Laryngeal Representation in English*

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This paper reanalyzes the laryngeal specification of stops in English, based on the aspiration account (Iverson & Salmons 1995, Avery & Idsardi 2000, Iverson & Ahn 2007, etc.). As has been shown in the earlier works, postulation of [spread] rather than [voice] as the marked laryngeal feature for English as well as many other Germanic languages leads to deeper understanding of the distribution of aspiration and to a more satisfying analysis of other related issues, such as word-final laryngeal neutralization, compensatory vowel lengthening, and passive voicing, etc. In this paper, I show how this new account demonstrates the optimal description of English stops. I then show that the parallelism of the "classic" Optimality Theory (McCarthy & Prince 1995, Benua 1997) or the recent theory of OT-CC (McCarthy 2006, 2007) cannot account for the allophonic variation of aspiration and vowel lengthening in English. Regarding this problem, I propose to incorporate the concept of (full) "serialism" and the cyclic application of constraints in Optimality Theory.

Keywords: English, laryngeal feature, aspiration, allophonic variation, parallelism, Optimality Theory, serialism, cyclic application, Lexical Phonology

1. Introduction: Laryngeal Categorization

In spite of the traditional description of the two-way laryngeal contrast for the [±voice] categorization, it has been recognized that the voiced stops of Romance (or Slavic) languages are thoroughly voiced, with early VOT, but the "voiced" stops of English and most other Germanic languages are often not voiced at all at the beginning of the word, with comparatively late VOT (Lisker & Abramson 1964). Therefore, the English-type is often called "lenis" rather than truly voiced (Yavaş 2006). Moreover, the voiceless stops of Ro-

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mance languages are produced with relatively early VOT, whereas the VOT of the Germanic voiceless stop series is considerably delayed. Romance voiceless stops are thus categorized as "unaspirated", whereas those of Germanic as (often heavily) aspirated (Iverson & Salmons 1995, Flemming 1995, Iverson & Ahn 2007, etc.).[1] Therefore, employing the feature [±spread glottis] (previously, [±aspiration]) representing the presence and absence of aspiration, the scheme outline in (1) shows the typological difference in laryngeal properties (Iverson & Ahn 2007).

(1) Conventional description of a "voice" contrast: binary [±voice] & [±spread]

Germanic (English, German)		Romance (French, Spanish)	
/t/	/d/	/t/	/d/
[–voice]	[+voice]	[–voice]	[+voice]
↓	↓	↓	↓
[+spread]	[–voice] (initial) [–spread]	[–spread]	[–spread]
[tʰ]	[d̥], [d]	[t]	[d]

According to the conventional representation, voiceless and voiced stops are distinguished with respect to the [±voice] distinction. In Romance languages, where aspiration plays no role, the negative value for [spread] is supplied to the voiced as well as the voiceless series. In Germanic, however, we observe aspiration among initial voiceless stops, so the positive value for [spread] needs to be supplied to the voiceless series, and the negative value to the voiced series, which itself also acquires the negative value for [voice] in initial positions.[2]

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[1] According to Ladefoged (1993: 144), the laryngeal properties of the English stops are substantially different from that of other languages such as French. In other words, the voicing of /b/ is much weaker than that of /b/ in French or Thai.

	English	*French*	*Thai*	*Korean*
Full voicing		b	b	
	b			
Partial voicing				
Voiceless unaspirated	(s)p	p	p	
Voiceless (tense) unaspirated				p'
Voiceless slightly aspirated	p			p
Voiceless heavily aspirated			p^h	p^h

The same aspect of the VOT continuum can be found in Yavaş (2006: 10).

[2] If the third laryngeal feature, [constricted], were taken into account here, its negative value needs to be supplied as well to all of the stops in both types of languages (Iverson & Ahn 2007).

Employing an underspecified representation, we can replace the negatively valued features with representational absence, while the presence of the features can replace the positive values. Thus, both voiced ([voice]) and voiceless ([ ]) stops are unaspirated in Romance languages since the privativity in representation does not provide the feature [spread]. Similarly, [constricted] is not supplied, either, so we do not need any specific statement to account for the glottally unconstricted character of stops in either French or English (except in glottalized environments). As the English type of phonemically voiceless stop is aspirated in initial environments, however, we need a statement to provide this property there, which can be formulated based on the absence rather than presence of structure (i.e., [ ]), while the [voice] property needs to be removed from word-initial voiced stops.

(2) Conventional description of a "voice" contrast: privative [voice] & [spread]

<u>English, German</u>		<u>French, Spanish</u>	
/t/	/d/	/t/	/d/
[ ]	[voice]	[ ]	[voice]
↓	↓		
[spread]	∅ (initial)		
[t^h]	[d̥], [d]	[t]	[d]

Given that two features are at play here, however, the relevant underlying property is not voicing or its absence in all cases, but rather glottal spread. That is to say, the Romance type of system remains the same under the binary assumption, but the Germanic type is redefined with glottal spread being the contrastive property, as shown in (3). Under this alternative for the Germanic type of language, voicing is fully derivative, attracting laryngeally unmarked obstruents in voicing-friendly (i.e., medial) environments (Iverson & Ahn 2007).

(3) Phonetically more informed description: binary [±voice] & [±spread]

<u>English, German</u>		<u>French, Spanish</u>	
/t^h/	/d/	/t/	/d/
[+spread]	[–spread]	[–voice]	[+voice]
↓	↓	↓	↓
[–voice]	[+voice] (medial)	[–spread]	[–spread]
[t^h]	[d̥], [d]	[t]	[d]

Now, as shown in (4), by converting the binary system of (3) into its more restrictive privative equivalent, we can maintain the basic distinction between English as a fortis/lenis language and French as a voiceless/voiced language. Moreover, we can posit a much simpler representation as shown in (4) since negatively valued features simply are not specified.[3]

(4) Phonetically more informed description: privative [voice] & [spread]

English, German		French, Spanish	
$/t^h/$	/d/	/t/	/d/
[spread]	[ ]	[ ]	[voice]
	[voice] (medial)		
$[t^h]$	[d̥], [d]	[t]	[d]

2. Comparison between Privative [spread] and Privative [voice]

As claimed in Iverson & Ahn (2007), assimilatory progressive devoicing in clusters is easily describable in terms of rightward association of the feature [spread] into a laryngeally unmarked obstruent as with examples like the /t + z/ of *cats*. On the other hand, as illustrated in (5), the assimilation cannot even be easily described if privative [voice] is assumed rather than [spread] as there is no negative value of [voice] available. We, therefore, have to appeal to other unnatural devices, including deletion of the offending obstruent or epenthesis of a vowel into the cluster (Iverson & Ahn 2007).

(5) Laryngeal assimilation in English: privative [spread] vs. privative [voice]

/t + z/	(*cats*)	/t + z/
	vs.	
[spread]		[voice]

Similar difficulties may emerge in the description of regular and irregular noun plurals. As illustrated in (6), the assumption of [spread] allows for cluster as-

[3] This new viewpoint on Germanic languages is further supported by Harris (1994: §3.6) observing that the series /b d g/ in French is always fully voiced and the /p t k/ series unaspirated. He suggests that the French /p t k/ is the neutral series, while it is /b d g/ in English since the two series are for all intents and purposes (phonetically) identical. Ewen & van der Hulst (2001: 111) also suggest that the glottal opening feature is active in English, while [slack vocal folds] are active in French and Dutch, and the voiceless series is thus 'neutral'. Ewen & van der Hulst (2001) employ the single-valued feature representations, O and L, for Glottal opening and [slack vocal folds], respectively. (O replaces the possible alternative H, i.e., [+stiff vocal folds], as the use of both H and L may contradicts their single-valued feature framework.)

English		French		Dutch		
/p, t, k/	/b, d, g/	/p, t, k/	/b, d, g/	/p, t, k/	/b, d, g/	
H						H tier
			L		L	L tier
cool	ghool	peau	beau	tuin	duin	
		'skin'	'beautiful'	'garden'	'dune'	

similation in regular plurals (/f + z/ > [fs] in *safes*) and for idiosyncratic weakening in the irregular plurals (/f + z/ > [vz] in *leaves*). Positing [voice], however, would generate an inappropriately ordinary-looking description of the irregular plurals as they are subject to assimilation rather than to (the more historically accurate) weakening (Iverson & Ahn 2007).

(6) Regular and irregular noun plurals: privative [spread] vs. privative [voice]

/f + z/ (*safes*)	/f + z/ (*leaves*)	vs.	/f + z/ (*safes*)	/f + z/ (*leaves*)
[spread]	[spread]		[voice]	[voice]
(assimilation)	(weakening)		(devoicing)	(assimilation?)

The positing of [spread] (rather than [voice]) as the marked laryngeal feature for English thus leads to a deeper understanding of the aspiration processes and to a more satisfying analysis of the assimilatory devoicing that affects both sonorants and obstruents.

Along this line of work, a compelling variation on the privative theme emerged in Avery & Idsardi's (2001) laryngeal phonology which distinguishes laryngeal contrasts according to the three "dimensions" of Glottal Width, Glottal Tension, and Larynx Height (rather than the three privative features [voice], [spread], and [constricted]). In the Avery & Idsardi system, the dimensions represent phonetically antagonistic "gestures", which are essentially the same properties as the phonological features of conventional theories. As shown in (7), the dimensions and gestures relate to each other and they are then implemented under the "articulator" Laryngeal.

(7) Geometry of Laryngeal Representation in Dimensional Theory

Articulators	*Dimensions*	*Gestures*
	Glottal Width	[spread]
		[constricted]
Laryngeal	Glottal Tension	[stiff]
		[slack]
	Larynx Height	[raised]
		[lowered]

Only one member of an antagonistic gestural pair may be used contrastively in a given system, though the other gesture may be invoked as a phonetic embellishment, or "enhancement", for highlighting a contrast. Thus, [spread] and [constricted] form an antagonistic pair under the dimension of Glottal Width, so only one of these properties may be phonologically active. Similarly, [stiff] and [slack] constitute the antagonistic pair which belongs to Glottal Tension, hence just one of these may take a phonological function in a given system (as in French, whose [slack] voiced stops contrast with laryngeally empty voiceless unaspirated ones). The default selection among these dimensions is such that Glottal Width normally implicates [spread], and Glottal Tension typically implicates [slack]. Finally, there is the Larynx Height dimension, which implicates either [raised] (ejectives) or [lowered] (implosives).

Based on the framework of Dimensional Phonology, the conventional feature systems in (8) can translate into a dimensional representation as in (9) (Iverson & Ahn 2007).

(8) Laryngeal contrasts employing privative [voice], [spread], [constricted]

	/p ~ b̥/	/b/	/pʰ/	/p'/	/bʰ/
Hawaiian	[ ]				
K'ekchi	[ ]			[constr]	
French	[ ]	[voice]			
English	[ ]		[spread]		
Thai	[ ]	[voice]	[spread]		
Hindi	[ ]	[voice]	[spread]		[spread] [voice]

(9) Laryngeal contrasts employing the three dimensions

	/p ~ b̥/	/b/	/pʰ/	/p'/	/bʰ/
Hawaiian	[ ]				
K'ekchi	[ ]			LH	
French	[ ]	GT			
English	[ ]		GW		
Thai	[ ]	GT	GW		
Hindi	[ ]	GT	GW		GT&GW

3. Comparison of two Optimality Accounts

Based on the discussions shown so far, we take English as an aspiration language in which the [aspiration] feature takes a distinctive role. As we now move on to the discussion on the optimality accounts of English aspiration, we will first observe how the [voice] and [aspiration] views can be dealt within Optimality Theory (OT, McCarthy & Prince 1995).

3.1. A voice Account

The traditional application of [voice] contrast has been employed in a series of approaches accounting for the voicing alternation in Germanic languages (Rubach 1990; Lombardi 1991, 1999; etc.). Assuming the [voice] distinction, for example, we can also posit the following constraints (as shown in Lombardi (1999)) in order to account for the voicing alternation in English (Jessen & Ringen 2002).

(10)	a.	IDENTONSET(Lar)	A presonorant consonant in an onset should be faithful to its underlying laryngeal specification.
	b.	IDENT(Lar)	Consonants should be faithful to their underlying laryngeal specification.
	c.	AGREE	Obstruent clusters should agree in laryngeal specification.[4]
	d.	*[voi/sg]	Voiced spread glottis stops are prohibited.[5]
	e.	*Lar	Do not have laryngeal features.

With these constraints, we can now observe how we end up with a problem in a classical OT account, assuming the constraint ranking IDENTONSET(lar) >> *Lar >> AGREE, IDENT(Lar). (☜ is used for the suboptimal output, while ☹ for the unselected actual output.)

(11) cab

/kæb/	IDONS(Lar)	*Lar	AGREE	ID(Lar)
☞? a. kæp				*
b. kæb		*!		

(12) gap

/gæp/	IDONS(Lar)	*Lar	AGREE	ID(Lar)
☹ a. kæp	*!			*
☜ b. gæp		*!		

If we set aside the aspiration distinction, we can select the correct output candidate with the given constraint in (11). The problem, however, is that we still

4 Following the suggestion by a reviewer, I modified the AGREE constraint by (Jessen & Ringen 2002) shown below.
Obstruent clusters should agree in voicing. (Jessen & Ringen 2002: 195)

5 Even if we do not specify the [voice] feature, we may still need [voice] specification as the stops undergo intervocalic voicing at the allophonic level.

need a way to make the intial consonant aspirated but such as candidate would (fatally) violate the initial constraint IDONS(Lar). Moreover, (12) shows that a wrong output emerges due to the role of the initial constraint, IDENTONSET(Lar). A similar problem occurs in the other examples that have word-medial consonant clusters with different inputs for [voice].

(13) magpie

	ma/g+p/ie	IDONS(Lar)	*Lar	AGREE	ID(Lar)
a.	ma[g.p]ie		*	*	
☞? b.	ma[k.p]ie				*

(14) batboy

	ba/t+b/oy	IDONS(Lar)	*Lar	AGREE	ID(Lar)
☜ a.	ba[t+b]oy		*	*	
☹ b.	ba[t.p]oy	*!			*

As in the earlier examples, the example in (13) shows a correct output (if we set aside the aspiration here), while we expect a wrong output in (14). We may thus think of changing the given constraint ranking, but such a simple manipulation would not work here since reversing the constraint ranking would jeopardize the correct outputs in (11) and (13). Furthermore, we need an additional constraint to account for the initial aspiration, i.e., [kæp] → [kʰæp] and we will have to rely on a special aspiration rule or a constraint.

3.2. An Aspiration Account

Those problems shown in the [voice] account in (11) and (12) can be easily resolved in the aspiration account. Moreover, we can easily explain the laryngeal agreement in medial consonant clusters and the non-release of the final stop. For this, we introduce a low-ranking constraint *Stop[sg] which discourages final stop release.

(15) *Stop[sg]# Word/syllable-final stops may not be aspirated.

(16) cab

	/k[sg]æp/	IDONS(Lar)	*Lar	AGREE	*Stop[sg]#	ID(Lar)
☞ a.	kʰæp					*
b.	kʰæpʰ		*!			**

(17) gap

/kæp[sg]/	IDONS(Lar)	*Lar	AGREE	*Stop[sg]#	ID(Lar)
☞ a. kæp					*
b. $kæp^h$		*!		*	

In (16) and (17), we can observe that, without changing the constraint ranking, the earlier problem with the [voice] account is now resolved in the aspiration account. The following tableaux (18) and (19) also show that the other two cases are explained in our aspiration account without any problem.

(18) magpie

ma/k+p[sg]/ie	IDONS(Lar)	*Lar	AGREE	*Stop[sg]#	ID(Lar)
a. ma[k.p]ie	*!		*		
☞ b. ma[k.p^h]ie		*	*		*

(19) batboy

ba/t[sg]+p/oy	IDONS(Lar)	*Lar	AGREE	*Stop[sg]#	ID(Lar)
a. ba[t[sg]+p]oy		*	*	*	
☞ b. ba[t.p]oy					*

The /p/ in *magpie* is aspirated in general since the word is perceived as a compound and *pie* thus has a secondary stress. In the case of *batboy*, however, no aspiration occurs word-initially or medially. These examples indicate that the aspiration account is superior to the voice account in that we do not need any special rule or constraint for aspiration in the OT framework.[6]

4. Variation in Aspiration

Being a Germanic language, English shows a variation of aspiration which can be both phonemic (as in *pie* ~ *buy*) and allophonic (as in *pie* ~ *spy*).

(20) a. Phonemic: *pie*[p^haj] ~ *buy*[paj]
b. Allophonic: *pie* [p^haj] ~ *spy* [spaj]

As was already mentioned above, aspiration occurs when the stop is word (or foot)-initial but this is a consequence of its inherent marking for [spread], not

[6] As was argued in (Iverson & Ahn 2007), aspiration occurs when the stop is word (or foot)-initial but this is a consequence of its inherent marking for [spread], not the effect of allophonic aspiration rules.

the effect of allophonic aspiration rules (Iverson & Ahn 2007). If an "s + stop" cluster occurs, however, the [spread glottis] feature is shared, which causes the inherent aspiration of the stop to be absorbed, (assuming that the English /s/ is spontaneously aspirated à la Vaux's law (Vaux 1998, Ahn & Iverson 2004). These varying realizations of the same privative feature, [spread glottis], are portrayed below (Iverson & Salmons 1995, Iverson & Ahn 2007, etc.).

(21) Laryngeal sharing: clusters and aspiration (*spay* vs. *pay* vs. *play*)

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 C   V          C   V          C   C   V
 /\  |          |   |          |   |   |
s p  e          p   e          p   l   e
 \/             |              |
[sg]           [sg]           [sg]
([sp e])       ([pʰ e])       ([pʰ l̥ e])
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These figures show that the aspiration of the voiceless stops may occur when the [sg] feature can spread to the right sonorant segment in a binary-branching manner. However, the [sg] feature is not realized on the surface (i.e., "absorbed") when it is shared by two obstruents. Therefore, this account not only explains the aspiration of word/foot-initial stops but also the devoicing of sonorants immediately following these aspirated stops. Furthermore, the non-aspiration (i.e., deaspiration) of /sC/ cluster can be explained in a more natural way.[7]

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[7] As for the non-occurrence of aspiration in /p, t, k/ following an /s/, we also consider the observation by Kim (1970): the absence of aspiration in "s+stop" clusters is due to the cluster's containing just a single instance of a constantly timed [spread] gesture. That is, as the peak of glottal opening occurs during the mid-point rather than at the end of clusters like /sp/, the vocal folds will have already come together by the time of the release of the stop, hence the absence of aspiration in /p/ following /s/. Quotations from the phonetics literature supporting this understanding of the [spread] gesture in clusters are given below.

> ...the glottal movement for /p/ of /sp/ will start during /s/...if the glottis is instructed to open to the same degree and for the same period for /p/ of /sp/ as it would for initial /p/, the glottis will begin to close by the time the closure for /p/ is made, and consequently, by the time /p/ is released, the glottis will have become so narrow that the voicing for the following vowel will immediately start, and thus we have an unaspirated /p/ after /s/ (C-W Kim 1970:80).

> Peak glottal opening in clusters of a fricative followed by a stop does not occur at the same time relative to the oral articulations as it would for either a fricative or a stop occurring alone. The most typical point is close to the boundary between the two oral articulations, a temporal compromise between the early peak of the fricative and the late peak of the stop. (Kingston 1990:427)

4.1. Optimality Accounts

The conventional /p/ ~ /b/ distinction is now interpreted as the presence vs. absence of the [spread glottis] feature in the current aspiration account. And *Lar is lower ranked in the following tableaux since English and most other Germanic languages use the [spread] feature to represent phonemic distinctions. Therefore, due to the role of ID[Lar], the distinction of [sg] appears as a crucial factor at the phonemic level.

(22) i. pie [p^haj]

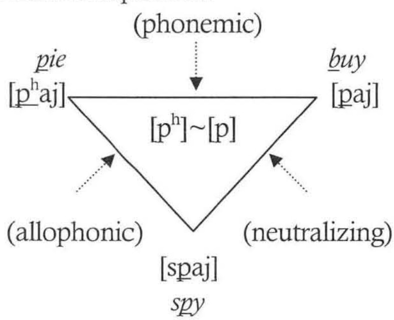
$p^{[sg]}$aj	IDENT(LAR)	*[voice/sg]	*Lar
☞ a. p^haj			*
b. paj	*!		

ii. buy [paj] (i.e., [b̥ aj])

paj	IDENT(LAR)	*[voice/sg]	*Lar
☞ a. paj			
b. p^haj	*!		*

Unlike the phonemic distinction in the pair *pie* ~ *buy*, however, the phonemic distinction in the input seems to be neutralized in the pair *buy* ~ *spy*. Therefore, there are at least three possible interactions of aspiration which can be schematized as follows.

(23) Variation in aspiration



(24)

	Input	Output	
a. pie	/$p^{[sg]}$/	[p^h]	
b. spy		[p]	neutralized
c. buy	/p/	[p]	

We note that the distinction between (24a) and (24b) is just allophonic, whereas the stop in (24c) should be distinguished phonemically from that of (24a-b). Within the so-called "classic" parallel OT evaluation, however, there is no way to distinguish these phonemic and allophonic realizations even if we posit a different constraint ranking as in (25ii).

(25) i. IDENT(LAR), *[voice/sg] »*Lar

pie [p^haj]

$p^{[sg]}aj$	IDENT(LAR)	*[voice/sg]	*Lar
☞ a. p^haj			*
b. paj	*!		

spy [spaj]

$sp^{[sg]}aj$	IDENT(LAR)	*[voice/sg]	*Lar
☹ a. sp^haj			*
☜ b. spaj	*!		

buy [paj] (i.e., [b̥aj])

paj	IDENT(LAR)	*[voice/sg]	*Lar
☞ a. paj			
b. p^haj	*!		*

ii. *Lar » *[voice/sg], IDENT(LAR)

pie [p^haj]

$p^{[sg]}aj$	*Lar	IDENT(LAR)	*[voice/sg]
☹ a. p^haj	*!		
☜ b. paj		*	

spy [spaj]

$sp^{[sg]}aj$	*Lar	IDENT(LAR)	*[voice/sg]
a. sp^haj	*!		
☞ b. spaj		*	

buy [paj] (i.e., [b̥aj])

paj	*Lar	IDENT(LAR)	*[voice/sg]
☞ a. paj			
b. p^haj	*!	*	

In either constraint ranking, we end up with a wrong output for either *pie* or *spy*, while *buy* can be realized as a correct output in both cases.

In order to solve this problem, we may postulate a new constraint banning two consecutive [sg] obstruents in a row. Recall the earlier description that, being "absorbed", the [sg] feature is not realized when it is shared by two obstruents. We, therefore, invoke the following NULL[sg] constraint.[8]

(26) NULL[sg] Being absorbed, two consecutive [sg] features may not be realized. **(Violable)**

This constraint, NULL[sg], is invoked to account for the deaspiration of non foot-initial stops, that is, those unaspirated stops occurring after an /s/. Suppressing the input [sg] feature from being realized, it is inherently in conflict with the faithfulness constraint, IDENT[sg]. Therefore, as NULL[sg] is crucial in the account of deaspiration in the *s*+stop clusters, we seem to get the desired results by positing the NULL[sg] constraint as having the top ranked position.

(27) NULL[SG] » IDENT(LAR), *[voice/sg] » *Lar

i. *spy* [spaj]

$sp^{[sg]}aj$	NULL[SG]	IDENT(LAR)	*[voice/sg]	*Lar
a. sp^haj	*!			*
☞ b. spaj		*		

ii. *pie* [p^haj]

$p^{[sg]}aj$	NULL[SG]	IDENT(LAR)	*[voice/sg]	*Lar
☞ a. p^haj				*
b. paj		*		

There is, however, a logical fallacy in this analysis due to the violability of the NULL[sg] constraint as specified in (26). Note that the aspiration distinction in *spy* is allophonic and the NULL[sg] constraint is thus "violable", while the violation of *[voice/sg] is phonemic and thus "fatal". Therefore, the NULL[sg] cannot dominate the non-violable constraint *[voice/sg], at least for phonemic distinction.

In order to overcome this logical fallacy, we need to incorporate the notion of cyclicity into the OT analysis (Rubach 2000a, b, 2003; Kiparsky 2000; Ahn 2006a, b, c; etc.). Then, we can separate the evaluations of the phonemic distinctions from those of the allophonic ones, so that the earlier analysis for (22) can be assigned to Cycle 1, specifically, the phonemic level, while the neutralization process in (25) to the next cycle, i.e., Cycle 2.

Employing this Null constraint in (26), therefore, we can now get the optimal outputs for *pie*, *spy*, and *buy* as shown in the following tableaux. This

[8] This constraint is akin to the general OCP constraint banning two consecutive identical elements. In this paper, however, we invoke a separate constraint NULL[sg], considering that it is violable (at the allophonic level) and two consecutive [sg] features in a stop cluster cancel each other in the representation.

analysis shows that, being unaspirated, the phonemic status of /p/ can be neutralized with that of /b/ in a non-initial position at the allophonic level. That is, both stops are pronounced the same (or very similarly) at the phonetic level. We use the same examples shown in (25i) for comparison. Note that the stop representations for *spy* and *buy* are still distinctive in Cycle 1 but neutralized in Cycle 2 due to the promotion of Null[sg] in the constraint ranking. (Observe that the first candidate in (28ii) is realized as a non-standard variety.)

(28) Cycle 1: phonemic level

i. pie

p$^{[sg]}$aj	Ident(Lar)	*[voice/sg]	*Lar	Null[sg]
☞ a. p^{h}aj			*	
b. paj	*!			

ii. spy

sp$^{[sg]}$aj	Ident(Lar)	*[voice/sg]	*Lar	Null[sg]
☞ a. sp^{h}aj			*	*
b. spaj	*!			

iii. buy

paj	Ident(Lar)	*[voice/sg]	*Lar	Null[sg]
☞ a. paj				
b. p^{h}aj	*!		*	

(29) Cycle 2: allophonic level[9]

i. pie [p^{h}aj]

p$^{[sg]}$aj	**Null[sg]**	Ident(Lar)	*[voice/sg]	*Lar
☞ a. p^{h}aj				*
b. paj		*		

ii. spy [spaj]

sp$^{[sg]}$aj	**Null[sg]**	Ident(Lar)	*[voice/sg]	*Lar
a. sp^{h}aj	*			*
☞ b. spaj		*		

iii. buy [paj] (i.e., [b̥aj])

paj	**Null[sg]**	Ident(Lar)	*[voice/sg]	*Lar
☞ a. paj				
b. p^{h}aj		*		*

9 As we are evaluating the candidates at the "allophonic" level, we may not need a fatal violation mark for the top constraint.

Assuming that all the constraints are universal and thus existing in English, the lower-ranking constraint in the first cycle, NULL[sg] is promoted to the higher ranked position at the next cycle (for allophonic variation) in this serial (hence, cyclic) account. Furthermore, even if it is top-ranked, we need to make this constraint violable (i.e., in the post-lexical cycle), so that we can allow (optional) aspiration in non-standard pronunciation. Therefore, as the non-standard variety can occur in the earlier cycle, we can account for the (dialectal/idiolectal) variation in terms of the specific cycle employed in pronunciation.

The crucial role of NULL[sg] is further supported by the analysis of the deaspiration of word-internal obstruent clusters, such as *tactics* [t^{h}æk.tiks] in which the (underlined) medial stop clusters are not aspirated, even though they are allophonic. As indicated in the following table, the NULL[sg] constraint again plays a crucial role in Cycle 2 (i.e., post-lexical), in the account of the obstruent clusters as well. In (30), we omit *[voice/sg] for a simpler display. (It is also assumed that voiceless fricatives are (inherently) aspirated à la Vaux's law (Vaux 1998, Ahn & Iverson 2004). (Following the conventional notation, however, I will not represent the (inherent) aspiration of /s/ in the input/output representation. As the aspiration is unspecified, therefore, no violation of NULL[sg] is marked for *s*.)

(30) Cycle 2: tactics [t^{h}æk.tiks]

	t$^{[sg]}$æk$^{[sg]}$t$^{[sg]}$ik$^{[sg]}$s	NULL[sg]	IDENT(LAR)	*Lar
a.	t^{h}æk^h.t^{h}ik^{h}s	***		****
b.	t^{h}æk^h.t^{h}iks	*	*	***
c.	t^{h}æk^h.tiks	*	**	**
d.	t^{h}æk.t^{h}iks	*	**	**
☞ e.	t^{h}æk.tiks		***	*

In the table, all of the aspirated stops except the initial one violate the top-ranked (nevertheless violable) constraint NULL[sg]. As a consequence, the last candidate (30e) is chosen as the optimal output in which the word-internal clusters do not show aspiration.

4.2. Vowel Lengthening and Devoicing

As was already mentioned above, the voicing of /b, d, g/ are not realized in an initial position since the "voiced" stops of English are often not voiced at all at the beginning of the word and in other voicing-unfriendly environments, with comparatively late VOT.[10]

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[10] Unlike German, there is not enough release of the stop in a word/syllable-final position (Iverson & Ahn 2007). That is, an English word-final stop is not released, so that, by being devoiced,

Note, however, that the phonemic (i.e., voicing or aspiration) distinction in the input is neutralized on the surface in a word/syllable-final position, but the earlier phonemic distinction is compensated for by the length distinction of the preceding vowel.[11] In pairs like *cap~cab, bit~bid, pick~pig,* for example, only those vowels preceding a "voiced" stop are lengthened, so that the pairs can be distinguished. This phenomenon is well documented in the literature (Liskjer 1957, Jensen 1993, Yavaş 2006, etc.). For this compensatory distinction, therefore, we need an additional constraint requiring a longer vowel when preceding an input stop lacking [sg] (i.e., a "voiced" stop in a traditional definition). And this additional constraint is inherently in conflict with the faithfulness constraint IDENT-V[long].

(31) a. V:[-sg] — A stop lacking [sg] is to be preceded by a long vowel.
b. IDENT-V[long] — The vowel length of the input is to be preserved in the output.

As observed above for the case of aspiration, the parallel version of OT cannot deal with the distinction in the pairs like *cap~cab, bit~bid, pick~pig,* etc. where we get different vowel length and stop neutralization. (We omit the irrelevant constraints for convenience here.)

(32) i. bit

pit$^{[sg]}$	*Stop[sg]#	**V:[-sg]**	IDENT(LAR)	ID-V[long]	*Lar
a. pit^h	*				*
☹ b. pit		*	*		
☞ d. pi:t			*	*	

word-final /b, d, g/ are neutralized with /p, t, k/. PW-R[sg] is, therefore, ranked lower than *Stop[sg]# in English so that there is no word-final aspiration in the examples like *stand up, exit, tactic*, etc. In German, however, we would need the opposite constraint ranking since syllable-final stops are often released in post-lexical phonology.

(i) Pw-R[sg] — A prosodic word-final obstruent is [spread glottis].

(ii) English: *Stop[sg]# » Pw-R[sg] e.g., *tag* [tʰæk], *write* [rajt] (cf. *ride* [rajt])
German: Pw-R[sg] » *Stop[sg]# e.g., *Tag* [tʰakʰ], *rad* [ratʰ] (cf. *rat* [ratʰ])

Due to the different ranking, the German final stops are aspirated, while the corresponding final stops in English are neither voiced nor aspirated (regardless of the input forms).

11 A reviewer comments that most speakers exploit the cue of vowel duration to carry the distinction but not all speakers do this. Citing Prunel et al. (2005), he adds that speakers appear to engage in 'cue trading', or balancing cues against each other.

ii. bid

	pit	*Stop[sg]#	**V:[-sg]**	IDENT(LAR)	ID-V[long]	*Lar
a.	pit^h	*		*		*
b.	pit		*			
☞ c.	pi:t					

(32) shows the identical output candidates [pi:t] for both cases in the parallel evaluation tableaux. The only solution to this problem, therefore, is to permit an intermediate stage to which this constraint applies, i.e., a serial OT. Employing the required constraints, the traditional voicing contrast in English is now realized as the presence/absence of aspiration, which can be accounted for within a new cyclic version of OT as follows.

(33) Cycle 1: lexical

i. bit

	$pit^{[sg]}$	**IDENT(LAR)**	**ID-V[long]**	*Stop[sg]#	V:[-sg]	*Lar
☞ a.	pit^h			*		*
b.	pit	*!			*	
c.	pi:t	*!	*			

ii. bid

	pit	**IDENT(LAR)**	**ID-V[long]**	*Stop[sg]#	V:[-sg]	*Lar
a.	pit^h	*!		*		*
☞ b.	pit				*	
c.	pi:t		*!			

In the first cycle, i.e., lexical, the top-ranked constraints IDENT(LAR) and ID-V[long] make the correct output selection, producing [pit^h] and [pit] where the input [sg] specification remains intact. Here any violation of the top-ranked constraints are fatal at the lexical level. Now, the outputs from the lexical cycle are transferred to the next cycle as the inputs, in which the V:[-sg] constraint is promoted, while IDENT(LAR) and ID-V[long] are demoted. However, all of the constraints are now violable in this post-lexical cycle. (We also note that the first candidate in (34i) represents a non-standard variety.)

(34) Cycle 2: post-lexical

i. bit

	$pit^{[sg]}$	**V:[-sg]**	IDENT(LAR)	ID-V[long]	*Stop[sg]#	*Lar
☞ a.	pit^h				*	*
b.	pit	*	*			
c.	pi:t		*	*		

ii. bid

pit	**V:[-sg]**	IDENT(LAR)	ID-V[long]	*Stop[sg]#	*Lar
a. pit^h		*		*	*
b. pit	*				
☞ c. pi:t			*		

Now, due to the difference in [sg] specification, the vowel length distinction can be obtained by the role of the "promoted" top constraint V:[-sg]. The two different outputs then move to the next cycle for the final evaluation, in which the lower-ranked *Stop[sg]# and ID-V[long] are "re-promoted", while the earlier top constraint V:[-sg] is "re-demoted".

(35) Cycle 3: post-lexical[12]

i. bit

pit^h	**ID-V[long]**	***Stop[sg]#**	V:[-sg]	IDENT(LAR)	*Lar
a. pit^h		*			*
☞ b. pit			*	*	
c. pi:t	*			*	

ii. bid

pi:t	**ID-V[long]**	***Stop[sg]#**	V:[-sg]	IDENT(LAR)	*Lar
a. pit^h		*		*	*
b. pit			*		
☞ c. pi:t					

As we can see in the above tableaux, the promoted two constraints ID-V[long] and *Stop[sg]# play crucial roles in the selection of the optimal outputs. Therefore, we need not only a serial model of evaluation but we may also need more than one cycle in the post-lexical domain.

4.4. Optional Aspiration

Besides the description made so far, it can also be observed that the presence/absence of aspiration can be regarded as a matter of degree in many cases. Thus, depending on the context or the speaker's intention, non foot-initial voiceless stops may or may not be released, while, as described above, aspiration of foot-initial stops and non-aspiration after /s/ within a foot are

[12] We can apply the same procedure for the description of the post-lexical distinction in *writer* ~ *rider* in which due to flapping the distinction between two stops are neutralized but can be compensated for by the distinction in vowel length, i.e., [rajɾər] ~ [raj:ɾər].

obligatory. For example, we may observe very weak aspiration as the targets are not foot-initial but are still word-initial as shown in (36).

(36) Word-initial (but not foot-initial): Optional (weak) aspiration
e.g., *Patrícia, pertáin, tomórrow, collíde, courágeous,* etc.

For these cases of (optional) word-initial aspiration, we can then postulate the concept of "positional faithfulness" (Beckman 1997, Lombardi 1998) to posit IDENT-INI[sg], observing that word-initial voiceless stops are (albeit slightly) aspirated in general even if they are non-foot-initial. Moreover, we also need a constraint which discourages aspiration of a non foot-initial stop. And, being broader in application, this new constraint can replace or subsume the *Stop[sg] constraint.

(37) IDENT-INI[sg] Corresponding input and output word/foot-initial segments have the same specification for [spread glottis].
*X[sg] Non foot-initial [sg] specification may not be realized.

Adding these constraints to the evaluation tableaux, we can get the optimal candidate in a satisfactory way. (We omit irrelevant constraints here for convenience.)

(38) *pertain*

p$^{[sg]}$ərt$^{[sg]}$ejn	IDENT-INI[sg]	*X[sg]	IDENT(LAR)	*Lar
a. p^{h}ərtéjn		*	*	*
b. Pərt^{h}éjn	*(p^{h})		*	*
☞ c. p^{h}ərt^{h}éjn		*		**

(39) *carpet*

k$^{[sg]}$ɑrp$^{[sg]}$ɪt$^{[sg]}$	IDENT-INI[sg]	*X[sg]	IDENT(LAR)	*Lar
a. k^{h}ɑ́rp^{h}ɪt^{h}		**		***
b. k^{h}ɑ́rp^{h}ɪt		*	*	**
☞ c. k^{h}ɑ́rpɪt			**	*

Here we observe that, dominating Ident-IO[sg], this positional faithfulness constraint, IDENT-INI[sg], can account for the aspiration of /p, t, k/ not only in foot-initial but also in word-initial positions. Moreover, as the aspiration is not obligatory, the violation of the constraints may not be fatal in this post-lexical level evaluation. On the other hand, *X[sg] actually eliminates unnecessary realization of the non foot-initial [sg] specifications.

4.4. Passive Voicing

As described in Jessen & Ringen (2002) for German, the English intervocalic stops lacking [spread glottis] also undergo passive voicing in the post-lexical cycle, producing [b, d, g]. Therefore, we can posit the constraint, PASSVOICE, which in turn conflicts with *[voice].

(40) a. PASSIVEVOICE Obstruents are voiced between sonorants.
b. *[voice] Voiced obstruents are prohibited.

Note, however, that passive voicing may not occur in an example like *begin* [k] (*[g]) as it is in a metrically strong position. We then modify the faithfulness constraint made above in (40) as follows.

(41) IDENT-INI(Lar): Modified version
A word/foot-initial segment of the output should have the same laryngeal property as in the input.

Now, as shown in (42), the modified faithfulness constraint, IDENT-INI(Lar), discourages a foot-initial stop from changing the laryngeal property (i.e., [spread glottis] or [voice]) of the input. (We omit the irrelevant constraints again.)

(42) a. begin

/pikin/	IDENT-INI(LAR)	PASSVOI	*[voice]	*LAR
a. $pik^hín$	*!	*		*
b. pigín	*!		*	
☞ c. pikín		*		

b. piggy

$/p^{[sg]}iki/$	IDENT-INI(LAR)	PASSVOI	*[voice]	*LAR
a. $p^híki$		*		*
b. pígi	*!		*	
☞ c. $p^hígi$			*	*

Based on the argument presented so far, it is now claimed that we get four variants for stops in English from the single distinction of [spread glottis] in the input representation. We can then schematize the alternation pattern of the /p, t, k/ ~ $/p^h, t^h, k^h/$ pairs as follows:

(43)	/k$^{[sg]}$/	[k$^{[sg]}$] ⇦	(/k$^{[sg]}$/ → Foot-initial: *kit* [k^{h}] (/k$^{[sg]}$/), *acquire* [k^{h}] Word-initial: *career* [k^{h}]
	/k/	[k] ⇦	(/k$^{[sg]}$/ → Final, CC: *kick* [k], *tactics* [k.t] (/k$^{[sg]}$t$^{[sg]}$/) /k/ Initial, Final, CC: *gig* [k], *abduct* [p.t] (/pt/)
		[g] ⇦	(/k/ → Intervocalic (not foot-initial): *legacy, piggy*

Here the realization of aspiration is due to the input containing [sg], while the passive voicing of a stop occurs only in the input lacking [sg]. Conversely, the [sg] distinction of the last input stops in *kick* or *gig* can be neutralized as [k] but it is compensated for by the vowel length distinction in the post-lexical evaluation.

5. Further Remarks

5.1. The Opacity: An Alternative OT Account

The compensatory vowel lengthening and the subsequent final devoicing produce an opacity issue as they are applied in a counter-bleeding order. The following example (44) shows an opaque rule application within a traditional [voice] account.

(44)	Traditional	rule application: [voice] account
	/skid/	'skid' [counter-bleeding]
	ski:d	V lengthening
	ski:t	Final devoicing

This example shows a case of counter-bleeding opacity. That is, if the rules were applied in the opposite order, final devoicing would bleed vowel lengthening in a transparent way. This sort of opacity can be moved when we reanalyze this case in terms of the aspiration, i.e., [spread glottis], account.

(45)	Aspiration	account
	/sk^{h}it/	'skid'
	sk^{h}i:t	V lengthening
	ski:t	Deaspiration

In (45), there is no counter-bleeding opacity since the final stop does not have the [spread glottis] specification in its underlying representation. That is, even if deaspiration applies first, it does not affect the length of the preceding vowel. Therefore, the problem of opacity seems to have been removed. Note, however, that another opacity issue emerges when we extend this aspiration account to other cases, such as 'spit'. To clarify, the following aspiration account of 'spit' shows an opposite case of opacity, namely, counter-feeding.

(46)	$/sp^hit^h/$	'spit' [counter-feeding]
	---	V lengthening
	spit	Null, Deaspiration

This is a case of (counter-feeding) opacity because, if applied first, final deaspiration would generate a context which makes vowel lengthening applicable.

The issue of "opacity" has been one of the most controversial issues in phonology. The notion is defined as follows in Kiparsky (1973a).

(47) Phonological processes are opaque if their effects or their contexts are not visible in surface forms.

Within the traditional rule-based theory since SPE, this sort of opacity has been treated in terms of counterfeeding or counterbleeding, leaving various controversies (Anderson 1974, Kiparsky 1968, 1973, Koutsoudas et. al. 1974, Kenstowicz & Kisseberth 1971, etc.).

On the other hand, the "classic" OT (McCarthy & Prince 1995) and other parallel versions of OT (Benua 1997) have a natural bias toward transparent (i.e., feeding and bleeding) interaction. That is, markedness constraints can only state generalizations about surface structure, but not any intermediate structure, as shown in the following diagram (McCarthy 2006).

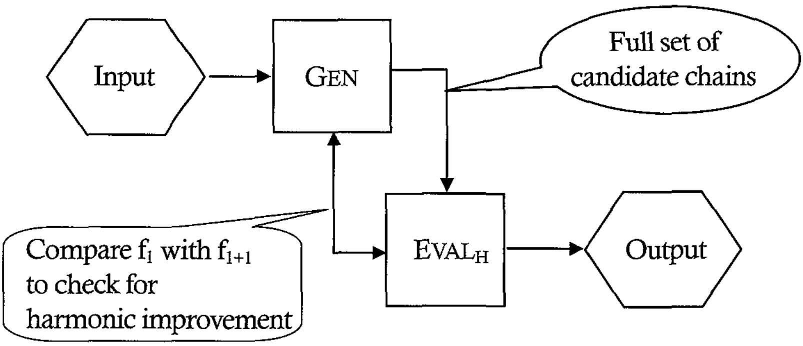
(48) Classic OT

Input (Underlying representation)	→	GEN	→	EVAL$_H$	→	Output (Surface representation)

As we can see here, Classic OT has only two levels of representation, INPUT and OUTPUT. GEN generates the output candidates and, comparing the output candidates, EVAL selects the optimal output in a given (language-particular) constraint hierarchy. That is, the class OT is nonderivational, mapping inputs directly to outputs without intermediate stages. With OT markedness constraints, what you see is what you get. But in opacity, what you see is not always what you get (McCarthy 2006). This is a big challenge to classic OT.

To solve the problem of opacity, therefore, there have been numerous attempts to employ the notion of "serialism" within OT (Rubach 2000a, b, 2003; Clements 2000; Kiparsky 2000; etc.). For instance, in a series of papers, McCarthy (1999, 2002) attempted to solve the dilemma by "implicitly" manipulating the parallel candidates in a serial way but he could not achieve much success. Recently, McCarthy (2006) has proposed a new model, OT-Candidate Chain (OT-CC), incorporating a derivational account within OT.

(49) The outline of OT-CC



The framework of OT-CC is another version of OT in that, like the earlier classic OT, it has violable constraints, a constraint hierarchy, and candidate comparison. However, unlike classic OT evaluating fully formed output candidates, OT-CC evaluates derivational steps as well through hypothesized candidate chains. McCarthy (2006) claims that for any input in any language, the set of valid candidate chains is finite and the number of operations required to produce this candidate is also finite. In other words, we allow an infinite candidate set in Classic OT as GEN imposes no natural bounds on the number of candidates, while the infinite proliferation of candidates is controlled by EVAL through a selection process whereby unfaithful candidates lose unless a certain markedness constraint favors them. In OT-CC, however, we may achieve the finiteness in candidate chains by allowing only those candidate chains with harmonic improvement. Therefore, what is crucial in OT-CC is to posit a PRE(cedence) constraint which can inspect both input and output in a candidate chain. McCarthy (2006) proposes this constraint as follows[13]:

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[13] In a recent work, however, McCarthy (2007: 98) proposes a formal notion PREC constraint in (i), based on the basic notions shown in (ii).

(i) PREC(A, B)(*cand*)
Let A' and B' stand for LUMS that violate the faithfulness constraints A and B, respectively.
Let *cand*=(*in*, *out*, $\mathscr{L}$, rL)
(i) $\forall B' \in \mathscr{L}$, if $\nexists A' \in \mathscr{L}$, where $\langle A', B' \rangle \in r\,\mathscr{L}$, assign a violation mark.
and
(ii) $\forall B' \in \mathscr{L}$, if $\exists A' \in \mathscr{L}$, where $\langle B', A' \rangle \in r\mathscr{L}$, assign a violation mark.

(ii) Candidate in OT-CC
A candidate is an ordered 4-tuple (*in*, *out*, $\mathscr{L}$-set, rLUMSeq), where
in is a linguistic form, the input;

(50) PREC(edence) constraints (informal, McCarthy 2006)
PREC(A, B)
Let A' and B' stand for forms that add violations of the faithfulness constraints A and B respectively.
To any chain of the form <X, B', Y>, if X does not contain A', assign a violation mark and to any chain of the form <X, B', Y>, if Y contains A', assign a violation mark.

Employing the Prec constraint, we can get the correct candidate chain for *skid* [ski:t] as shown below.[14] (Here I use the constraint *Stop[sg], instead of *X[sg], for easier comparison. Moreover, for easier demonstration, I will use the classical "evaluation tableau", rather that the "comparative tableau format" proposed in Prince (1998, 2002).

(51) /sk^{h}it/ 'skid'	NULL [sg]	*STOP [sg]#	PREC(ID-V[LONG], ID(LAR))	ID-V[LONG]	ID (LAR)
a. ☞ <sk^{h}it, sk^{h}i:t, ski:t> <ID[sg], Id-V[long]>				*	*
b. <sk^{h}it, skit, ski:t> <ID[sg], Id-V[long]>			**	*	*
c. <sk^{h}it, ski:t> <ID[sg], Id-V[long]>			*	*	*
d. <sk^{h}it> < >	*!				

out is a linguistic form, the output;
$\mathcal{X}$-set is a set of LUMs on *in* $\rightarrow$ *out*
and rLUMSeq is a partial ordering on a subset of $\mathcal{X}$-set.

LUM represents a *localized unfaithful mapping*; that is, a single violation of a basic faithfulness constraint in a specific location in a form. This notion of "LUM" thus indicates gradualness in a candidate chain as the successive forms in a candidate chain are required to accumulate all of their predecessor's LUMs. And a form may add exactly one LUM to those of its immediate predecessor. $\mathcal{X}$-set is a list of all the elements that enter into the ordering—that is, {A, B, C}. The $\mathcal{X}$-set, then, is simply a list of all the LUMs violated in a chain or set of convergent chains. A LUMSeq is projected from a candidate chain and the singleton chain has the empty LUMseq.

14 We would get the wrong output if we postulate a Prec constraint where ID[sg] and ID-V[LONG] are rearranged in the opposite order, i.e., PREC(ID[SG], ID-V[LONG]).

/sk^{h}it/ 'skid'	Null[sg]	*STOP[sg]#	PREC(ID[sg], ID-V[LONG])	ID-V[LONG]	ID(LAR]
a. <sk^{h}it, sk^{h}i:t, ski:t> <ID[sg], Id-V[long]>			**	*	*
b.☜ <sk^{h}it, skit, ski:t> <ID[sg], Id-V[long]>				*	*
c. <sk^{h}it, ski:t> <ID[sg], Id-V[long]>			*		
d. <sk^{h}it> < >	*!				

As shown in (51), the PREC constraint correctly selects the optimal output (51a) showing harmonic improvement, in which the compensatory lengthening for phonemic distinction precedes the allophonic deaspiration. The current analytic device, however, does not work due to the problem of indeterminacy in choosing the B' in a PREC(A, B) constraint. Note that it is difficult to postulate an intermediate form (i.e., B') since any form violating IDENT[sg] at least once can be used as B' in the PREC(A, B) constraint, i.e., < skit^h>, < sk^{h}it>, or <skit>. So, we need to refine the notion of PREC. Moreover, even if we take the forms in the middle in (52a-b) and the second one in (52c), all of the three candidates (52a-c) can be the possible candidates which are tied in the evaluation.

(52)	/sp^{h}it^h/ 'spit'	NULL [sg]	*STOP [sg]#	PREC(ID-V[LONG], ID(LAR))	ID-V[LONG]	ID (LAR)
a.?	<sp^{h}it^h, spit^h spit> <Id[sg]>			*		**
b.?	<sp^{h}it^h, sp^{h}it, spit> <Id[sg]>			*		**
c.?	<sp^{h}it^h, spit> <Id[sg]>			*		**
d.	<sp^{h}it^h> <Id[sg]>	*!	*			*

Due to this problem of indeterminacy in harmonic evaluation, the current version of OT-CC is not satisfactory for the analysis of the allophonic variations in English. (In fact, we do not need any intermediate stage in this case as we are dealing with the same allophonic variation of aspiration.) Nevertheless, when we deal with both phonemic and allophonic processes together, we need more than one intermediate element in the candidate chains but it would not be easy to take care of the opaque derivations as their derivational sequences may not show harmonic improvement.

As was discussed above, just like the earlier parallel versions of OT, the (partially serial) OT-CC framework would not work for the various cases of allophonic alternations in English unless we manipulate certain input forms or rely on intermediate levels (Ahn 2006b, c). The cyclic account proposed in this paper, however, does not require such restrictions. Moreover, by not invoking a PREC constraint or a candidate chain, this cyclic account is not only simpler but intuitively more explanatory. Lastly, postulating the division among cycles can be easily justified in that it reflects the phonemic/allophonic distinction or dialectal variations. Therefore, we need multiple evaluation cycles in analyzing a morphological complex forms or allophonic alternations. By importing the notion of cyclicity, we can not only resolve the problem of opacity but set up an intuitively more plausible OT grammar.

5.2. Implications

So far, we have discussed the laryngeal specification of stops in English and German, based on the so-called aspiration account (Iverson & Salmons 1995, Avery & Idsardi 2000, Ahn & Iverson 2004, etc.). First, it was shown that positing [spread] rather than [voice] as the marked laryngeal feature for English leads to deeper understanding of the distribution of aspiration and to a more satisfying analysis of other related issues, such as word-final laryngeal neutralization, compensatory vowel lengthening, and passive voicing, etc. Here we observed that this new account not only shows the optimal description of the English obstruents but also the typological characteristics of the Germanic languages. Based on this theoretical background, I then proposed a new Optimality account of these processes to rectify the failing of parallelism of the "classic" Optimality Theory (McCarthy & Prince 1995, Benua 1997) to account for these variations. I, therefore, proposed to incorporate the concept of "serialism" and the cyclic application of constraints in Optimality Theory (Kiparsky 2000; Rubach 2000a, b, 2003; Ahn 2006a, b, c, 2007; etc.). Here I argued for positing a re-ranking mechanism in each evaluation cycle, in which violation of certain higher-ranked constraints may not be fatal in the post-lexical cycle if optimal output is optionally realized. Furthermore, the most common problems can be satisfactorily described by importing the cyclic mechanism as shown in Derivational Optimality Theory (Rubach 2000a, b, 2003). But the categorization of each evaluation cycle differs from that of Derivational Optimality Theory (solely relying on pure phonological cycles), as the current account is based on the basic concept of Lexical Phonology (Kiparsky 1985; Ahn 2006a, b, c) requiring the lexical vs. post-lexical distinction in phonology. Here, of course, we may think of alternative approaches like the employment of the Faith-IO vs. Faith-OO demarcation (Benua 1997) or the notion of comparative markedness (McCarthy 2002). But either of them would not be able to account for the *bit~bid* distinction since we are not dealing with a derivational process. That is, we need to invoke an intermediate stage for this distinction within a new framework of a serial OT as proposed in this paper.

Finally, it must be added that the [spread glottis] feature in English is implemented into voiceless stops in various ways as English aspiration is affected by the position of the target voiceless stops in a syllable: at the beginning of a stressed syllable, it is fully realized, less so at the beginning of an initial unstressed one and not much at all at the beginning of an internal unstressed one (so the /p/ in *potato* is less aspirated than the first /t/, and the last /t/ is not aspirated at all, although all are [spread glottis]). Moreover, the feature is shared, hence aspiration is somewhat "absorbed" in syllable-initial clusters like *sp, st, sk,* etc. As shown in the following table below, therefore, the stop is still [spread glottis] and it is just a matter of degree as to how much aspiration (if any) is realized, (assuming that [sg] is absorbed in a s+stop cluster).[15] Furthermore, a syllable-final /p, t, k/ often gets glottalized, rather than aspirated.

(53)	a. Foot-initial (preceding a stress)	(Strong) aspiration	*Pátrick, potáto, volcáno,* etc.
	b. Word-initial (not foot-initial)	(Weak) aspiration	*Patrícia, tomórrow, collíde,* etc.
	c. Non foot/syllable-initial (after /s/)	No aspiration	*Spáin, státic, skip,* etc.
	d. Syllable-final	No aspiration, (Glottalization)	*Stop it, kick,* etc.
	e. Syllable-internal cluster	No aspiration	*Tactical, cockpit,* etc.

These examples show that there should be a way to differentiate these allophonic variations from the phonemic ones. As was proposed in the previous section, therefore, we need to employ the cyclic evaluation in OT, in which the lexical cycle precedes the subsequent post-lexical cycle.

References

Ahn, Sang-Cheol. (2006a). Laryngeal specification in Germanic: A cyclic OT account. Paper presented at the 12th Germanic Linguistics Annual Conference, University of Illinois at Urbana-Champaign.

Ahn, Sang-Cheol. (2006b). Pre-liquid schwa insertion in English. Paper presented at the 2006 autumn conference, The Linguistic Society of Korea.

Ahn, Sang-Cheol. (2006c). A cyclic optimality analysis of Polish vowel alternation. *Studies in Phonetics, Phonology and Morphology* 12.3, 597-621. The Phonological Society of Korea.

Ahn, Sang-Cheol. (2007). On the ambivalent representation of the Korean liquid. Paper presented at the 15th Manchester Phonology Meeting.

Ahn, Sang-Cheol and Gregory K. Iverson. (2004). Dimensions in Korean Laryngeal Phonology. *Journal of East Asian Linguistics* 13.4, 343-379.

Anderson, Stephen R. (1974). *The Organization of Phonology*. Academic Press.

15 Within a gestural account, therefore, it can be stated that aspiration is not a feature per se either, but rather a variable automatic consequence of the phonetic implementation of [spread glottis]. That is, it is an epiphenomenon of the manifestation of the feature or gesture [spread glottis], not itself a feature, and ranges prosodically from heavy to light to none.

Avery, J. Peter. (1996). *The Representation of Voicing Contrasts*. Doctoral dissertation, University of Toronto.

Avery, Peter and William Idsardi. (2001). Laryngeal dimensions, completion and enhancement. In T. A. Hall and U. Kleinhanz, eds., *Studies in Distinctive Feature Theory.* 41-70. Mouton de Gruyter.

Beckman, Jill. (1997). *Positional Faithfulness*. Doctoral Dissertation, University of Massachusetts.

Benua, Laura. (1997). *Transderivational Identity: Phonological Relations between Words.* Doctoral dissertation, University of Massachusetts.

Browman, Catherine P. and Louis Goldstein. (1992). Articulatory Phonology: an overview. *Phonetica* 49,155-180.

Clements, G. N. (2000). In defense of serialism. *The Linguistic Review* 17.2-4, 81-97.

Ewen, Collin J. and Harry van der Hulst. (2001). *The Phonological Structure of Words.* Cambridge University Press.

Flemming, Edward. (1995). *Auditory Representations in Phonology*. Doctoral dissertation, UCLA.

Harris, John. (1994). *English Sound Structure*. Blackwell.

Iverson, Gregory K. and Sang-Cheol Ahn. (2007). English Voicing in Dimensional Theory. *Language Sciences: Issues in English Phonology.* [Special Issue edited by Philip Carr & Patrick Honeybone] 29.2-3, 247-269.

Iverson, Gregory K. and Joseph C. Salmons. (1995). Aspiration and laryngeal representation in Germanic. *Phonology* 12.369-396.

Iverson, Gregory K. and Joseph C. Salmons. (2003). Laryngeal enhancement in Early Germanic. *Phonology* 20, 43-72.

Jensen, John T. (1993). *English Phonology*. John Benjamins.

Jessen, Michael. (1998). *Phonetics and Phonology of Tense and Lax Obstruents in German.* John Benjamins Publishing Co.

Jessen, Michael and Catherine Ringen. (2002). Laryngeal features in German. *Phonology* 19.2, 189-218.

Kager, René. (1999). *Optimality Theory.* Cambridge University Press.

Kenstowicz, Michael and Charles Kisseberth. (1971). Unmarked bleeding orders. *Studies in the Linguistic Sciences* 1, 8-28.

Kim, Chin-Wu. (1970). A theory of aspiration. *Phonetica* 21,107-116.

Kingston, John. (1990). Articulatory binding. In J. Kingston & M. Beckman, eds., *Papers in Laboratory Phonology I: Between the Grammar and Physics of Speech,* 406-434. Cambridge University Press.

Kiparsky, Paul. (1968). Linguistic universals and linguistic change. In E. Bach and R. Harms, eds., Universals in Linguistic Theory, 170-202. Holt, Rinehart and Winston.

Kiparsky, Paul. (1973). Abstractness, opacity and global rules. In O. Fujimura, ed., *Three Dimensions in Linguistic Theory*, 57-86. TEC.

Kiparsky, Paul. (1985). Some consequences of Lexical Phonology. *Phonology* 2, 85–138.

Kiparsky, Paul. (2000). Opacity and cyclicity. *The Linguistic Review* 17.2-4, 351-367.

Koutsoudas, Andreas, Sanders, Gerald, and Craig Noll. (1974). On the application of phonological rules. *Language* 50, 1-28.

Ledefoged, Peter. (1993). *A Course in Phonetics*. Harcourt Brace.

Ladefoged, Peter. (2001). *Vowels and Consonants*. Blackwell.

Ladefoged, Peter and Ian Maddieson. (1996). *The Sounds of the World s Languages*. Blackwell.

Lombardi, Linda. (1991). *Laryngeal Features and Laryngeal Neutralization*. Doctoral dissertation, University of Massachusetts at Amherst. Published 1994 by Garland Press.

Lombardi, Linda. (1998). Restrictions on direction of voicing assimilation: An OT account. *University of Maryland Working Papers in Linguistics* 3, 89-115.

Lombardi, Linda. (1999). Positional faithfulness and voicing assimilation in Optimality Theory. *Natural Language and Linguistic Theory* 17, 267-302.

McCarthy, John. (1999). Sympathy, culminativity, and Duke-of-York Gambit. ROA-327.

McCarthy, John. (2002a). Comparative markedness. Ms. ROA-489.

McCarthy, John J. (2002b). *A Thematic Guide to Optimality Theory*. Cambridge University Press.

McCarthy, John. (2006). Derivations as candidates in Optimality Theory. Talk given at the Phonology Forum 2006. The Phonological Society of Japan, Waseda University in Tokyo.

McCarthy, John. (2007). *Hidden Generalization: Phonological Opacity in Optimality Theory*. London: Equinox Publishing.

McCarthy, John and Alan Prince. (1995). Faithfulness and reduplicative identity. *University of Massachusetts Occasional Papers 18: Papers in Optimality Theory*, 249-384.

Petrova, Olga, Rosemany Plapp, Catherine Rignen, and Szilárd Snentgyörgyi. (2000). Constraints on voice : an OT typology. Paper presented at the 74th Annual Meeting, LSA, Chicago.

Prince, Alan. (1998). A proposal for the reformation of tableaux. Ms. Rutgers University.

Prince, Alan. (2002). Arguing optimality. *Papers in Optimality Theory* II (=*University of Massachusetts Occasional Papers* 26), 269-304. [Available on ROA-562]

Prince, Alan and Paul Smolensky. (1993/2004). *Optimality Theory: Constraint Interaction in Generative Grammar*. Blackwell. [Revision of 1993 technical report, Rutgers University Center for Cognitive Science. Available on ROA-537.]

Purnell, Thomas, Joseph Salmons, Dilara Tepeli, and Jennifer Mercer. (2005). Structured heterogeneity and change in laygneal phonetics: Upper Midwestern final obstruents. *Journal of English Linguistics* 33.4, 307-333.

Rubach, Jerzy. (1990). Final voicing and cyclic syllabification in Germanic. *Linguistic Inquiry* 21, 79-94.

Rubach, Jerzy. (2000a). Backness switch in Russian. *Phonology* 17, 39-64.

Rubach, Jerzy. (2000b). Glide and glottal stop insertion in Slavic languages: A DOT analysis. *Linguistic Inquiry* 31, 271-317.
Rubach, Jerzy. (2003). Polish palatalization in Derivational Optimality Theory. *Lingua* 113, 197-237.
Vaux, Bert. (1998). The laryngeal specification of fricatives. *Linguistic Inquiry* 29, 497-511.
Yavaş, Mehmet. (2006). *Applied English Phonology*. Blackwell.

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