]]	[[bomb]]

	g/b deletion	g --> ø	b --> ø
	Cycle 2	[[lon.ger]]	[[bom.bard]]
	g/b deletion	d.n.a.	d.n.a.

b. **n deletion**

Level 1			
	Cycle 1	condem(n)	
	n- deletion	blocked by SCC or extrametricality	
	Cycle 2	condem.na.tion	
	n-deletion	d.n.a.	
Level 2			
	Cycle 1		[[condemn]]
	n-deletion		n --> ø
	Cycle 2	[[con.dem.na.tion]]	
	n-deletion	d.n.a.	

c. **Prenasal g deletion**

Level 1			
	Cycle 1	sig(n)	
	g- deletion	blocked by SCC or extrametricality	
	Cycle 2	sig.na.ture	
	g- deletion	d.n.a.	
Level 2			
	Cycle 1		[[sign]]
	g- deletion		g --> ø
	Cycle 2	[[sig.na.ture]]	
	g-deletion	d.n.a.	

The key characteristics of Borowsky's analysis are the use of extrametricality, the SCC, and the automatic application of a word cycle at level 2 prior to suffixation. Borowsky introduces extrametricality only at level 1 to block the application of consonant deletion rules. Thus, although she does not assign a domain for the application of consonant deletion rules, her analysis has the result that the rules apply only at level 2. Next, the word cycle given automatically at level 2 is an architecture to make a level 2 structure lead to a derived environment, so that the deletion rules may apply in conformity with the SCC.

P. Lee (1992: 72-75) also presents an account of *g/b* deletion in the framework of Lexical Phonology, invoking ambisyllabicity and the SCC. He does not invoke extrametricality. According to him, *g/b* deletion occurs at level 1 where *g* and *b* are deleted in the coda position if they are not ambisyllabic. However, ambisyllabic *g* and *b* are not deleted at that level. The *g/b* deletion rule is formalized as in (18). P. Lee does not deal with the [mn] ~ [mø] and [gn] ~ [øn] alternations.

(18) g/b-deletion (Lee, P. 1992 : 75)[4]

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⎡-cor  ⎤
⎢+voice⎥   ---> ø /        σ   x
⎣-cont ⎦                   / \  /
                          C   C
                          |   |
                      [+nas] ___
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According to P. Lee's account, the *g* and *b* in monomorphemic words like *sing* and *bomb* are deleted at level 1 because they satisfy the SD of the rule, as seen in (19). The *g* and *b* are in the coda position preceded by a nasal. Nasal Assimilation, which assimilates a placeless nasal to the place of articulation of the following obstruent at level 1, creates a derived environment. Thus, the deletion rule applies at level 1. In the same way, the *g* and *b* in class 2 suffixed words like *singer* and *bomber* are deleted at level 1, because the suffix *-er* is attached to the stems at level 2, and thus the *g* and *b* are in the coda position preceded by a nasal at level 1.

(19) Level 1		siNg	boNb
	Nasal Assimilation	ŋ[5]	m
	g/b deletion	g --> ø	b --> ø
Level 2			
	Suffixation	siŋøer	bomøer

On the other hand, class 1 suffixed forms like *longer* and *bombard* do not show *g/b* deletion because the *g* and *b* in the forms are ambisyllabic and thus do not satisfy the environments for the deletion rule.

A problem with P. Lee's account concerns the interpretation of Nasal Assimilation with respect to the SCC. It has been claimed in the literature (e.g., Kiparsky 1982) that assimilation, which is considered to be the spreading of a

4) The mark "x" indicates that the target consonant is not associated with the onset of the following syllable.

5) The angma, derived by Nasal Assimilation at level 1, is not a phoneme. This violates Structure Preservation, which states that a segment, which is not part of the underlying segment inventory, cannot appear at level 1. According to Kiparsky (1982) and Borowsky (1986), Structure Preservation should not be violated at level 1.

feature to a segment unspecified for that feature, is a structure building rule. A structure building rule does not result in a derived environment because it does not bring about structural change. Thus, the structure changing rule, *g/b* deletion in this case, cannot apply to the output of Nasal Assimilation, a non-derived environment, because of the SCC. However, *g/b* deletion applies to the output of Nasal Assimilation in P. Lee's analysis. To overcome this contradiction, P. Lee distinguishes structure building rules like stress placement and syllabification from structure filling rules like Nasal Assimilation. According to him, structure filling rules result in a derived environment but structure building rules do not. Since Nasal Assimilation is structure filling, it creates a derived environment for the later application of deletion. The distinction between structure building rules and structure filling rules is crucial for P. Lee's analysis, yet he gives no explicit arguments for the distinction or for why only structure filling rules create a derived environment.

The derivational analyses discussed above have some drawbacks. First, they treat the very similar phonological alternations in NC clusters as unrelated, separate processes. That is because the rule-based analyses have difficulty finding a single rule collapsing three different SDs and SCs into a single SD and SC. Second, the analyses do not explain the motivation for deletion in NC clusters or the reason why a specific consonant is deleted; for example, *g* is deleted in *gn*, not *n*.

4. Prosodic word structure and NC simplification

It has been argued that prosodic constituency stands independent of morphological constituency (Inkelas 1989, McCarthy and Prince 1993a, b). The argument comes from the observation that prosodic constituents do not necessarily correspond to morphological constituents in phonological processes. The main function of prosodic constituents is to play a role in defining a domain for phonological processes. Although there is no agreement on the detailed structure of the prosodic hierarchy, it is agreed that the prosodic word is recognized as a prosodic constituent. I will analyze the prosodic structures of derived words in English in terms of the prosodic word.

I argue that the morphological structure [Stem-Class 1 suffix] consists of a single prosodic word, while the morphological structure [Stem-Class 2 suffix] involves recursive prosodic words, as schematized in (20a) and (20b), respectively. I assume, following Inkelas (1989), that prosodic constituents can be recursive. My proposal, however, differs from Inkelas's (1989). Inkelas argues that class 1 suffixed forms consist of the recursive prosodic constituent α(alpha), while class 2 suffixed forms consist of the recursive prosodic constituent β, as exemplified in (21).

(20) a. Stem-Class 1 suffix: [Stem-Class 1 suffix]$_{PrWd}$
b. Stem-Class 2 suffix: [[Stem]$_{PrWd}$ -Class 2 suffix]$_{PrWd}$

(21) a. [[Stem]pα Class 1 suffix]pα e.g. [[conform]pα ity]pα
b. [[Stem]pβ Class 2 suffix]pβ e.g. [[happy]pβ ness]pβ

A monomorphemic word, of course, qualifies as a prosodic word, and a compound, which can be regarded as consisting of independent stems, is made up of independent prosodic words, as seen in (22a) and (22b), respectively.

(22) a. [long]$_{PrWd}$; [sing]$_{PrWd}$; [bomb]$_{PrWd}$; [damn]$_{PrWd}$; [sign]$_{PrWd}$
b. [[sign]$_{PrWd}$ [book]$_{PrWd}$]$_{PrW}$; [[bomb]$_{PrWd}$ [destroy]$_{PrWd}$]$_{PrWd}$

The morphological structures of [Stem-Class 1 suffix] and [Stem-Class 2 suffix] seem to be identical in that the stem is followed by the suffix. However, it is well-known that the two morphological structures play different roles in the phonological processes in English. The whole structure of [Stem-Class 1 suffix] functions as a single prosodic word, while the stem in the structure of [Stem-Class 2 suffix] works as an independent prosodic word.

First, let us consider Word-final i Lengthening in American English. Final vowel /i/ lengthens in word final position of monomorphemic words and compounds, as seen in (23a) and (23b).

(23) a. happy, fancy, beauty, dandy, ugly, mummy
b. beauty treatment, fancy-man

According to Halle and Mohanan (1985) and Borowsky (1986), stem-final /i/ lengthens before class 2 suffixes, whereas it does not lengthen before class 1 suffixes, as seen in (24a) and (24b), respectively.

(24) a. happiness, merriment
b. beautify, dandify, uglify, mummify, countrify

The stem in the structure of [Stem-Class 2 suffix] in (24a) behaves the same as the monomorphemic words in (23a) and the independent stem of the compounds in (23b), in terms of Word-final i Lengthening. This observation leads us to claim that the stem in the structure of [Stem-Class 2 suffix] works as an independent prosodic word, as seen in (20b) above. On the other hand, the stem in the structure of [Stem-Class 1 suffix] does not undergo Word-final i Lengthening. According to Borowsky (1986: 250), a short vowel occurs only word-medially and all vowels except schwa [ə] are long in word final position. Thus, we can say that the morphological structure of [Stem-Class 1 suffix] constitutes a single prosodic word: $[\text{Stem-Class 1 suffix}]_{PrWd}$.

Second, the English syllable template proposed by Clements and Keyser (1983) and Borowsky (1989) indicates that rimes of more than two timing slots are possible only at word-edges and inside compounds, as seen in (25a) and (25b), respectively. The rimes under consideration are underlined.

(25) a. serene(VVC), saint(VVCC), child(VVCC), ghost(VVCC), field(VVCC)
b. handsman(VCCC), coltsfoot(VVCCC), helmsman(VCCC)

The claim that the stem in the structure of [Stem-Class 2 suffix] is a prosodic word entails the claim that rimes of more than two slots can occur before class 2 suffixes because they appear at word final position. This prediction is verified by English words consisting of a stem and a class 2 suffix, as in (26).

(26) childhood, worldly, saintly, cowardly, eventful

On the other hand, rimes of more than two timing slots in the stem of the structure [Stem-Class 1 suffix] are subject to vowel laxing and resyllabification, as seen in (27a), where the underlined vowels are lax and the period indicates the syllable boundary. This fact follows from the claim that the stem in class 1 suffixed forms is not an independent prosodic word, as opposed to the stem in class 2 suffixed forms.

(27) sere. nity (serene), abun. dance (abound), profun. dity (profound)

Velar Softening also gives supporting evidence to the proposal that the whole morphological structure with a stem and a class 1 suffix functions as a single prosodic word, while the stem of the structure [Stem-Class 2 suffix] works as an independent prosodic word. According to SPE (219-220), underlying /k/ changes into [s] before a non-low, non-back vowel word-internally, as illustrated in (28).

Chomsky and Halle postulate that the final vowel in words like *reduce* and *induce* is underlyingly front and mid.

(28) a. /k/ ---> [s] / ___ V [-low, -back]
b. reduce (reduction), induce (induction)

If Velar Softening applies only within a prosodic word, then under my analysis, stem final /k/ in class 1 suffixed forms should undergo Velar Softening, while stem final /k/ in class 2 suffixed forms should not undergo the rule because it is in the final position of a prosodic word. This pattern is seen in (29a) and (29b), respectively.

(29) a. logician (logic), musician (music), opacity (opaque)
b. panicky (panic), garlicky (garlic), physicky (physic)

Next, let us consider Trisyllabic Laxing in English. According to Kiparsky (1982) and Goldsmith (1990), Trisyllabic Laxing can explain, with some exceptions, a generalization about monomorphemic words: the antepenultimate syllable is lax in most monomorphemic words, as seen in (30).

(30) Canada, alibi, sycamore, camera, pelican, enemy, Amazon, Pamela

Trisyllabic Laxing also applies to class 1 suffixed forms, as seen in (31), which leads us to claim that the whole structure of [Stem-Class 1 suffix] functions as a single prosodic word.

(31) divinity (divine), ominous (omen), declarative (declare)

As far as Trisyllabic Laxing is concerned, I find no examples of the structure of [Stem-Class 2 suffix] meeting the environment for Trisyllabic Laxing. This is because there are no vowel initial disyllabic class 2 suffixes. If there are class 2 suffixed forms like *divin*-VCV containing a stem and a hypothetical suffix -VCV, my proposal predicts that Trisyllabic Laxing will not apply to the hypothetical words because the stem constitutes a single prosodic word.

A small portion of the English stress system also supports the claim that the structure of [Stem-Class 1 suffix] works as a single prosodic word, while the stem in the structure of [Stem-Class 2suffix] functions as an independent prosodic word. In English, the primary stress is on the antepenultimate syllable in monomorphemic nouns when the nouns contain a light penultimate syllable, as in (32).

(32) América, pátina, cínema, Menómini, cánnibal

This pattern of main stress holds of class 1 suffixed forms as well, as seen in (33).

(33) curiósity (cúrious) medícinal (médicine), theátrical (théater)

This pattern, on the other hand, does not apply to the class 2 suffixed forms, as in (34), where the antepenult of the stem has a main stress, but the antepenult of the whole word does not receive a main stress.

(34) cúriously (cúrious) , cánnibalism (cánnibal)

The asymmetry for main stress between class 1 suffixed and class 2 suffixed forms follows from the claim that the structure of [Stem-Class 1 suffix] defines a prosodic word, while the stem in the structure of [Stem-Class 2 suffix] functions as an independent prosodic word. Goldsmith (1990) suggests that stress modification in class 1 suffixed forms signifies the prosodic structures proposed here. He says that stress modifications in class 1 suffixed forms make the derived word look more like a monomorphemic word.

Further supporting evidence for my proposal comes from the prohibition on vowel concatenation word-internally. According to Goldsmith (1990: 260), the sequence of a nonhigh vowel followed by a vowel is not found word-internally in English; for instance, the sequence of a.i (V[-high].V) is disallowed. This kind of prohibition holds of the morphological structure of [Stem-Class 1 suffix], as in (35).

(35) tantra-ic ---> tantrøic

On the other hand, the prohibition of word-internal vowel sequences does not hold of the structure of [Stem-Class 2 suffix] , as seen in (36), which can be accounted for by limiting the restriction to vowel sequences contained within the same prosodic word. The data in (36) are from Goldsmith (1990: 260).

(36) Indiana-ism ---> Indianaism (indicating a philosophy)
Bermuda-ize ---> Bermudaize

To sum up, I have argued that the whole structure of [Stem-Class 1suffix] is a single prosodic word, while the morphological structure of [Stem-Class 2suffix] involves recursive prosodic words, by showing that those two morphological structures function differently for various kinds of English phonological phenomena.

5. The proposed analysis of NC simplification

5.1 Basic Constraints for NC simplification

The generalization discussed above is that the NC clusters are not permitted in final position in a PrWd, while they are admitted in medial position in a PrWd. This generalization is based on the four types of phonological alternations in (37).

(37) [mø] ~ [mb]; [ŋø] ~ [ŋg]; [mø] ~ [mn]; [øn] ~ [gn]

The observation that NC clusters cannot be permitted in the coda position of a PrWd can be accounted for by a universal constraint termed No Complex Coda (38).

(38) No Complex Coda
No more than one consonant may associate to the coda.

The application of the constraint No Complex Coda to NC clusters is illustrated by tableau (39), which includes a partial set of possible candidates. The symbol "☞" marks the optimal candidate and "*" stands for a constraint violation. This tableau shows that a candidate with an unparsed consonant in an NC cluster is the winner. This optimal candidate satisfies No Complex Coda. I will discuss in section 5.2 the issue of which consonant is unparsed in NC clusters.

(39)

Candidates	No Complex Coda
☞ a. [bom<b>]$_{PrWd}$	
b. [bomb]$_{PrWd}$	*

On the other hand, the fact that the optimal candidate in (39) have an unparsed consonant in the NC clusters indicates that the optimal candidate violates the faithfulness condition, which requires that underlying information be preserved. In this case, constraint (40), which prohibits underlying consonants from being unparsed, is violated.[6]

(40) Max(C) An underlying consonantal position should be preserved.

However, candidate (39b) satisfies the Max(C) constraint. We can thus say that No Complex Coda dominates Max(C) in a ranking hierarchy, as seen in (41) below. The symbol "!" indicates a critical constraint violation. The solid line between constraint columns signifies the ranking between constraints. The dotted line between constraint columns is used in this paper when two constraints are not motivated for ranking. The shaded cells mean that they do not play a role in the decision. If Max(C) were ranked higher than No Complex Coda, then it would be incorrectly predicted that candidate (41b) is optimal.

(41)

Candidates	No Complex Coda	Max(C)
☞ a. [bom<b>]$_{PrWd}$		
b. [bomb]$_{PrWd}$	*!	

In medial position in a PrWd, NC clusters surface intact because the second part of the NC cluster is syllabified as the onset of the next syllable, and thus the coda is not complex, as in (42), where the parenthesis is used for identifying the edge of a syllable. As argued above, class 1 suffixed forms define a single PrWd. Thus, syllabification in (42) takes place in the domain of a single PrWd.

(42) [(bom)(bard)]$_{PrWd}$, [(lon)(ger)]$_{PrWd}$, [(dam)(na)(tion)]$_{PrWd}$, [(sig)(na)(ture)]$_{PrWd}$

However, there is no a priori reason to say that each syllabification in (42) is an absolutely unique option. In Optimality Theory (OT), the optimal output is just a candidate whose structure best satisfies relevant constraints among potential candidates; thus, each structure in (42) is just an optimal output evaluated by well-formedness constraints among a set of potential candidates. Let us consider the potential candidates, including the anticipated outputs in (42). I will deal with the word *bombard*, among the data in (42), since the treatment of *bombard* can extend to other cases. The function Gen can provide the word *bombard* with the following partial set of candidates in (43). Among the candidates in (43), candidate

6) I use the angled bracket "<>" to represent deletion in this paper, for the convenience of presentation, even though I adopt faithfulness constraints advanced in Correspondence Theory (McCarthy and Prince 1995).

(43a) is chosen as optimal by the two constraints discussed above, No Complex Coda and Max(C):

(43)

Candidates	No Complex Coda	Max(C)
☞ a. [(bom)(bard)]$_{PrWd}$		
b. [(bo<m>)(bard)]$_{PrWd}$		*!
c. [(bomb)(ard)]$_{PrWd}$	*!	
d. [(bom)(<b>ard)]$_{PrWd}$		*!
e. [(bom<b>)(ard)]$_{PrWd}$		*!
f. [(bo<m>b)(ard)]$_{PrWd}$		*!

The candidate in (43c) is immediately ruled out because it violates the higher constraint No Complex Coda. Other candidates pass No Complex Coda. Thus, they move to the next constraint, i.e., Max(C). All candidates in (43) fail Max(C) except the two in (43a) and (43c). The candidate in (43c) has already been ruled out by the higher constraint No Complex Coda. Thus, the candidate in (43a) is optimal.

Let us now turn to NC clusters in class 2 suffixed forms like *bomber*, *singer*, *damning*, and *signer*: [[bomb]$_{PrWd}$ er]$_{PrWd}$, [[sing]$_{PrWd}$ er]$_{PrWd}$, [[damn]$_{PrWd}$ ing]$_{PrWd}$, [[sign] $_{PrWd}$ er]$_{PrWd}$. Class 2 suffixed forms show consonant deletion in NC clusters, as exemplifed in (44). The structure in (44) are the optimal phonological output.[7]

(44) [[(bom<b>)]$_{PrWd}$ (er)]$_{PrWd}$

The phonological structure in (44) satisfies No Complex Coda but violate Max(C). However, the No Complex Coda and Max(C) constraints alone cannot choose the optimal outputs in class 2 suffixed forms, unlike in unsuffixed and class 1 suffixed forms. In unsuffixed and class 1 suffixed forms, the optimal outputs can be chosen by ranking No Complex Coda above Max(C) constraints, as seen in (41) and (43) above.

Since the structure in (44) is just one of many possible candidates, it is necessary to consider the potential candidates in order to make sure that No Complex Coda and Max(C) are not sufficient to account for the NC cluster

7) This optimal phonological output may be different from the phonetic form, in which the surviving consonant in the coda position of the PrWd can be ambisyllabic. If ambisyllabicity is assumed in English as in McCarthy (1993), an ambisyllabic phonetic form can be interpreted as a result of phonetic implementation. However, some authors like Jensen (1993), do not admit ambisyllabicity. I leave the issue concerning ambisyllabicity open in this paper.

simplification in class 2 suffixed forms. Tableau (45) shows a partial set of potential candidates and the application of the two constraints.

(45)

Candidates	No Complex Coda	Max(C)
a. [(bom<b>)(er)]$_{PrWd}$		*
b. [(bo<m>b)(er)]$_{PrWd}$		*
c. [(bomb)(er)]$_{PrWd}$	*!	
d. [(bom)(<b>er)]$_{PrWd}$		*
e. [(bom)(b]er)]$_{PrWd}$		
f. [(bo<m>)(b]ard)]$_{PrWd}$		*

Candidate (45c) violates the No Complex Coda constraint that is satisfied by the other candidates, so it is immediately ruled out. Next, the surviving candidates move to Max(C). The candidates in (45a, b, d, and f) violate Max(C) because one consonant of the NC cluster is unparsed. On the other hand, the candidates in (45c and e) satisfy the constraint. Among the two candidates, the candidate in (45c) has already been ruled out because of violation of the higher constraint No Complex Coda. Thus, the candidate in (45e) should be optimal. However, this is not the case. Rather, the candidate in (45a) is the anticipated winner.

Since No Complex Coda and Max(C) alone cannot select the optimal output, we have to introduce other constraints to account for the fact that candidate (45a) is optimal. Let us reconsider candidates (45a) and (45e). The candidate in (45a) shows that syllabification of the stem *bomb* occurs within the independent PrWd and the suffix *-er* constitutes an independent syllable. On the other hand, (45e) reveals that the *b* of the stem *bomb* is syllabified as an onset of the vowel initial suffix, resulting in the overlapping structure, $[(b]_{PrWd})_{\sigma}$. Here, we can introduce two independently motivated constraints. One is Align Right (46a), which states that every prosodic word ends on a syllable edge. The other one is Onset (47b), which requires that every syllable have an onset. Thus, candidates (45a, e) show the conflict between Align Right and Onset.

(46) a. Align Right: Align (PrWd, R; Syll, R)
Every PrWd ends on a syllable edge.
b. Onset: Syllables must have the onset.

The fact that candidate (45a), which violates Onset but satisfies Align Right, is an optimal output implies that Align Right dominates Onset:

(47)

Candidates	Align Right	Onset
☞ a. [(bom<b>)]$_{PrWd}$ (er)]$_{PrWd}$		*
b. [(bom)(b]er)]$_{PrWd}$	*!	

If the constraint ranking between Align Right and Onset is reversed, then the result will be the opposite, which is the wrong prediction because candidate (47a) is the winner. Thus, Align Right should be ranked higher than Onset.

Align Right dominates Max(C), as seen in (48). The winner (48a) satisfies Align Right but violates Max(C), whereas (48b) violates Align Right but satisfies Max(C). The reverse ordering wrongly predicts that (48b) will be chosen as optimal.

(48)

Candidates	Align Right	Max(C)
☞ a. [(bom<b>)]$_{PrWd}$ (er)]$_{PrWd}$		*
b. [(bom)(b]er)]$_{PrWd}$	*!	

No other rankings are motivated; for example, Onset vs. Max(C), Align Right vs. No Complex Coda, and Onset vs. No Complex Coda. As a result, the crucial rankings for NC simplification can be summarized as follows:

(49) a. No Complex Coda >> Max(C)
b. Align Right >> Onset
c. Align Right >> Max(C)

5.2 The phonetic basis of NC Phonology

Let us now consider the issues about the underparsing of a segment in NC clusters. Why are the obstruent stops like *b* and *g* underparsed instead of the nasal stops like *m* and *n* in the clusters *mb*, *ŋg*, and *gn*? And, why is the coronal nasal *n* in *mn* underparsed instead of the labial nasal *m*? Is there a general constraint which answers these two questions? I will discuss these issues in this section.

The first question is illustrated by tableau (50). The two candidates tie for the relevant constraints. The only difference between (50a) and (50b) is the fact that candidate (50a) shows the unparsing of the obstruent *b* in *mb*, while (50b) displays the deletion of the nasal *m*.

(50)

Candidates	No Complex Coda	Max(C)
☞ a. [bom<b>]$_{PrWd}$		*
b. [bo<m>b]$_{PrWd}$		*

Stated in terms of syllable structure, deletion of a segment in *bomb* is a change from the more marked CVCC syllable structure to the less marked CVC syllable. This change can be accounted for in OT by ranking No Complex Coda over Max(C). No Complex Coda is motivated by the principle of articulation that values simple articulations, and Max(C) is motivated by the requirement that underlying contrast be maintained. However, if we focus only on the demand of Ease of Articulation, expressed by No Complex Coda, we do not explain the difference between (50a) and (50b) because both candidates satisfy the goal, i.e., Ease of Articulation, through deletion of a segment, resulting in CVC syllable structure. As a result, we also have to consider another universal principle, i.e., Perceptibility, which requires that speech be perceptible, to explain the deletion of an oral stop and the preservation of a nasal stop in NC clusters.

Here, I propose the Salience Hierarchy (51), which is defined by the complexity of the physiological and acoustic aspects of sounds.[8]

(51) Salience Hierarchy

Definition: Physiologically and acoustically, the more complex segments are more salient.

For example:

Nasal > Oral

Labial, Velar > Coronal

Nasal consonants are more salient than oral consonants. First, physiologically, nasal consonants are formed using more resonators (vocal tubes) than oral consonants. Nasal consonants are produced using two resonators, one consisting of the pharyngeal and nasal cavities and the other one formed by the oral cavity (Jakobson and Halle 1956, Denes and Pinson 1963 and Ohala 1993). In other words, nasal consonants are made by a velopharyngeal opening and a concomitant oral closure (Ohala 1975). Oral consonants, on the other hand, are made using a single resonator (tube) from the glottis to the lips. Second, acoustically, the spectrum of nasal consonants is more complex than the spectrum of oral consonants. The

8) I admit that further detailed study of the auditory mechanism for perception is needed to argue for or against this proposal.

spectral structure of nasal consonants is characterized not only by the resonances of the combined pharyngeal and nasal cavities but also the antiresonances of the oral cavity. The spectral structure of oral consonants (sonorants), however, is characterized only by the resonances (Kurowski and Blumstein 1993 and Ohala 1993). In the case of nasals and oral stops, nasal resonances can serve as class markers, distinguishing nasals from oral stops (Malécot 1956).

Labials and velars are more salient than alveolars. First, physiologically, labials and velars "have an ampler and less compartmented resonator" in the oral cavity than alveolars (Jakobson and Halle 1956: 31). Second, acoustically, vowel transitions are smaller for coronals than for labials and velars, according to Ladefoged (1982). This implies that "unreleased coronals are acoustically weaker than unreleased labials and velars with respect to place cues (J. Jun. 1994)." Thus, the more salient *m* remains intact to preserve underlying contrast, while the less salient coronal *n* is deleted in *mn* cluster.

Combined with the Salience Hierarchy, the Perceptibility principle forces the fixed constraint ranking Max(α) >> Max(β) when α has greater perceptual salience, which is illustrated in (52). The deleted C in a CC cluster is the one with the lower degree of perceptual salience.

(52)

Candidates	Max(More-Salient C)	Max(Less-Salient C)
☞ a. [bom<b>]$_{PrWd}$		*
b. [bo<m>b]$_{PrWd}$	*!	

Simplification in NC clusters results as a compromise between Perceptibility and Ease of Articulation. For example, on articulatory grounds, nasals are complex, so Ease of Articulation should result in deletion of nasals. However, nasals are preserved in favor of Perceptibility. Thus, we can say that the Max(More-Salientt C) dominates the No Complex Coda constraint, which is motivated by Ease of Articulation. On the other hand, No Complex Coda constraint ranks higher than Max(Less-Salientt C), as seen in (53). The winner (53a) satisfies No Complex Coda while it fails Max(Less-Salient C). A loser (53b) violates No Complex Coda while it satisfies Max(Less-St C). Candidate (53c) violates Max(More-Salient C) while it satisfies No Complex Coda and Max(Less-Salient C). If No Complex Coda were ranked in the lowest position, NC cluster simplification would not occur.

(53)

Candidates	Max(More-St C)	No Complex Coda	Max(Less-St C)
☞ a. [bom<b>]$_{PrWd}$			*
b. [bomb]$_{PrWd}$		*!	
c. [bo<m>b]$_{PrWd}$	*!		

To this point, the motivated ranking hierarchy for NC simplification can be summarized as follows:

(54) a. Align Right >> Max(More-St C) >> No Complex Coda >> Max(Less-St C)
b. Align Right > > Onset

The analysis proposed here and previous derivational analyses discussed above face two remaining questions for English NC clusters. First, why is the voiced alveolar stop *d* in *nd* (e.g. *band*) not simplified. And why are the clusters *mp* (e.g., camp), nt (e.g., cant), and ŋk (e.g., bank) not simplified. Previous analyses do not deal with these issues. On the other hand, the analysis proposed here would incorrectly predict that the voiced alveolar stop *d* in *nd* is deleted, and that voiceless oral stops *p* (*mp*), *t* (*nt*), and *k* (*ŋk*) are simplified in the NC clusters. Let us now consider these two problems.

It is suggested that the first problem is attributable to the coronality of clusters. The production of alveolars is the most economical because the distance between two articulators, passive (alveolar ridge) and active (tongue tip), is the shortest in the production of consonants. The coronal cluster is not hard to articulate, so the Ease of Articulation principle, which motivates the No Complex Coda constraint, need not be invoked, at the cost of underlying material loss.

As for the second problem, one possible solution would be to reverse the constraint ranking hierarchy between No Complex Coda and Max(Less-Salient C). This solution, however, cannot be maintained in English, since this would result in **bomb*, not the expected form *bom<b>*. Another possible solution, which I adopt here, is to appeal to an additional functional principle, given in (55):

(55) Positional Preference
Word-final position has a preference for voiceless consonants over voiced consonants.

This functional principle reflects a phonetic generalization. Word-final position tends to condition unreleased stops, which explains the voicing neutralization of word-final obstruents in many languages like German (Kiparsky 1968, Fourakis and Iverson 1984, Port and O'Dell 1985), Polish (Slowiaczek and Dinnsen 1985), and Catalan (Dinnsen and Charles-Luce 1984):

(56) a. German: Bund [bunt] 'federation' ~ Bundes [bundes] 'federation (gen)'
b. Polish: karb [karp] 'notch' ~ karby [karbɨ] 'notch pl.'
c. Catalan: fat (/fad/ --> [fat]) 'silly' (cf. fat /fat/ 'fate')

Nonrelease, according to Kahn (1976), can be interpreted in two ways. It can be interpreted as either the closure of the glottis or as a positive pressure behind the occlusion with no glottal closure. Either view explains the naturalness of voiceless sounds in word-final unrelease position, since both physiological movements can block the Bernoulli effect, which causes the vibration of vocal cords. Voicing is possible only when there is a significant amount of aperture, i.e., release.

The Positional Preference principle motivates the explosion of Final C constraint into Final C[-voice] and Final C[+voice] with a fixed constraint ranking: Final C[-voice] >> Final C[+voice], as illustrated in (57).[9] Final C states that a prosodic word ends in a consonant. The winner (57a) satisfies Final C[-voice] but violates Final C[+voice], while (57b) violates Final C but satisfies Final C[+voice].

(57)

Candidates	Final C[-voice]	Final C[+voice]
☞ a. [camp]$_{PrWd}$		*
b. [cam<p>]$_{PrWd}$	*!	

Max(Less-Salient C) is ranked higher than Final C[+voice], as seen in (58). The winner (58a) satisfies Max(Less-Salient C) but fails Final C[+voice]. Conversely, the loser (58b) violates Max(Less St C) but satisfies Final C[+voice].

(58)

Candidates	Max(Less-St C)	Final C[+voice]
☞ a. [camp]$_{PrWd}$		*
b. [cam<p>]$_{PrWd}$	*!	

There is still a problem with No Complex Coda. Since it is ranked higher than Max(Less-St C), as motivated above, we should get deletion of <p> in *camp*. We

9) Prepositional Preference, in some sense, might be replaced by Ease of Articulation.

need to make N_iC_i clusters exempt from deletion, when C_i is voiceless. The immunity of voiceless consonants to deletion is explained if we assume that Final C[-voice] is ranked above No Complex Coda, as seen in (59). Candidate (59a) with no simplification is the winner, which satisfies Final C[-voice] but fails No Complex Coda, while the loser (59b) violates Final C[-voice] but satisfies No Complex Coda.

(59)

Candidates	Final C[-voice]	No Complex Coda	Final C[+voice]
☞ a. $[\text{camp}]_{PrWd}$		*	
b. $[\text{cam<p>}]_{PrWd}$	*!		

The ordering between Max(More-Salient C) and Final C[-voice] is not crucial, as seen in (60). The winner (60a) satisfies both constraints, while the losers (60 b,c) violate one of them.

(60)

Candidates	Max(More-St C)	Final C[-voice]
☞ a. $[\text{camp}]_{PrWd}$		
b. $[\text{cam<p>}]_{PrWd}$		*!
c. $[\text{ca<m>p}]_{PrWd}$	*!	

Then, we can ask why the final stop in *bomb* is not simply devoiced to **bomp*. The dominance of Final C[-voice] over No Complex Coda would predict that the devoiced form **bomp* is the winner over *bom<b>*. Here, we can invoke a constraint termed Dep(voice), which bans insertion of [voice]. In English a contrast of consonant voicing is preserved in word-final position, as seen in *bea/d/* vs. *bea/t/*, even though voicelessness wins over voicedness in word-final position when Voicing Assimilation in CC clusters is concerned.[10] If we assume that Dep(voice) dominates Final C[-voice], we can select the anticipated form *bomb* as the winner, not the devoiced form **bomp*, as seen in (61). Irrelevant constraints are omitted here.

(61)

Candidates	Dep(voice)	Final C[-voice]	No Complex Coda	Max(Less-St)C
☞ a. [bom<b>]		*		*
b. [bomp]	*!		*	

10) An analysis of Voicing Assimilation is beyond the scope of this paper. See J.-Y. Lee (1996) for an Optimality Theoretic analysis of Voicing Assimilation.

In sum, I have argued that English NC cluster phonology, including consonant simplification, can be accounted for in a principled, unified way by appealing to phonetics-based principles such as Ease of Articulation, Perceptibility, and Positional Preference. These functional principles motivate grammatical constraints.

6. Conclusion

I have shown that the alternations regarding English NC clusters are accounted for in a unified way within the OT framework by appealing to functional principles. I have also argued that the simplification of NC clusters is a result of compromising the tension between Ease of Articulation and Perceptibility.

The functional principles give rise to specific well-formedness constraints. Ease of Articulation is expressed in the No Complex Coda constraint, which effects deletion in $CC]_{PrWd}$ clusters. The No Complex Coda constraint is satisfied by deletion of either consonant in a $CC]_{PrWd}$ cluster. Perceptibility is expressed in an exploded set of Max(C) constraints with a fixed ranking: Max(α) >> Max(β) when α has greater perceptual salience than β. I claim that perceptual salience is defined by the complexity of physiological and acoustic aspects of sounds. By the salience hierarchy of Max constraints, the deleted C in a $CC]_{PrWd}$ is the one with the lower degree of perceptual salience.

It is also argued here that the morphological structure [stem-Class 1suffix] defines a single PrWd, whereas the morphological structure [Stem-Class 2suffix] involves recursive prosodic words.

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서울대학교 어학연구소