The distribution of aspirated stops and /h/ in American English and Korean: an alignment approach with typological implications*

STUART DAVIS AND MI-HUI CHO

Abstract

Languages that have both aspirated stops and the phoneme /h/ often manifest a close parallel in their distribution. Previous work in phonology either has failed to recognize this close parallel or does not formally account for it. For example, American English witnesses a close parallel in the distribution of /h/ and aspirated stops that has largely gone unrecognized in the phonological literature. This paper offers a detailed optimality-theoretic analysis of the distribution of aspirated stops and /h/ for both American English and Korean. For each of these languages we delineate their distribution and show how an optimality-theoretic analysis can account for it. We develop an alignment analysis of their distribution that makes reference to constraints that require positions of prominence (such as word-initial or foot-initial position) to be aligned with the feature [spread glottis]. We further demonstrate how the alignment analysis predicts a typology of patterning of aspirated stops and /h/. Crucially, the typology does not predict that every language should have a close parallel in their distribution like American English, but as we show, it predicts a range of patterns that are instantiated.

Languages that have both aspirated stops and the phoneme /h/ frequently manifest a close parallel in their distribution. This is not surprising given that such sounds are characterized by the feature [spread glottis] (henceforth, [s.g.]). Previous work in phonology either has failed to recognize the close distributional parallel between aspirated stops and /h/ or does not formally account for it. For example, virtually none of the work on American English phonology observes the similarity of distribution that exists between them. In this paper we develop an alignment analysis of the feature [s.g.] that accounts for the close parallel in the distribution of /h/ and aspirated stops. In the first part of this paper we illustrate the close
parallelism in their distribution in American English and then offer an analysis of it within optimality theory. Crucial to our analysis of English is a constraint aligning the beginning of a foot with the feature [s.g.]. In the second part of the paper we consider the distribution of /h/ and aspirated stops in Korean. We show that in Korean their distribution is only partially parallel in that aspirated stops can surface in more phonetic environments than /h/. We account for the difference between English and Korean in terms of different constraint rankings in an optimality-theoretic grammar. For the analysis of Korean we reference a constraint aligning the beginning of the word with the feature [s.g.]. Thus, given our analysis of English and Korean, we account for the patterning of the feature [s.g.] by reference to constraints that require [s.g.] to surface in various positions of prominence. The organization of this paper is as follows. In section 1 we present the data that show the parallel distribution between /h/ and aspirated stops in American English. In section 2 we develop an optimality-theoretic analysis accounting for the distribution of aspirated stops and /h/ in American English in a unified way. In section 3 we discuss two other possible approaches in accounting for the distribution of /h/ and aspirated stops in American English and note their shortcomings. In section 4 we present the Korean data showing the distribution of /h/ and aspirated stops and in section 5 we offer an optimality-theoretic analysis of it. In section 6 we consider the typological implications of our analysis by examining the distribution of aspirated stops and /h/ in other languages. Section 7 concludes the paper.

1. The distribution of aspirated stops and /h/ in American English

In considering aspirated stops and /h/ in American English, there are certain positions in the word where these can occur and other positions where they cannot. Their distribution is quite parallel. Both aspirated stops and /h/ surface at the beginning of a syllable with primary stress whether that syllable is word-initial or elsewhere in the word. This is seen by the data in (1) where the (a) column shows aspirated stops and the (b) column /h/.

(1) At the beginning of a syllable with primary stress

<table>
<thead>
<tr>
<th>a.</th>
<th>b.</th>
</tr>
</thead>
<tbody>
<tr>
<td>póny</td>
<td>hábit</td>
</tr>
<tr>
<td>térrible</td>
<td>héro</td>
</tr>
<tr>
<td>cándy</td>
<td>history</td>
</tr>
<tr>
<td>atómic</td>
<td>prohibit</td>
</tr>
<tr>
<td>appéar</td>
<td>Tahiti</td>
</tr>
<tr>
<td>matériel</td>
<td>mahógyan</td>
</tr>
<tr>
<td>opticián</td>
<td>adhérence</td>
</tr>
</tbody>
</table>
Aspiration and /h/ also surface at the beginning of a syllable with secondary stress as in (2).

(2) At the beginning of a syllable with secondary stress

- a. dávenpört [pʰ]  
  Atáscadéro [tʰ]  
  titánic [tʰ]  
  cúcumber [kʰ]  
  Chéspapêke [pʰ]
- b. álcohól [h]  
  Ahâsuérus [h]  
  hypótenuse [h]  
  Ojái [h]  
  Ídahô [h]

Another position where both aspiration and /h/ occur is at the beginning of the word before a stressless syllable. This is exemplified by the data in (3).

(3) At the beginning of a word-initial stressless syllable.²

- a. Pacific [pʰ]  
  tomató [tʰ]  
  connéc [kʰ]  
  potáto [pʰ]
- b. horizon [h]  
  Hawái [h]  
  habitual [h]  
  hypócrisy [h]

A further position where both aspirated stops and /h/ occur is in the onset of a word-internal stressless syllable when the preceding syllable is also stressless. This is exemplified by the third syllable of the data items in (4). It should be mentioned that data like that in (4a) is often not discussed in the literature on English aspiration (e.g. Iverson and Salmons 1995; Selkirk 1982), though Jensen (2000) credits Withgott (1982) with first observing aspiration in such an environment.³ Data like that in (4b) seem exceedingly rare, but nonetheless parallel the aspiration pattern of (4a).

(4) At the beginning of a stressless syllable when immediately preceded by a stressless syllable and followed by a stressed one

- a. Méditerránean [tʰ]  
  Návratióva [tʰ]  
  lôlapalóozan [pʰ]  
  Winepessáuukee [pʰ]  
  perípatétic [pʰ]  
  Nêbucadnézzar [kʰ]  
  abrácadábra [kʰ]
- b. Tàrahumára [h]

On the other hand there are several environments where neither aspiration nor /h/ surfaces. The data in (5) show that neither surfaces in coda position. The words in (5a) all have voiceless stops in coda position, but they are not realized as aspirated. The words in (5b) are all borrowed
words containing a coda /h/ in the source language. The /h/ is not realized in the American English pronunciation.

(5) In coda position (h indicates a possible /h/ that does not surface)\(^4\)

<table>
<thead>
<tr>
<th>Example</th>
<th>Pronunciation</th>
</tr>
</thead>
<tbody>
<tr>
<td>at.las</td>
<td>[t(^\prime)]</td>
</tr>
<tr>
<td>ac.ne</td>
<td>[k(^\prime)]</td>
</tr>
<tr>
<td>hyp.no.sis</td>
<td>[p(^\prime)]</td>
</tr>
<tr>
<td>lapse</td>
<td>[p(^\prime)]</td>
</tr>
<tr>
<td>Teh.ran</td>
<td></td>
</tr>
<tr>
<td>brah.min</td>
<td></td>
</tr>
<tr>
<td>Yah.weh</td>
<td></td>
</tr>
<tr>
<td>Fahd</td>
<td></td>
</tr>
</tbody>
</table>

The data in (6) show that neither aspiration nor /h/ occurs intervocally as the onset to a stressless syllable that follows a stressed one.

(6) At the beginning of a (noninitial) stressless syllable following a stressed one

<table>
<thead>
<tr>
<th>Example</th>
<th>Pronunciation</th>
</tr>
</thead>
<tbody>
<tr>
<td>átom</td>
<td>[t]</td>
</tr>
<tr>
<td>Mickey</td>
<td>[k(^\prime)]</td>
</tr>
<tr>
<td>ráp.id</td>
<td>[p]</td>
</tr>
<tr>
<td>hãppen</td>
<td>[p]</td>
</tr>
<tr>
<td>vé.hi.cle</td>
<td></td>
</tr>
<tr>
<td>prò.hi.bi.tion</td>
<td></td>
</tr>
<tr>
<td>ni.hi.lism</td>
<td></td>
</tr>
<tr>
<td>prè.hi.stò.ric</td>
<td></td>
</tr>
</tbody>
</table>

Finally, the data in (7) show that neither can occur as part of the second position of an onset even if in a stressed syllable.

(7) As a possible second member of an onset

<table>
<thead>
<tr>
<th>Example</th>
<th>Pronunciation</th>
</tr>
</thead>
<tbody>
<tr>
<td>ski</td>
<td>[k]</td>
</tr>
<tr>
<td>exposition</td>
<td>[p]</td>
</tr>
<tr>
<td>extinguish</td>
<td>[t]</td>
</tr>
<tr>
<td>Bhutan</td>
<td></td>
</tr>
<tr>
<td>exhibition</td>
<td></td>
</tr>
<tr>
<td>exhibit</td>
<td></td>
</tr>
</tbody>
</table>

While there has been little discussion on the parallel distribution of /h/ and aspiration in the phonological literature,\(^5\) their parallel distribution has been particularly emphasized in the phonetics literature by Goldstein (1992). In commenting on a paper by Pierrehumbert and Talkin (1992) that examined the magnitude of the laryngeal gesture for /h/ in words like those in the (b) column in (1)–(3) above, Goldstein (1992: 121–122) noted the following: that there was very little difference in gestural magnitude between word-initial and word-medial positions for /h/ at the beginning of a stressed syllable; that the laryngeal gesture in word-initial position is longer when that syllable is stressed (first three examples in [1b]) than when it is not stressed (as in [3b]); but that for unstressed syllables there is a word-position effect so that the laryngeal gesture is larger at the beginning of a word-initial stressless syllable (as in [3b]) as opposed to a word-medial stressless syllable (as in [6b]). Goldstein compares Pierrehumbert and Talkin’s (1992) findings on the magnitude of the laryngeal gesture for /h/ with work by Cooper showing the magnitude of the laryngeal gesture coordinated with an oral (voiceless) stop. In comparing these studies, Goldstein noted that the effects of the laryngeal
Aspirated stops and /h/

Aspirated stops and \(/h/\) gesture generalized over the presence or absence of coordinated oral gestures. That is, similar prosodic positions of the \(/h/\) and oral stops were coordinated with similar laryngeal gestures. In the words of Goldstein (1992: 122), “there is strong parallelism between prosodic effects on laryngeal gestures for \(/h/\) and on those that are coordinated with oral stops. This similarity is particularly impressive in face of the very different acoustic consequences of laryngeal gestures in the two cases: generation of breathy voice (\(/h/\)) and generation of voiceless intervals.” The observations of Goldstein (1992) need to be emphasized since it seems to be the only phonetic discussion that explicitly compares studies on the laryngeal gestures associated with oral stops and with \(/h/\). These observations support the claim of the close parallel in distribution between aspiration and \(/h/\) in American English as laid out in (1)–(7) in this section.6

2. An optimality-theoretic analysis of English aspiration and \(/h/\)

In this section we will develop an optimality-theoretic analysis of the data in (1)–(7) that accounts for the parallelism of the distribution of aspirated stops and \(/h/\). Before beginning, however, we first make clear our assumptions regarding the feature-geometric representation of \(/h/\) and aspirated stops in 2.1. We then discuss our assumptions about foot structure in American English in 2.2 since that will play a critical role in our analysis. We present our detailed optimality-theoretic analysis in 2.3. Section 3 will briefly discuss previous analyses of the distribution of aspirated stops and \(/h/\).

2.1. On the representation of \(/h/\) and aspirated stops

In this subsection we make clear our assumptions regarding the featural representation of \(/h/\) and aspirated stops. These segment types are similar in that they are both characterized by the feature [spread glottis] (cf. Halle and Stevens 1971). We assume the feature-geometric representation of \(/h/\) given in (8a) where \(/h/\) is viewed as placeless having only the laryngeal feature [spread glottis]. The phoneme \(/h/\) is assumed to have a root node and is not a floating segment. With respect to voiceless stops, we follow Spencer (1996) and others in making the standard assumption that [spread glottis] is not underlingly specified for voiceless stops in English. This is because the occurrence of the feature on voiceless stops is noncontrastive and predictable. However, this is not a crucial
assumption in our analysis. The optimality-theoretic analysis that we offer would readily account for their distribution even if we assume that [spread glottis] is underlyingly present on voiceless consonants. This is briefly discussed at the end of section 2.3. The underlying representation of a voiceless stop is shown in (8b). We assume that when [s.g.] is assigned to a voiceless stop it surfaces with both the features [s.g.] and [−voice].

(8) Underlying representation of English /h/ and aspirated stops in feature geometry ([s.g.] = spread glottis)  

\[
\begin{array}{c}
\text{Root node} \\
\text{Laryngeal} \\
\text{[s.g.]} \\
\end{array} \quad \begin{array}{c}
\text{Root node} \\
\text{Place} \\
\text{Laryngeal} \\
\text{[−voice]} \\
\end{array}
\]

2.2. On foot structure in American English

In order to understand the patterning of /h/ and aspirated stops (i.e. of the feature [s.g.]) in (1)–(7), it is necessary to discuss the nature of American English foot structure. This is because the basic generalization accounting for the distribution of [s.g.] in (1)–(7) is that it surfaces in foot-initial position. This is not an obvious generalization especially in light of the data in (3) and (4). With respect to English foot structure we take the view of Pater (2000) that feet in English words are trochaic. This is the standard view in the metrical literature on English, at least going back to Hayes (1981). In (1) and (2), the stressed syllable constitutes the initial syllable of a trochaic foot; thus, the voiceless stop and /h/ that are in foot-initial position in those words are realized with [s.g.].

An issue that arises regarding the nature of English foot structure concerns the footing in words like that in (3) and (4). The words in (3) and (4) are similar to one another in that they all contain a stressless syllable, not part of a preceding foot, which is immediately before the syllable with main stress. The parsing of this syllable into a foot is somewhat unclear as shown by the examples in (9) where it is left stranded or unparsed. (9a)–(9b) exemplify voiceless stops in this position while (9c)–(9d) show /h/. (Parentheses delimit the trochaic foot. For ease of exposition we ignore final extrametricality and assume bisyllabic feet as opposed to bimoraic foot.)
Aspirated stops and /h/

(9) a. po(tato)  b. (Navra)ti(lova)
   \[p^h\theta(t^\theta\epsilon\rho\alpha)\]  \[(n^\alpha\nu\nu\alpha)t^\alpha(\lambda\omega\alpha)\]
c. ho(rizon)  d. (Tàra)hu(mara)
   \[h\theta(r\acute{y}.z\alpha)\]  \[(t\acute{\i}r\alpha)h\alpha(m\acute{\i}r\alpha)\]

This should be compared with the data in (10), which do not have this stranded syllable.

(10) a. (happen)  b. (prohi)(bition)
   \[(h^\alpha\epsilon\nu\pi\alpha)\]  \[(p^h\rho\acute{\i}\acute{\i}b\acute{\i}z\alpha)\]

The status of the stranded syllable in words like (9) is somewhat controversial. One could posit that these stranded syllables are just left unparsed into foot structure as indicated in (9). However, this would fail to explain the appearance of [spread glottis] in the onset of these stressless syllables, especially given the fact that a stranded syllable at the end of the word typically cannot begin with an aspirated stop. This is seen in (11).

(11) a. (cano)py  b. (peli)can  c. (chari)ty
   \[(k^\alpha\epsilon\nu\alpha\pi\alpha)\]  \[(p^\alpha\epsilon\lambda\kappa\alpha\nu)\]  \[(c^\alpha\epsilon\i\alpha\alpha\i\alpha]\]

Another approach to the stranded syllables in (9) that has been suggested to us by Harry van der Hulst and one of the anonymous reviewers is to view such syllables as constituting a degenerate foot, even though they surface as stressless. While we could adopt this position given the foot-based analysis we develop, we do not pursue it given our view that metrical feet constitute a stress domain. Instead, we follow Jensen (2000), who proposes an analysis in which the stranded (monomoraic) syllable constitutes the initial syllable of a superfoot. His proposed structure is shown hierarchically in (12) for the words potato and lolapalooza. ($F =$ foot, $F_s =$ superfoot, $s_w =$ stressless syllable, $s_i =$ stress syllable)

(12) a. $F_s$  b. $F$  c. $F_s$

\[
\begin{array}{c}
\sigma_w \\
F \\
\sigma_i \quad \sigma_w \\
[p^h\theta \quad t^\epsilon \quad r\acute{o}] \\
\end{array}
\]

\[
\begin{array}{c}
\sigma_i \\
F \\
\sigma_i \quad \sigma_w \\
[l\circ \quad l\circ \quad p^h\theta \quad l\circ \quad z\circ]
\end{array}
\]
In (12a), we see that the word potato consists of a single superfoot. The superfoot, in turn, consists of a stressless syllable followed by a regular trochaic foot. In (12b), the first two syllables are part of a trochaic foot while the last syllables constitute the superfoot. By adopting Jensen’s (2000) proposal as illustrated in (12) we can account for the appearance of /h/ and aspirated stops in (1)–(7). Namely, these sounds surface in foot-initial position. This is most clearly seen in (12a), where the word-initial stop of the word potato is aspirated because it is at the beginning of the superfoot; the second stop is aspirated because it is initial in the trochaic foot; but the third stop is unaspirated (realized as a flap) because it is not foot-initial. Note also that given the structure in (12), English words will always begin with a syllable that is part of a foot, be it a superfoot as in (12a) or a trochaic foot with initial stress as in (12b).

There are several strong points to the foot structure for American English as illustrated in (12). First, it makes for a simple statement for where [s.g.] occurs, namely foot-initial position. Second, it is able to distinguish between the stranded syllables in (9) where [s.g.] is realized from those stranded word-final syllables in (11) where [s.g.] is not realized. The stranded syllables in (11), unlike those in (9), remain unparsed since there are no other syllables that follow. Thus their initial stops surface as unaspirated. And third, the foot structure in (12) is consistent with McCarthy’s (1982) observation that words like those in (4) show variation with respect to expletive infixation. For example, lolapalooza can have either the expletive form lola-fuckin-palooza or lolapa-fuckin-looza. Given McCarthy’s general observation that expletive insertion occurs at foot boundaries (i.e. immediately preceding a foot boundary), we see that the location of the infixed expletive can be before either the superfoot or the trochaic foot. In the remainder of the section on English we will assume the status of the superfoot. For space reasons we will not indicate English footing hierarchically as in (12) but with bracketing as shown in (13), where parentheses indicate the binary trochaic foot and braces delimit the superfoot.

(13) a. \{p^b\hspace{0.1cm} (t^b\text{éro})\} b. (lôla)\{p^b\hspace{0.1cm} (luzza)\}

2.3. A foot alignment analysis of [s.g]

Given our discussion in the previous subsection regarding American English foot structure, let us now consider the constraints necessary for the optimality-theoretic analysis of the data in (1)–(7). Crucial for our
Aspirated stops and /h/ analysis is the alignment constraint (14) that aligns the feature [spread glottis] to the beginning of the foot.

(14) AlignL(Ft,[sg]):
Align the left edge of the foot with the feature [spread glottis].

The motivation for the alignment constraint can be found in discussion by Iverson and Salmons (1995). For example, Iverson and Salmons argue that the beginning of the foot is a prominent or privileged position in the word. Accompanying this position with the feature [spread glottis] makes for a more forceful sound given the greater translaryngeal air flow that occurs with the articulation of a sound made with spread glottis. Such an articulation would be perceptually more salient than one made without spread glottis and would be one of the expected ways of indicating a prominent or privileged position. Iverson and Salmons (1995: 377) state that for English (and most other Germanic languages), “[spread glottis] is implemented with fully abducted vocal folds only in foot-initial position.” Thus, the constraint in (14) is compatible with the view of English aspiration as domain-initial strengthening.

The other important constraints for the analysis are the markedness constraints in (15)–(16) and the faithfulness constraints in (17)–(18) (cf. McCarthy and Prince 1995).

(15) *[s.g., + voice]:
The feature [s.g.] cannot be realized on sounds that are [+ voice].

(16) *[s.g.]
The feature [s.g.] is prohibited.

(17) MAX
A phoneme in the input must have a correspondent in the output (i.e. avoid deletion).

(18) DEP
A phoneme in the output must have a correspondent in the input (i.e. avoid insertion).

Given these constraints, let us now consider their ranking in accounting for the parallel distribution of aspiration and /h/ in the data in (1)–(7). The first crucial ranking is given in (19), in which the markedness constraint *[s.g., + voice] in (15) must outrank the alignment constraint in (14).

(19) *[s.g., + voice] ∗ AlignL(Foot,[sg])

This ranking is necessitated because voiced sounds are never realized with spread glottis in English, even when in foot-initial position (e.g. beans is not pronounced with an initial aspirated stop).
The second crucial ranking is given in (20), where the alignment constraint outranks the markedness constraint *(+s.g.) in (16).

(20) \text{AlignL(Ft,[sg])} \gg *(s.g.)

This ranking accounts for the fact that (unvoiced) sounds have the feature [s.g.] when at the beginning of the foot, as exemplified by words like caterpillar [kæ\textipa{\textasteriskcentered}æ\textipa{\textasteriskcentered}p\textipa{\textasteriskcentered}t\textipa{\textasteriskcentered}l\textipa{\textasteriskcentered}l\textipa{\textasteriskcentered}r\textipa{\textasteriskcentered}r\textipa{\textasteriskcentered}l\textipa{\textasteriskcentered}] and material [mæ\textipa{\textasteriskcentered}t\textipa{\textasteriskcentered}ə\textipa{\textasteriskcentered}l\textipa{\textasteriskcentered}r\textipa{\textasteriskcentered}l\textipa{\textasteriskcentered}l\textipa{\textasteriskcentered}] as in (16).

Another crucial ranking is that the constraint *(s.g.) outranks MAX, as in (21).

(21) *(s.g.) \gg \text{MAX}

This ranking is needed in order to account for /h/ not being realized in a word like vehicle. Finally, the constraint DEP would outrank the alignment constraint, as shown in (22).

(22) \text{DEP} \gg \text{AlignL(Ft,[sg])}

This ranking is necessary in order to prevent winning candidates with an inserted [h] at the beginning of a vowel-initial foot such as in atom ([hæ\textipa{\textasteriskcentered}æm]) or geometry ([ji.\textipa{\textasteriskcentered}æ\textipa{\textasteriskcentered}m\textipa{\textasteriskcentered}a\textipa{\textasteriskcentered}tri], not *[ji.h\textipa{\textasteriskcentered}h\textipa{\textasteriskcentered}æ\textipa{\textasteriskcentered}m\textipa{\textasteriskcentered}a\textipa{\textasteriskcentered}tri]). However, while both DEP and *(s.g., +voice) outrank the alignment constraint, the ranking between these two constraints cannot be determined.

The ranking of the constraints in (19)–(22) is given in (23).

(23) Ranking of constraints

\*

This ranking is all that is needed for the analysis of the parallel distribution of /h/ with aspirated stops in American English. To illustrate this, we will go through sample tableaux for the data in (1)–(7). Consider, first, data as in (1), where both aspiration and /h/ occur at the beginning of the trochaic foot containing primary stress. The tableaux are given in (24) and (25).

(24) “pony” /p\textipa{\textasteriskcentered}ə\textipa{\textasteriskcentered}ni/ — [p\textipa{\textasteriskcentered}b\textipa{\textasteriskcentered}\textipa{\textasteriskcentered}n\textipa{\textasteriskcentered}i]

<table>
<thead>
<tr>
<th>/p\textipa{\textasteriskcentered}ə\textipa{\textasteriskcentered}ni/</th>
<th>DEP</th>
<th>*(s.g., +voice)</th>
<th>AlignL(Ft,[sg])</th>
<th>*(s.g.)</th>
<th>MAX</th>
</tr>
</thead>
<tbody>
<tr>
<td>\textipa{\textasteriskcentered}a. (p\textipa{\textasteriskcentered}b\textipa{\textasteriskcentered}\textipa{\textasteriskcentered}n\textipa{\textasteriskcentered}i)</td>
<td>\textipa{\textasteriskcentered}</td>
<td>\textipa{\textasteriskcentered}</td>
<td>*</td>
<td></td>
<td></td>
</tr>
<tr>
<td>b. (p\textipa{\textasteriskcentered}n\textipa{\textasteriskcentered}i)</td>
<td>\textipa{\textasteriskcentered}</td>
<td>\textipa{\textasteriskcentered}</td>
<td>*!</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Aspirated stops and /h/

In the tableau in (24), candidate (b) lacking aspiration on the initial stop loses out to candidate (a) because of its violation of AlignL(Ft,[sg]). Likewise, in the comparison between the two candidates in the tableau in (25), the second candidate lacking the initial [h] loses out because of its violation of AlignL(Ft,[sg]). In the two tableaux, the (a) candidates violate *[s.g.] but this violation cannot be fatal given that (a) is the winning candidate. The parallel analysis of aspiration and /h/ is clear from the distribution of constraint violations shown in the tableaux in (24) and (25).

Now let us consider the analysis of the data in (2), where both aspiration and [h] occur at the beginning of the foot containing secondary stress.

(25) “habit” /hæβt/ — [hæβt]

<table>
<thead>
<tr>
<th>/hæβt/</th>
<th>DEP</th>
<th>*[s.g. + voice]</th>
<th>AlignL(Ft,[sg])</th>
<th>*[s.g.]</th>
<th>MAX</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. (hæβt)</td>
<td></td>
<td>*</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>b. (éβt)</td>
<td></td>
<td>*</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

In the tableau in (24), candidate (b) lacking aspiration on the initial stop loses out to candidate (a) because of its violation of AlignL(Ft,[sg]). Likewise, in the comparison between the two candidates in the tableau in (25), the second candidate lacking the initial [h] loses out because of its violation of AlignL(Ft,[sg]). In the two tableaux, the (a) candidates violate *[s.g.] but this violation cannot be fatal given that (a) is the winning candidate. The parallel analysis of aspiration and /h/ is clear from the distribution of constraint violations shown in the tableaux in (24) and (25).

Now let us consider the analysis of the data in (2), where both aspiration and [h] occur at the beginning of the foot containing secondary stress.

(26) “cucumber” /kyúkàmbor/ — [kʰyúkʰàmb.òɾ]

<table>
<thead>
<tr>
<th>/kyúkàmbor/</th>
<th>DEP</th>
<th>*[s.g. + voice]</th>
<th>AlignL(Ft,[sg])</th>
<th>*[s.g.]</th>
<th>MAX</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. (kʰyú)(kʰàm.òɾ)</td>
<td></td>
<td>*</td>
<td>**</td>
<td></td>
<td></td>
</tr>
<tr>
<td>b. (kʰyú)(kàm.òɾ)</td>
<td></td>
<td>*</td>
<td>*</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

(27) “hypotenuse” /háypáténus/ — [háypʰátənəs]

<table>
<thead>
<tr>
<th>/háypáténus/</th>
<th>DEP</th>
<th>*[s.g. + voice]</th>
<th>AlignL(Ft,[sg])</th>
<th>*[s.g.]</th>
<th>MAX</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. (háy)(pʰá.te)nus</td>
<td></td>
<td>*</td>
<td>**</td>
<td></td>
<td></td>
</tr>
<tr>
<td>b. (áy)(pʰá.te)nus</td>
<td></td>
<td>*</td>
<td>*</td>
<td></td>
<td></td>
</tr>
<tr>
<td>c. (háy)(pʰá.tʰe)nus</td>
<td></td>
<td>*</td>
<td>***</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

In the first two candidates in tableaux (26) and (27), a comparison is made between the (a) candidates that have the feature [s.g.] at the beginning of a syllable with secondary stress and the corresponding (b) candidates that lack the [s.g.] feature. In both tableaux, the (b) candidate loses
out because of the fatal violation of the constraint \( \text{AlignL(Ft,[sg])} \). The tableaux captures the symmetry in the distribution between /h/ and the aspirated stop. In (27c) we consider a candidate that is like the winning candidate (27a), but with an aspirated /t/ that is foot-internal. (27c) does not violate higher-ranked constraints such as *[s.g.+voice] nor \( \text{AlignL(Ft,[sg])} \). It nonetheless loses out because of the additional violation of *[s.g.] in comparison to the winning candidate.

Next consider data like that in (3), where both aspiration and /h/ surface in the onset of a word-initial stressless syllable. Recall from our discussion about (12) and (13) that such a syllable would be the first syllable of a superfoot. (The superfoot is indicated by braces.)

(28) “connect” /kəˈnɛkt/ — [kʰə.nɛkt]

<table>
<thead>
<tr>
<th>/kəˈnɛkt/</th>
<th>DEP</th>
<th>*[s.g.+voice]</th>
<th>AlignL(Ft,[sg])</th>
<th>*[s.g.]</th>
<th>MAX</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. {kʰə(nɛkt)}</td>
<td>*</td>
<td>*</td>
<td>*</td>
<td>*</td>
<td>*</td>
</tr>
<tr>
<td>b. {kə(nɛkt)}</td>
<td>*</td>
<td>*</td>
<td>*</td>
<td>*</td>
<td>*</td>
</tr>
<tr>
<td>c. {kʰə(nʰɛkt)}</td>
<td>*</td>
<td>*</td>
<td>*</td>
<td>*</td>
<td>*</td>
</tr>
</tbody>
</table>

(29) “horizon” /həˈræʒən/ — [hə.ˈræj.zən]

<table>
<thead>
<tr>
<th>/həˈræʒən/</th>
<th>DEP</th>
<th>*[s.g.+voice]</th>
<th>AlignL(Ft,[sg])</th>
<th>*[s.g.]</th>
<th>MAX</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. {hə(rəj.zən)}</td>
<td>*</td>
<td>*</td>
<td>*</td>
<td>*</td>
<td>*</td>
</tr>
<tr>
<td>b. {ə(rəj.zən)}</td>
<td>*</td>
<td>*</td>
<td>*</td>
<td>*</td>
<td>*</td>
</tr>
<tr>
<td>c. {hə(rʰəj.zən)}</td>
<td>*</td>
<td>*</td>
<td>*</td>
<td>*</td>
<td>*</td>
</tr>
</tbody>
</table>

As shown, the candidates in tableaux (28) and (29) consist of a trochaic foot that is embedded within a superfoot. The unstressed first syllable corresponds to the left edge of the superfoot while the stressed second syllable corresponds to the left edge of the trochaic foot. The first syllable in both (28) and (29) begins with an element that can have the feature [+s.g.] while the second syllable begins with a voiced (sonorant) consonant and so could not surface with the feature [s.g.]. Candidates (c) in (28) and (29) are those that show an aspirated sonorant at the beginning of the trochaic foot. This allows for perfect satisfaction of \( \text{AlignL(Ft,[sg])} \). However, as shown, the (c) candidates fatally violate
Aspirated stops and /h/ 619

the higher ranked *[s.g., + voice] and so do not surface. On the other
hand, the (b) candidates minimize violations of *[s.g.], but they lose out
because of the failure of [s.g.] to surface on the initial syllable. Thus, the
(a) candidates win out since they best satisfy the constraints.

Now let us consider the data in (4), which consist of an initial trochaic
foot followed by a superfoot. We will focus on the initial syllable of the
superfoot, which is unstressed, but aspirated. The tableaux are given in
(30) and (31).

(30) “peripatetic” /pêrîpâtêtîk/ — [pʰɛɾɛpʰətʰɛɾîk]

<table>
<thead>
<tr>
<th>/pêrîpâtêtîk/</th>
<th>DEP</th>
<th>*[s.g. + voice]</th>
<th>AlignL (Ft,[sg])</th>
<th>*[s.g.]</th>
<th>MAX</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. (pʰɛ.ɾi) {pʰə(tʰɛɾîk)}</td>
<td></td>
<td></td>
<td></td>
<td>***</td>
<td></td>
</tr>
<tr>
<td>b. (pʰɛ.ɾi) {pə(tʰɛɾîk)}</td>
<td></td>
<td></td>
<td>!</td>
<td>**</td>
<td></td>
</tr>
</tbody>
</table>

(31) “Tarahumara” /têrâhômâɾə/ — [tʰêɾəhômâɾə]

<table>
<thead>
<tr>
<th>/têrâhômâɾə/</th>
<th>DEP</th>
<th>*[s.g. + voice]</th>
<th>AlignL (Ft,[sg])</th>
<th>*[s.g.]</th>
<th>MAX</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. (tʰɛ.ɾə) {hə(má.ɾə)}</td>
<td>*</td>
<td></td>
<td></td>
<td>**</td>
<td></td>
</tr>
<tr>
<td>b. (tʰɛ.ɾə) {ə(má.ɾə)}</td>
<td>***</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>c. (tʰɛ.ɾə) {hə(mə.ɾə)}</td>
<td>!</td>
<td></td>
<td></td>
<td>***</td>
<td></td>
</tr>
</tbody>
</table>

In comparing the (a) candidates with the (b) candidates in (30) and (31)
we see that the (b) candidate loses because of a fatal violation of
AlignL(Ft,[sg]). Specifically, the fatal violation involves the lack of [s.g.]
on the first syllable of the superfoot. The failed candidate in (31c) shows
that [s.g.] cannot be added to a voiced sound even if it helps to satisfy
the AlignL(Ft,[sg]) constraint since that would lead to a violation of
higher-ranked *[s.g., + voice]. Another point of note is that in Tarahumara
the [h] is underlyingly present. In words where a superfoot or foot begins
with a vowel, an [h] cannot be added even it helps to satisfy the
AlignL(Ft,[sg]) constraint since adding an [h] would violate higher-
ranking DEP, which prohibits insertion. Consider the word in (32) with
the indicated foot structure.

(32) Indianapolis — (in.ɾi) {ə(næ.ɾə)lîs
In this word, both the initial foot and the superfoot begin with vowels.
If an /h/ were to be added to either or both of these feet, the form would
S. Davis and M.-H. Cho

incur a fatal violation of DEP. Thus, in comparing (32) with (31), the /h/ in *Tarahumara* is able to surface since it is underlingly present. As (32) shows, an [h] cannot be added at random before vowel-initial feet.

Now let us examine the data in (5)-(7), where the feature [s.g.] does not surface. First, consider the data in (5). Here, neither aspirated stops nor [h] surfaces in coda position. As shown by the tableaux in (33) and (34) the analysis that we have developed is able to account for this. (We do not consider candidates with voiced aspirated sounds since they would violate undominated *[s.g. + voice].)

(33) “lapse” /lɛps/ — [lɛps]

<table>
<thead>
<tr>
<th>/lɛps/</th>
<th>DEP</th>
<th>*[s.g. + voice]</th>
<th>AlignL (Ft.[sg])</th>
<th>*[s.g.]</th>
<th>MAX</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. (lɛp̚s)</td>
<td>*</td>
<td>*</td>
<td>*</td>
<td></td>
<td></td>
</tr>
<tr>
<td>b. (lɛps)</td>
<td>*</td>
<td>*</td>
<td>*</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

(34) “brahmin” /bráhm̚n/ — [brá.mn]

<table>
<thead>
<tr>
<th>/bráhm̚n/</th>
<th>DEP</th>
<th>*[s.g. + voice]</th>
<th>AlignL (Ft.[sg])</th>
<th>*[s.g.]</th>
<th>MAX</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. (bráhm̚n)</td>
<td>*</td>
<td>*</td>
<td>*</td>
<td></td>
<td></td>
</tr>
<tr>
<td>b. (brá.mn)</td>
<td>*</td>
<td>*</td>
<td>*</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

In the tableau in (33), the first candidate has a fatal violation of *[s.g.]. On this analysis, it is unnecessary to add aspiration into coda position since it is not foot-initial. The example in (34) is quite similar. The word *brahmin* is an example of a borrowed word where an [h] might surface in coda position in the English pronunciation, given the presence of a phoneme that has the feature [spread glottis] in the source language. However, if we compare candidate (34a), where [h] surfaces as a coda, with candidate (34b), where it is deleted, we note that (34a) violates *[s.g.] while (34b) violates MAX. It is the violation of higher-ranked *[s.g.] that eliminates candidate (34a) as the optimal candidate. Thus we see that in both (33) and (34) the constraint *[s.g.] eliminates the candidate with [s.g. since it is not in foot-initial position. It is worth mentioning that the same reasoning that accounts for the lack of [s.g.] from a coda position in (33) and (34) above would also account for the lack of [s.g.] for data like that in (7) where the feature [s.g.] could potentially occur.
on the second member of an onset. Consider, for example, the tableaux for *ski and *exhibition in (35) and (36), respectively.

(35) “ski” /ski/ — [ski]

<table>
<thead>
<tr>
<th>/ski/</th>
<th>DEP</th>
<th>*[s.g. + voice]</th>
<th>AlignL (Ft,[sg])</th>
<th>*[s.g.]</th>
<th>MAX</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. (skʰi)</td>
<td></td>
<td>*</td>
<td></td>
<td>*!</td>
<td></td>
</tr>
<tr>
<td>b. (ski)</td>
<td></td>
<td></td>
<td></td>
<td>*</td>
<td></td>
</tr>
</tbody>
</table>

(36) “exhibition” /ɛkshibɪˈsan/ — [ɛk.st.bi.ʃən]

<table>
<thead>
<tr>
<th>/ɛkshibɪˈsan/</th>
<th>DEP</th>
<th>*[s.g. + voice]</th>
<th>AlignL (Ft,[sg])</th>
<th>*[s.g.]</th>
<th>MAX</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. (ɛk.sh)(bi.ʃən)</td>
<td></td>
<td>**</td>
<td></td>
<td>*!</td>
<td></td>
</tr>
<tr>
<td>b. (ɛk.st.)(bi.ʃən)</td>
<td></td>
<td>**</td>
<td></td>
<td>*</td>
<td></td>
</tr>
</tbody>
</table>

Here the (a) candidates in (33) and (34) lose out because of the violation of *[s.g.]. Thus, the analysis presents a single account for the absence of [spread glottis] in foot-internal position.

Finally, the analysis accounts for the data in (6) where there is no *[s.g.] in the onset of the weak syllable of a foot. This is shown in (37) and (38) with the words *atom and *prohibition.

(37) “atom” /ætəm/ — [æ.təm]

<table>
<thead>
<tr>
<th>/ætəm/</th>
<th>DEP</th>
<th>*[s.g. + voice]</th>
<th>AlignL (Ft,[sg])</th>
<th>*[s.g.]</th>
<th>MAX</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. (æ.tʰəm)</td>
<td></td>
<td>*</td>
<td></td>
<td>*!</td>
<td></td>
</tr>
<tr>
<td>b. (æ.təm)</td>
<td></td>
<td></td>
<td></td>
<td>*</td>
<td></td>
</tr>
</tbody>
</table>

(38) “prohibition” /prɔʰbiˈsan/ — [pʰro.ə.bi.ʃən]

<table>
<thead>
<tr>
<th>/prɔʰbiˈsan/</th>
<th>DEP</th>
<th>*[s.g. + voice]</th>
<th>AlignL (Ft,[sg])</th>
<th>*[s.g.]</th>
<th>MAX</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. (pʰro.ə)(bi.ʃən)</td>
<td></td>
<td>*</td>
<td></td>
<td>**!</td>
<td></td>
</tr>
<tr>
<td>b. (pʰro.ə)(bi.ʃən)</td>
<td></td>
<td>*</td>
<td></td>
<td>*</td>
<td>*</td>
</tr>
</tbody>
</table>
Again, the (a) candidates in (37) and (38) are eliminated due to the fatal violation of *[s.g.]. These violations are fatal because of the occurrence of a segment that is [+s.g.] in a position that is not foot-initial. Since the underlying /t/ in atom does not surface in foot-initial position it does not receive aspiration. Likewise, the underlying /h/ in prohibition deletes since it would not be in foot-initial position. These should be compared with the related forms from (1), atomic and prohibit, where the relevant segments do surface in foot-initial position with the feature [s.g.]. Our analysis accounts for this, as shown in (39) and (40).

(39) “atomic” /ætәmɪk/ — [ɔ.tʰá.mɪk]

<table>
<thead>
<tr>
<th>/ætәmɪk/</th>
<th>DEP</th>
<th>*[s.g. + voice]</th>
<th>AlignL (Ft,[sg])</th>
<th>*[s.g.]</th>
<th>MAX</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. {ɔ(ʰá.mɪk)}</td>
<td></td>
<td>*</td>
<td></td>
<td>*</td>
<td></td>
</tr>
<tr>
<td>b. {ɔ(á.mɪk)}</td>
<td></td>
<td></td>
<td>**</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

(40) “prohibit” /prәbɪt/ — [pʰro hi bi t]

<table>
<thead>
<tr>
<th>/prәbɪt/</th>
<th>DEP</th>
<th>*[s.g. + voice]</th>
<th>AlignL (Ft,[sg])</th>
<th>*[s.g.]</th>
<th>MAX</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. {pʰro( hi bi t)}</td>
<td></td>
<td></td>
<td>**</td>
<td></td>
<td></td>
</tr>
<tr>
<td>b. {pʰro( i bi t)}</td>
<td></td>
<td></td>
<td></td>
<td>*</td>
<td>*</td>
</tr>
</tbody>
</table>

In summary, the optimality-theoretic analysis that we offer here formally accounts for the close parallel in distribution between aspirated stops and /h/ in American English as reflected by the data in (1)–(7). We have presented the tableaux above in a way that highlights the parallel distribution. This close parallel has either gone unnoticed in previous work or has not been accounted for. If we consider all the cases where neither /h/ nor aspiration surfaces, as in the tableaux in (33)–(38), in every instance it is a violation of *[s.g.] that eliminates the (a) candidate. The feature [spread glottis] only surfaces in foot-initial position, as shown by the tableaux in (24)–(31). Moreover, the analysis will readily work even under the assumption that the feature [spread glottis] is part of the input for voiceless stops, as is assumed by Iverson and Salmons (1995). For example, if the [p] is underlingly aspirated in (33), lapse, then the ranking *[s.g.] ≫ MAX-sg would account for the lack of aspiration in the winning candidate. Thus, a single ranking of a few constraints captures the parallel between the distribution of /h/ and aspirated stops.
Aspirated stops and /h/ in American English. In the next section we briefly consider two other approaches to the distribution of /h/ and aspirated stops in American English.

3. **Previous analyses of English aspiration and /h/**

In the previous section we have offered a unified analysis within optimality theory accounting for the distribution of /h/ and aspiration in American English. As far as we are aware, there are no previous analyses (other than our own preliminary work) that attempt to offer a unified account of American English aspiration and /h/ distribution, although there are many analyses of English aspiration and a few of /h/ distribution. Given this, we do not have a specific source with whom we can directly compare our analysis. Our intent in this section is not to take every analysis of English aspiration and see how it would apply to the distribution of /h/, or to take every analysis of /h/ distribution and see how it would apply to aspiration. Instead, we will consider a syllable-based analysis of English aspiration and a government-phonology analysis of English /h/ distribution and show the issues that arise when these analyses are extended to account for aspiration and /h/ distribution in a unified way.

Most contemporary studies on English aspiration adopt either a foot-based approach or a syllable-based approach. As discussed in section 2.2, our analysis opts for the foot-based approach. On this approach, voiceless stops are aspirated when foot-initial. Other researchers who have adopted this approach include Nespor and Vogel (1986), Iverson and Salmons (1995), and Jensen (2000). We have incorporated the foot structure proposed by Jensen (2000) in accounting for the appearance of aspiration on the voiceless stop in words like *Mediterranean* and *lolapalooza*. This specific environment, at the beginning of a stressless syllable that is sandwiched between a stressless syllable and a stressed one, has often been neglected in studies on aspiration. As discussed in section 2.2, we adopt the position of Jensen (2000), where this syllable is viewed as being initial in a superfoot, illustrated in (12b). An alternative approach to the analysis of the distribution of English aspirated stops is the syllable-based approach, which can be found in such works as Kahn (1976), Selkirk (1982), and Giegerich (1992) in rule-based phonology. Under this view, a rule aspirates voiceless stops when in syllable-initial position. This is exemplified by the derivation in (41), following Selkirk.
(41) Sample derivation for “appear” [ə.pʰɪr]

Underlying representation (UR): /ə.pʰɪr/
   a. syllabification: ə.pʰ
   b. stress: ə.pʰ
   c. aspiration rule: ə.pʰʰ

Phonetic representation (PR): [ə.pʰʰ]

One aspect of the syllable-based analysis is that it assumes a rule of stress-based resyllabification. While different researchers disagree as to whether the resyllabified segment is ambisyllabic or entirely in a coda, we informally state the rule in (42), based on Selkirk (1982).

(42) Stress-based resyllabification (SBR):
Resyllabify an onset consonant of a stressless syllable into the coda of a stressed syllable.

The rule of SBR is necessary in order to account for the lack of aspiration on the stops in words such as *atom* and *happen*, which would appear to be at the beginning of the stressless syllable. SBR would apply before the aspiration rule and bleed it. The derivation for the word *happen* is given in (43).

(43) UR: /hæpɪn/
   a. syllabification: hæ.pɪn
   b. stress: hæ ´ pɪn
   c. SBR: hæ ´ pɪn
   d. aspiration rule: does not apply

PR: [hæ ´ pɪn]

Selkirk (1982) does not apply her rule of SBR to the analysis of /h/ distribution; however, Borowsky (1984, 1986) does. Borowsky then explains the lack of /h/ in words like those in (5b) and (6b) by a rule that deletes /h/ in coda position, given in (44), below.

(44) h-deletion: h → θ / Coda

This rule is crucially ordered after SBR. It neatly accounts for data like that in the (b) columns in (1)–(3) and (5)–(6). Sample derivations are given in (45).

(45) Derivation of horı´ zon, ve´ hicle, prohı´ bit, pro`hibı´ tion (aspiration is ignored)
   a. UR: /hərærzn/  
      1. syllabification: hə.rær.zn
      2. stress: hə.rær.zn
Aspirated stops and /h/ 625

3. SBR: h\text{\textipa{ra\text{\textipa{y}z.m}}
4. h-deletion: (does not apply)
PR: [h\text{\textipa{ra\text{\textipa{y}z.m}}]

b. UR: /vihi\text{\textipa{kol}}/
1. syllabification: vi.hr.k\text{\textipa{kol}}
2. stress: vi.hr.k\text{\textipa{kol}}
3. SBR: vi.hr.k\text{\textipa{kol}}
4. h-deletion: vi.i.k\text{\textipa{kol}}
PR: [vi.i.k\text{\textipa{kol}}]

c. UR: /prohi\text{\textipa{b\text{\textipa{t}}}}/
1. syllabification: pro.hr.bt.
2. stress: pro.hr.b.t
3. SBR: pro.hr.b.t
4. h-deletion: (does not apply)
PR: [pro.hr.b.t]

d. UR: /prohi\text{\textipa{b\text{\textipa{t}}}}n/
1. syllabification: pro.hr.br.\text{\textipa{sm}}
2. stress: pr\text{\textipa{r}}.hr.bi.\text{\textipa{sm}}
3. SBR: pr\text{\textipa{r}}.hr.bi.\text{\textipa{sm}}
4. h-deletion: pr\text{\textipa{r}}.i.bi.\text{\textipa{sm}}
PR: [pr\text{\textipa{r}}.i.bi.\text{\textipa{sm}}]

Taken together, Selkirk’s analysis of aspiration and Borowsky’s analysis of /h/ distribution can be seen as a way of accounting for these phenomena by crucially referring to SBR. While we consider the Borowsky–Selkirk analysis of English /h/ and aspiration interesting and insightful, it has at least two shortcomings. First, there is the technical problem that the analysis actually fails to account for the forms in (7b). Especially problematic would be the word \textit{exhibit}. Clearly, the /h/ in that word would not be part of a coda, yet it does not surface. Second, the assumption of SBR is quite controversial and we do not assume it in our analysis. From our perspective, though, the main shortcoming of the Borowsky–Selkirk analysis is that it misses the fact that /h/ and aspirated stops display parallel distribution. There would be the rule in (44) that states where /h/ deletes (i.e. in coda position), but there would be a different rule that states where aspiration occurs (i.e. syllable-initially). The parallel distribution of /h/ and aspirated stops goes unrecognized. We would maintain that the preferred analysis should directly capture their parallel distribution.

Within the framework of government phonology, Harris (1994, 1997) implicitly recognizes the parallel distribution between English /h/ and aspirated stops. However, Harris’s specific analysis accounting for the
distribution of /h/ is problematic when extended to cover aspiration. Harris (1994: 210) considers the restricted set of h-data in (46).

(46) a. [h]it, [h]um, [h]ot
    b. be[h]alf, be[h]ind, appre[h]end
    c. ve[h]icular vs. vé[h]icle, pro[h]hibit vs. pro[h]ibition

To account for the lack of /h/ in vehicle and prohibition in (46c), Harris offers the generalization in (47) couched in the terminology of government phonology.

(47) Harris (1994: 211):

```
A licensed nucleus fails to bestow on a preceding onset the necessary capacity to license a lone h element'' (emphasis added).
```

To understand what this means, we first note that a licensed nucleus is one that is typically the stressless vowel of a bisyllabic foot. It is licensed by the preceding stressed nucleus of the foot. Second, a segment consisting of a lone h element would be the phoneme /h/, given the featural-element theory of government phonology adopted by Harris. In (48), we show Harris’s (1994) specific representations of an /h/, a voiceless stop, and a fricative (h = noise, R = coronal, ? = stop, H = stiff).

(48) a. /h/
    b. /t/
    c. /s/  

\[\begin{array}{ccc}
x & x & x \\
| & | & | \\
h & R & R \\
| & | & | \\
h & h & h \\
| & | & |
\end{array}\]  

Harris’s analysis in (47) then says that a licensed nucleus cannot be immediately preceded by the segment [h]. In the word vêhicle, for example, the second vowel is licensed by the preceding stressed nucleus. It thus cannot itself license the lone h element; consequently, the /h/ cannot surface in the word vehicle. It does surface in the word vehi´cular; since the stressed nucleus in this word is not licensed, it can license a lone h element.

Harris’s analysis of English /h/ distribution is quite neat and readily extends to other /h/ data in (1)–(7). For example, it extends to the data in (3b), where [h] surfaces before a stressless vowel in the initial syllable (as in the word horizon). Since the vowel in an initial syllable is not
preceded by another vowel, that vowel, even if stressless, cannot be licensed; thus it is able to license a lone $\text{h}$ element, correctly accounting for the [h] in (3b).

While Harris’s analysis captures the distribution of /h/, it becomes problematic when extended to aspiration. To see this, consider our rewording of Harris’s generalization in (47), without the word *lone*, as in (49).

(49) A licensed nucleus fails to bestow on a preceding onset the necessary capacity to license an $\text{h}$ element.

Eliminating the word *lone* in (49) would seem to extend the generalization to cover the distribution of aspiration, given that voiceless stops can have an $\text{h}$ element as in (48b). However, Harris crucially represents fricatives with an $\text{h}$ element as well, as in (48c). (This representation is not trivial since it would account for the debuccalization of fricatives to [h] in many languages.) The broader generalization in (49) would wrongly predict the lack of fricatives before (word-medial) stressless vowels. Consequently, Harris is careful in his wording of the generalization in (47) regarding the distribution of /h/. Thus, while Harris implicitly recognizes the parallel distribution of /h/ and aspiration, his analysis of /h/ can be considered problematic when extended to cover aspiration.

In summary, in this section, we have examined two additional analyses of the distribution of English /h/ and aspiration. One is the syllable-based analysis of Borowsky and Selkirk, and the other is Harris’s government-phonology analysis. Both the analyses are important and insightful. As we see it, the main shortcoming of the Borowsky–Selkirk analysis is that it misses the fact that /h/ and aspirated stops have a completely parallel distribution. There would be the rule in (44) that states where /h/ deletes (i.e. in coda position), but there would be a different rule that states where aspiration occurs (i.e. syllable-initially, after SBR). The parallel distribution of /h/ and aspirated stops goes unrecognized. The main shortcoming of Harris’s analysis of /h/ is that if it is extended to cover aspiration it wrongly predicts the lack of fricatives before stressless (word-medial) vowels. While it may be possible to modify these analyses in ways that more readily capture the close parallel in distribution between aspiration and /h/, it is not our intent to do so. Rather, we have made clear and treated more thoroughly than previous analyses the parallelism between the distribution of aspirated stops and /h/ American English, and we have also shown how it can be insightfully analyzed within optimality theory. In the following two sections we will extend our optimality-theoretic analysis so that it can account for the somewhat different distribution of /h/ and aspirated stops manifested in Korean.
4. The distribution of aspirated stops and /h/ in Korean

While the distribution of aspirated stops and /h/ in American English is closely parallel, in standard Korean (Seoul dialect) their distribution is somewhat less parallel. The distribution in Korean is parallel in that neither /h/ nor aspirated stops appear in coda position while both can appear in word-initial position. However, the parallelism breaks down when we consider the onsets of noninitial syllables. In this environment, aspirated stops can occur but /h/ is normally deleted.14 (It should be mentioned that Korean disallows complex onsets generally, so that /h/ could never surface as a second member of an onset.) In order to account for the distribution of [s.g.] in Korean, we make reference to a constraint requiring alignment between the beginning of the word and the feature [s.g.]. The distinction between word-initial position (which allows for the surfacing of both /h/ and aspirated stops) and syllable-initial position word-internally (which allows for aspirated stops but not /h/) is accounted for by the interaction of this alignment constraint with other constraints.

Let us now consider the specific Korean data. First, the data in (50) and (51) show that neither /h/ nor aspirated stops appear in syllable coda position.15 (Sources for the Korean data include Kim-Renaud 1986 and S. Lee 1998, as well as the native judgments of the second author.)16

(50) No [h] in coda position
a. /anh/ [an] ‘inside’
b. /anh + pak/ [am.pʰak] ‘inside and outside’
c. /coh-ko/ [co.kʰo] ‘like (and)’
d. /nah-ta/ [na.tʰa] ‘give birth (declarative)’
e. /suh/ [su] ‘male’
f. /suh + pan/ [su.pʰam] ‘male tiger’
g. /suh + nom/ [sun.nom] ‘male creature’

(51) No aspiration in coda position
a. /nipʰ/ [nip] ‘swamp’
b. /pʰatʰ/ [pʰat] ‘red bean’
c. /puokʰ-to/ [puok.tʰo] ‘kitchen (also)’17
d. /nopʰ-ta/ [nop.tʰa] ‘high (declarative)’

Second, the data in (52) and (53) illustrate that both /h/ and aspirated stops can occur in word-initial position:

(52) [h] at the beginning of the word
a. hilk ‘dirt’
b. ha-ta ‘to do (declarative)’

(53) No /h/ in word-initial position
a. /anh/ [an] ‘inside’
b. /anh + pak/ [am.pʰak] ‘inside and outside’
c. /coh-ko/ [co.kʰo] ‘like (and)’
d. /nah-ta/ [na.tʰa] ‘give birth (declarative)’
e. /suh/ [su] ‘male’
f. /suh + pan/ [su.pʰam] ‘male tiger’
g. /suh + nom/ [sun.nom] ‘male creature’
Aspirated stops and /h/  629

c. hyaŋki    ‘smell’
d. halmo ni    ‘grandmother’

(53) Aspirated stops at the beginning of the word (the symbol “c” represents a voiceless palato-alveolar affricate)
a. pʰa    ‘green onion’
b. tʰal    ‘mask’
c. cʰo    ‘vinegar’
d. kʰi    ‘height’

Third, the data in (54) and (55) show the absence of a parallel in the distribution between [h] and aspirated stops in onset position beyond the initial syllable. (54) exemplifies the lack of [h] in such positions, while (55) illustrates the presence of aspirated stops. (The forms in phonetic transcription in [54] show the pronunciation and syllabification when the /h/ deletes. [54d] shows some allophonic changes that are not relevant for our study.)

(54) Lack of [h] in onset position beyond the initial syllable (the line through the /h/ indicates that it is not pronounced)
a. co.ha  [co.a]    ‘like (stative)’
b. man.ha  [ma.na]    ‘much (stative)’
c. no.hi.ni  [no.i.ni]    ‘put (associative)’
d. sil.ho  [si.ro]    ‘dislike (stative)’

(55) Aspirated stops in onset position beyond the initial syllable
a. ki.pʰo    ‘air bubble’
b. hwag.tʰo    ‘mud’
c. ki.cʰa    ‘train’
d. kʰul.kʰul    ‘(snoring sound)’

In comparing Korean with English, the Korean data are similar to the English data in that aspirated stops and /h/ both surface at the beginning of the word while failing to surface in coda position. However, the similarity with English as well as the parallel distribution of /h/ and aspirated stops fails to be reflected in (54) and (55). Here we see a difference between the patterning of /h/ and aspirated stops. While /h/ does not usually surface in the onset of a noninitial syllable, (54), aspirated stops do, (55). Also, it needs to be pointed out that the aspirated stops in (55) do not necessarily correlate with the beginning of a foot. Recall that, in English, aspirated stops occur at the beginning of a foot, but not foot-internally, as seen by words like atom and rapid in (6). Foot structure and stress in Korean are subject to much controversy and disagreement among linguists working on standard Korean. There are at
least four different views. One view is that there is a trochaic (left-headed) foot over the first two syllables so that stress always goes on the initial syllable (e.g. Lee 1992; Davis and Lee 1996). A second view is that there is an initial iambic foot such that stress goes on the first syllable if it is heavy, otherwise on the second syllable (e.g. Kim 1998). A third view is that Korean has an unbounded right-headed foot so that stress goes on the leftmost heavy syllable, otherwise on the final syllable (e.g. Jun 1994). The fourth view is that standard Korean does not have word stress at all (e.g. Lim 1999). This disagreement reflects not only a disagreement on the analysis but a fundamental disagreement among linguists working on Korean as to where stress occurs in the word. Nonetheless, what is clear is that aspirated stops can occur in the onset of any syllable of the word. While the data in (55) only illustrate examples with the first two syllables, a Korean word like [k'æk'itʰata] ‘is clean’ shows that aspirated stops can occur after the first two syllables. Consequently, we see from the data in (50)–(55) that while aspirated stops can occur generally in syllable-initial position, /h/ only occurs word-initially. An optimality-theoretic analysis of Korean would need to account for this difference in the distribution of /h/ and aspirated stops.

One other point of difference between Korean and English concerns words where an underlying /h/ is deleted. In Korean, a remnant of the deleted /h/ triggers aspiration if it is next to a stop consonant. This has been termed ‘aspiration merger’ (e.g. Kim-Renaud 1986). The data in (50b)–(50d), repeated in (56a)–(56c), are examples of progressive aspiration merger, while the examples in (56d)–(56f ) show regressive aspiration merger.

(56) Korean aspiration merger (i.e. aspiration triggered by the deletion of /h/)
   a. /anh + pak/ [am.pʰak] ‘inside and outside’
   b. /coh-ko/ [co.kʰe] ‘like (and)’
   c. /nah-ta/ [na.tʰa] ‘give birth’
   d. /sok + hi/ [sokʰi] ‘fast (adverbial)’
   e. /ip + hak/ [ipʰak] ‘admission’
   f. /kut-hi-ta/ [kucʰita] ‘hardens’

English does not have clear examples of data like that in (56), where the deleted /h/ triggers aspiration in a neighboring stop. This is because English does not have suffixes beginning with an initial /h/. Possible compound data such as *uphill* and *backhand* tend to retain a secondary stress on the second syllable so that the /h/ in these words would be pronounced. The aspiration merger shown in (56) only occurs if the
Aspirated stops and /h/ can be aspirated.\textsuperscript{20} If the neighboring consonant cannot be aspirated, then the /h/ deletes without triggering aspiration. This is seen in (57).

\begin{enumerate}
\item[(57)] Korean /h/ deletion without aspiration merger
\begin{enumerate}
\item /norah-my\textsuperscript{e}n/ [noramy\textsuperscript{e}n] ‘if it is yellow’
\item /anh+saram/ [ans\textsuperscript{a}ram] ‘wife’
\item /coh-a/ [coa] ‘like (stative)’
\end{enumerate}
\end{enumerate}

Consequently, an analysis would need to account for the effect of the deleted /h/ in triggering aspiration. In the next section we turn to an optimality-theoretic account of the patterning of /h/ and aspirated stops in Korean.

5. An optimality-theoretic analysis of Korean /h/ and aspirated stops

In comparing the patterning of /h/ and aspirated stops in Korean with that in English, there are a number of differences in Korean that have an effect on the active constraints that will be employed for the optimality-theoretic analysis. One major difference between the two languages is that aspirated stops are phonemic in Korean; thus the feature [spread glottis] must be part of the underlying representation of aspirated stops. In English, where aspiration is not phonemic, we did not need to assume an underlying [spread glottis] feature for the analysis that was presented and discussed in section 2.

A second difference between Korean and English is, as mentioned, the asymmetry between /h/ and aspirated stops in Korean, where /h/ surfaces only at the beginning of a word-initial syllable while aspirated stops can surface at the beginning of any syllable. To account for this difference we make reference to the alignment constraint in (58) and the constraint mitigating against the phoneme /h/ in (59).\textsuperscript{21}

\begin{enumerate}
\item[(58)] AlignL (Word,[sg]):
Align the left edge of the word with the feature [s.g.].
\item[(59)] *h:
[h] is not allowed.
\end{enumerate}

The ranking of the alignment constraint in (58) over the constraint in (59) will ensure the appearance of /h/ in word-initial position, as exemplified by the data in (52). Nonetheless, the relative ranking of *h over the familiar MAX constraint given in (17) will ensure the deletion of /h/ in noninitial position, as seen in data like (50) and (54). Moreover, it should be noted that neither [h] nor the feature [s.g.] can be inserted at the
beginning of a word to satisfy the alignment constraint in (58). The feature [s.g.] only surfaces when it is underlingly present. The undominated constraint militating against the insertion of [s.g.] is given in (60).

(60)  Dep-sg:
The feature [spread glottis] in the output must correspond to a [spread glottis] feature in the input.\textsuperscript{22}

A third difference between Korean and English has to do with the analysis of the failure of the feature [s.g.] to be realized in the coda. In the analysis of English, the lack of [s.g.] in coda position resulted from a fatal violation of the constraint *[s.g.]. However, in Korean, both the lack of /h/ and aspirated stops in coda position can be understood more generally as a reflection of the fact that all coda consonants in Korean are unreleased (cf. Steriade 1993; Iverson and Sohn 1994; Tak 1997).

Thus, the only allowable coda in Korean is an unreleased [−continuant] sound. (This includes unreleased oral stops, unreleased nasal stops, and the unreleased lateral.) Segments with the marked laryngeal features (tense or aspiration) as well as [+continuant] (fricative) segments do not surface with such features in coda position, but as unreleased stops. Consequently, Korean has the high-ranking (inviolable) coda condition constraint in (61):

(61)  Coda condition (CodaCon):
Only unreleased segments are allowed in the coda.

This constraint often results in the deletion of the feature [s.g.], as in (51), where the underlying aspirated stops do not surface as such. Thus, (61) interacts with the constraint in (62) that militates against the deletion of [s.g.].

(62)  Max-sg:
The feature [s.g.] in the input must have a corresponding feature [s.g.] in the output.

Given these constraints, we now present our analysis of the distribution of /h/ and aspirated stops in Korean. We will further discuss the rankings of these constraints as we present the tableaux for the Korean data in (50)–(57).

In order to see how the various constraints are ranked for the Korean analysis let us first consider the data in (52) and (53), repeated in (63), which illustrate the presence of /h/ and aspirated stops at the beginning of the word. The tableau for the word in (63b) is shown in (64) where the two undominated (inviolable) constraints discussed above in (60) and (61) appear as the first two contraints in the tableau.
(63) [h] and aspirated stops at the beginning of the word

a. hiłk ‘dirt’
   b. ha-ta ‘to do (declarative)’
   c. hyanjki ‘smell’
   d. halmani ‘grandmother’
   e. pʰa ‘green onion’
   f. tʰal ‘mask’
   g. cʰo ‘vinegar’
   h. kʰi ‘height’

(64) /ha-ta/ — [hata] ‘to do’, (63b), (52b)

<table>
<thead>
<tr>
<th>/ha-ta/</th>
<th>Dep-sg</th>
<th>CodaCon</th>
<th>AlignL (Word,[sg])</th>
<th>*h</th>
<th>MAX</th>
<th>Max-sg</th>
</tr>
</thead>
<tbody>
<tr>
<td>→ a. ha.ta</td>
<td></td>
<td></td>
<td></td>
<td>*</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>b. a.ta</td>
<td></td>
<td>*!</td>
<td>*</td>
<td>*</td>
<td></td>
</tr>
</tbody>
</table>

Here we see that candidate (64a), which preserves the initial /h/, is the winning candidate despite its violation of *h. The tableau shows that AlignL(Word,[sg]) must be higher-ranked than *h or else (64b) would wrongly be the winner. The ranking established by tableau (64) is shown in (65).

(65) AlignL(Word,[sg]) ≫ *h

Similarly, the tableau in (66) shows an example of an underlying initial aspirated stop being realized as aspirated on the surface. Here, the winning candidate does not violate any relevant constraint.

(66) /pʰa/ — [pʰa] ‘green onion’, (63c), (53a)

<table>
<thead>
<tr>
<th>/pʰa/</th>
<th>Dep-sg</th>
<th>CodaCon</th>
<th>AlignL (Word,[sg])</th>
<th>*h</th>
<th>MAX</th>
<th>Max-sg</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>a. pʰa</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>b. pa</td>
<td></td>
<td>*!</td>
<td></td>
<td>*</td>
<td></td>
</tr>
</tbody>
</table>

Tableaux (66) and (64) show that the distribution of aspirated stops and /h/ are parallel in word-initial position. Now consider the asymmetry reflected by the data in (54) and (55), where /h/ fails to surface at the beginning of noninitial syllables while aspirated stops do appear. First, the tableau in (67) shows the case where the phoneme /h/ fails to surface at the beginning of a noninitial syllable.
S. Davis and M.-H. Cho

In the tableau above, candidate (67a) is eliminated because of its violation of undominated Dep-sg, despite the fact that it satisfies the alignment constraint. This provides an argument for the ranking in (68) of Dep-sg over AlignL(Word,[sg]).

(68) Dep-sg \gg AlignL(Word,[sg])

The interesting comparison in the tableau in (67) is between candidates (67b) and (67c). (67b) is the faithful candidate and has fewer constraint violations than (67c), but it is nonetheless a losing candidate. The key constraint that (67b) violates is \(*h\). This constraint is respected by the winning candidate (67c). On the other hand (67c) violates Max-sg and MAX. For (67c) to be the winner *h must be higher-ranked than both Max-sg and MAX.

To be clear, (67c) violates Max-sg since the \([s.g.]\) feature from the /h/ does not surface, and it violates MAX because the phoneme slot (or root node) of the /h/ is deleted. The ranking that emerges from the comparison of (67b) with (67c) is shown in (69).

(69) \(*h \gg Max-sg, MAX^{23}\)

This ranking can be combined with (65) to yield the fuller ranking in (70).

(70) AlignL(Word,[sg]) \gg *h \gg Max-sg, MAX

The ranking of *h over Max-sg and MAX militates against the appearance of /h/, but the ranking of AlignL(Word,[sg]) over *h requires the surfacing of an input word-initial /h/. Thus /h/ only surfaces word-initially. Because the relevant constraint is one militating against the surfacing of /h/ (*h), and not against the feature [spread glottis] generally, underlying aspirated stops are unaffected by *h and so can appear at the beginning of noninitial syllables (as well as at the beginning of a word). This is shown by the tableau in (71) for the word in (55a).
Aspirated stops and /h/

In tableau (71), the faithful candidate (b) is the winning candidate despite its violation of AlignL(Word,[sg]). Candidate (71a), on the other hand, satisfies the alignment constraint by adding the aspiration to the initial consonant. However, since the initial consonant is not underlyingly aspirated it incurs a fatal violation of higher-ranked Dep-sg. The candidate in (71c) loses out because of its violation of Max-sg in comparison with the winning candidate (71b). There is no reason for the deaspiration of the stop to occur in (71c) and so it is eliminated. Thus, our analysis with the critical ranking in (70) is able to account for both the appearance of word-internal aspirated stops at the beginning of syllables and the lack of realization of /h/ word-internally.

Let us now consider both the lack of aspiration and lack of [h] in syllable coda position. As discussed, Korean has an undominated coda condition constraint, given in (61), which requires coda consonants to be unreleased. This prevents a consonant with the feature [s.g.] from surfacing in a coda. Consider the tableau in (72), which reflects the data in (51) where an underlying aspirated stop surfaces without aspiration in coda position.

In tableau (71), the faithful candidate (b) is the winning candidate despite its violation of AlignL(Word,[sg]). Candidate (71a), on the other hand, satisfies the alignment constraint by adding the aspiration to the initial consonant. However, since the initial consonant is not underlyingly aspirated it incurs a fatal violation of higher-ranked Dep-sg. The candidate in (71c) loses out because of its violation of Max-sg in comparison with the winning candidate (71b). There is no reason for the deaspiration of the stop to occur in (71c) and so it is eliminated. Thus, our analysis with the critical ranking in (70) is able to account for both the appearance of word-internal aspirated stops at the beginning of syllables and the lack of realization of /h/ word-internally.

Let us now consider both the lack of aspiration and lack of [h] in syllable coda position. As discussed, Korean has an undominated coda condition constraint, given in (61), which requires coda consonants to be unreleased. This prevents a consonant with the feature [s.g.] from surfacing in a coda. Consider the tableau in (72), which reflects the data in (51) where an underlying aspirated stop surfaces without aspiration in coda position.

<table>
<thead>
<tr>
<th>/kipʰo/</th>
<th>Dep-sg</th>
<th>CodaCon</th>
<th>AlignL (Word,[sg])</th>
<th>*h</th>
<th>MAX</th>
<th>Max-sg</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. kʰi.pʰo</td>
<td>*!</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>c. ki.pʰo</td>
<td>*</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>b. ki.pʰo</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Here we see that because the constraint CodaCon is undominated, (72b) is the winning candidate. The faithful candidate in (72a) violates CodaCon. The winning candidate in (72b) respects CodaCon; by respecting CodaCon it induces a violation of Max-sg. Thus the tableau in (72) constitutes an argument for the ranking in (73) since the reverse ranking would result in (72a) wrongly being the winner.

<table>
<thead>
<tr>
<th>/nipʰ/</th>
<th>Dep-sg</th>
<th>CodaCon</th>
<th>AlignL (Word,[sg])</th>
<th>*h</th>
<th>MAX</th>
<th>Max-sg</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. nipʰ</td>
<td>*!</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>b. nip</td>
<td>*</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Here we see that because the constraint CodaCon is undominated, (72b) is the winning candidate. The faithful candidate in (72a) violates CodaCon. The winning candidate in (72b) respects CodaCon; by respecting CodaCon it induces a violation of Max-sg. Thus the tableau in (72) constitutes an argument for the ranking in (73) since the reverse ranking would result in (72a) wrongly being the winner.
If we turn our attention to the data in (50) showing the lack of a surface [h] in coda position, an interesting complication occurs. While /h/ does delete in coda position, as would be predicted given the ranking reflected in the tableau in (72), the [spread glottis] feature of the underlying /h/ is still realized, as aspiration on a neighboring onset stop. This is referred to by Kim-Renaud (1986) as aspiration merger. Additional examples of this were provided in (56). Consider the tableau in (74) for the word /nah-ta/, originally given in (50d) and repeated in (56c). In accounting for this form we make use of a constraint that militates against coalescence. McCarthy and Prince (1995) term the constraint *uniformity*, while, Lamontagne and Rice (1995) refer to it as *MC* militating against multiple correspondence. We give the wording of the constraint in (75) following Lamontagne and Rice (1995: 218).

(74) /nah-ta/ — [nat$^b$a] ‘give birth’, (50d), (56c)

<table>
<thead>
<tr>
<th>/nah-ta/</th>
<th>Dep-sg</th>
<th>CodaCon</th>
<th>AlignL. (Word,[sg])</th>
<th>*h</th>
<th>MAX</th>
<th>Max-sg</th>
<th>*MC</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. nah.ta</td>
<td>![symbol]</td>
<td>*!</td>
<td>*</td>
<td>*</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>b. na.t$^b$a</td>
<td></td>
<td>*</td>
<td>*</td>
<td>*</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>c. na.ta</td>
<td></td>
<td>*</td>
<td>*</td>
<td>*!</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

(75) *MC: 
Elements in the input and the output must stand in a one-to-one correspondence relationship with each other.

In (74), the faithful candidate (74a) has [h] in coda position. This constitutes a critical violation of undominated CodaCon and thus (74a) is eliminated. Candidate (74c) completely deletes the offending [h], while candidate (74b) preserves the [spread glottis] feature of the /h/ on the neighboring voiceless stop /t/. This means that candidate (74b) better satisfies the constraint Max-sg. (74b), however, incurs a violation of *MC since the features of the [t$^b$] in (74b) come from two different input phonemes. Specifically, while most of the features of [t$^b$] in (74b) come from the input /t/, its [s.g.] feature comes from the input /h/. This constitutes a violation of *MC. Nonetheless, (74b) is the winning candidate. Consequently, *MC must be ranked lower than Max-sg or else (74c) would be the winning candidate. Thus, the ranking in (76) accounts for the aspiration merger involving /h/.

(76) Max-sg $\gg$ *MC
It should be noted that aspiration merger does not always occur. This is seen in comparing the data in (56), where a deleted /h/ leads to aspiration merger, with that in (57), where the [s.g.] feature of the deleted /h/ is completely unrealized. The data are repeated below for convenience.

(56) Korean aspiration merger (i.e. aspiration triggered by the deletion of /h/)
   a. /anh+pak/ [am.phak] ‘inside and outside’
   b. /coh-k0/ [co.kho] ‘like (and)’
   c. /nah-ta/ [na.tha] ‘give birth’
   d. /sok+hi/ [sokhi] ‘fast (adverbial)’
   e. /ip+hak/ [ipakh] ‘admission’
   f. /kut-hi-ta/ [kuchita] ‘hardens’

(57) Korean /h/ deletion without aspiration merger
   a. /norah-nyen/ [noramyn] ‘if it is yellow’
   b. /anh+saram/ [ansaram] ‘wife’
   c. /coh-a/ [coa] ‘like (stative)’

In comparing the two sets of data it should be clear why aspiration merger fails to occur in (57). The sounds adjacent to /h/ in (57) are not sounds that can be aspirated in Korean. That is, they are not voiceless stops. This suggests that, in Korean, feature-cooccurrence constraints such as *[s.g., + voiced] (given in 15) and perhaps *[s.g., + continuant] are undominated, thus preventing aspiration merger in (57).

The situation of aspiration merger always involves /h/ in the input. There are data, however, involving an aspirated stop, such as that in (77) (repeated from [51c] and [51d]) where an aspirated stop is followed by a plain voiceless stop in the input. In such situations the [s.g.] feature is not realized.

(77) a. /puakʰ-to/ [puak.tʰo] ‘kitchen (also)’
   b. /nopʰ-ta/ [nop.tʰa] ‘high (declarative)’

The data in (77) reflect a general tensification or fortition process in Korean (cf. Kim-Renaud 1986), which requires the second of two adjacent obstruents to be tense. In an optimality-theoretic approach this would be expressed by a tensification constraint, along the lines of (78).

(78) Tensification (TENSE):
    In a sequence of two obstruents, the second one is tense.

For the Korean analysis, this constraint would need to be higher-ranked than the Max-sg constraint. A tableau for (77b) is provided in (79).
The faithful candidate, (79a), is eliminated because of the violation of undominated CodaCon. The candidate with aspiration merger, (79b), fails due to its violation of TENSE. (Candidate [79b], does not violate Dep-sg since the aspiration on the [tʰ] corresponds to the aspiration on the input /pʰ/.) The winning candidate in (79c) respects CodaCon, though it fares worse on Max-sg, thus motivating the ranking in (80).

(80) \text{TENSE} \gg \text{Max-sg}^{26}

It should be noted that the tableau in (79) accounting for tensification does not have an effect on the data with /h/ showing aspiration merger as in (56a)–(56c). To see this, consider the form in (56c), which was shown in tableau (74). In (81) we show the tableau for the same form, but with the tensification constraint along with additional relevant candidates. The candidate with aspiration merger is still the winner.

(81) /nah-ta/ — [natʰa] ‘give birth’, (50d), (56c)

Notice that the winning candidate, (81b), does not incur a violation of TENSE. This is because the constraint refers to an output with two adjacent obstruents. Since (81b) does not have two adjacent obstruents, it vacuously satisfies the constraint. The closest competing candidates, (81c) and (81e), are eliminated because they each fare worse on the constraint Max-sg. The tableau confirms the ranking shown in (76), where Max-sg outranks *MC. Thus the rankings in (76) along with those
Aspirated stops and /h/ account for both Korean aspiration merger, which affects an input /h/, and tensification, which can affect an aspirated stop.

In summary, we have provided a detailed analysis of the distribution of aspirated stops and /h/ in Korean. Their distribution in Korean is parallel to an extent in that neither /h/ nor aspirated stops appear in coda position while both can appear in word-initial position. However, the parallelism breaks down when we consider the onsets of noninitial syllables. In this environment, aspirated stops can occur but /h/ is normally deleted. To account for this difference, we showed that Korean has the constraint ranking reflected in (70), where the *h constraint outranks the Max-sg and MAX constraints, but where *h itself is outranked by AlignL(Word,[sg]). Since *h has no effect on underlying aspirated stops, it does not prevent such stops from surfacing in the onsets of noninitial syllables. In (82) we give the crucial constraint rankings for the Korean analysis with reference to the critical tableaux showing the rankings in parentheses.

\begin{align*}
\text{(82) Coda-Con} & \gg \text{Max-sg (72)} \\
\text{Dep-sg} & \gg \text{AlignL(Word,[sg]) (67)} \\
\text{AlignL(Word,[sg])} & \gg *h (64) \\
*h & \gg \text{MAX,Max-sg (67)} \\
\text{TENSE} & \gg \text{Max-sg (79)} \\
\text{Max-sg} & \gg *MC (74)
\end{align*}

6. Typological implications

In the first part of this paper we illustrated how the distribution of aspirated stops and the phoneme /h/ are closely parallel in American English. Previous analyses of this have either failed to recognize this close parallel or do not formally account for it. We showed how an optimality-theoretic approach can account for the distribution of aspirated stops and /h/ in a unified way. Crucial to our analysis was the constraint AlignL(Foot,[sg]), which aligns the beginning of the foot with the feature [s.g.]. In the second part of the paper we considered the distribution of these sounds in standard Korean. Here, the parallel distribution broke down when we considered the onsets of noninitial syllables: aspirated stops occur in such positions but not [h]. Crucial to our analysis was the ranking in (70) where AlignL(Word,[sg]) played a key role. With the ranking in (70) we were able to account for the appearance of aspirated stops at the beginning of any syllable as well as the restriction of [h] to word-initial position. In the remainder of this section, we want to briefly
explore some of the typological implications of our analysis. First, we consider the role of our alignment constraints for the analysis of aspiration and /h/ in other languages. Then we consider the parallel distribution of /h/ and aspirated stops more generally, where we emphasize that the different rankings of constraints predict a typology of distribution patterns with respect to /h/ and aspirated stops; the patterns that are predicted do not always entail a parallel distribution or even a close parallel in distribution between /h/ and aspirated stops.

Our analysis of aspirated stops and /h/ in English and Korean can be termed an alignment analysis of [s.g.], since the analysis makes crucial reference to the alignment constraints that we repeat in (83). Notice that the constraints refer to the prominent positions in a word such as word-initial and foot-initial positions. From the phonetic perspective, one can view the alignment phenomena in English and Korean as examples of domain-initial strengthening, in which the beginning of a prosodic domain is enhanced by a perceptually salient feature. From the phonological perspective, the alignment phenomena reflect the role of positional prominence as developed from an optimality-theoretic perspective in works like that of Beckman (1997) and Zoll (1997).\footnote{27}

(83) The alignment constraints
   a. AlignL(Foot,[sg])
   b. AlignL(Word,[sg])

An alignment analysis with a constraint like (83a) was briefly considered and then rejected by Jensen (2000: 215) for English because nonaspirated sounds can occur in foot-initial position.\footnote{28} But as we showed in our analysis of English in section 2.3, (83a) is dominated by feature-cooccurrence constraints so that nonaspirated voiced sounds, for example, can surface in foot-initial position. The question arises as to whether the constraints in (83) play a role in languages other than English and Korean. With respect to (83a), Iverson and Salmons (1995) suggest that the English pattern of aspiration applies in some of the other Germanic languages as well. Along these lines, Hall (1992) offers an analysis of German syllabification where aspiration occurs at the beginning of the foot.

An interesting case where the constraint in (83b), AlignL(Word,[sg]), plays a role is in the Arawakan language Bare. Consider the data in (84) and compare it with that in (85) (these data are discussed by Aikhenvald 1995; Haspelmath 1997; Oliveira 1998).

(84) a. haba ‘fingernail’
   b. hnu-aba ‘my fingernail’
   c. pʰi-aba ‘your fingernail’

(85) a. haba ‘fingernail’
   b. hnu-aba ‘my fingernail’
   c. pʰi-aba ‘your fingernail’
The data in (84) can be understood if the morpheme meaning ‘fingernail’ is underlyingly /aba/, but having a floating [s.g.] feature. This is shown in (86), where “s.g.” indicates a floating [spread glottis] feature.

(86) s.g. s.g. s.g.
    a. /aba/    b. /nu-aba/    c. /bi-aba/

The constraint in (83c), AlignL(Word,[s.g.]), would be high-ranking, forcing the floating feature [s.g.] to surface word-initially. The floating feature [s.g.] is realized as an [h] if the first sound of the lexical word is a sonorant as in (84a) and (84b), and it is realized as part of an aspirated stop if the first sound of the lexical word is an oral stop, as in (84c). The word in (85a), [nene] ‘tongue’, would be an example of a lexical item that does not have a floating [s.g.] feature. Thus, we see evidence for the relevance of the alignment constraints in (83) from languages other than English and Korean.

One could ask a further question with respect to the role of a possible constraint aligning the beginning of the syllable with the feature [s.g.], namely AlignL(syllable,[sg])). Consider, for example, standard Bangla (Bengali) mentioned by Vijayakrishnan (1999), where underlying aspirated consonants deaspirate in coda position, so that aspirated consonants only surface syllable-initially. Here, such a pattern can be accounted for by the interaction of coda condition constraints with faithfulness constraints without any need to refer specifically to a constraint like AlignL(syllable,[sg])). Consequently, if one views the alignment constraints in (83) as manifestations of domain-initial strengthening, then perhaps the relevant domains are the larger domains such as the foot or the (prosodic) word, but not the syllable. There may be functional reasons for this that we will not speculate about.

In our discussion of English we show that the distribution of aspirated stops and /h/ are closely parallel; in Korean it is somewhat less so. We offered a detailed optimality-theoretic analysis for each of these languages that accounts for the close parallel in distribution of aspirated stops and /h/. However, we want to make clear that our analysis does not predict that their distribution is necessarily parallel (or closely parallel) in all languages. In fact, different constraint rankings would predict a typology of distribution patterns with respect to /h/ and aspirated stops. For example, one might expect to find languages that have aspirated stops but no [h]. Here, the constraint *h would be undominated. An example
might include certain dialects of British English that seem to be completely lacking [h] but have aspirated stops (John Harris, personal communication). Moreover, we would also expect to find languages such as modern standard French, where a constraint like *[s.g.] in (16) is undominated, so that neither [h] nor aspirated stops surface (leaving aside the possible issue of the feature [s.g.] being realized on fricatives). We would further expect to find a language where /h/ and aspirated stops can appear anywhere in a word. Arabic is such a language. Here the constraints on feature faithfulness would outrank any of the other relevant constraints. Finally, we would expect to find languages that have [h] but lack aspirated stops. Such languages may be analyzed with a high-ranking *[s.g.] constraint along with a higher-ranking MAX constraint that would have the effect of preserving an input /h/. Examples might include Japanese as well as nonstandard French dialects that preserve the pronunciation of (historic) /h/ but lack aspirated stops (Julie Auger, personal communication).

As a final question, we can ask if there are attested distributions of /h/ and aspirated stops that we do not predict. One potentially problematic example is Javanese, where [h] normally only occurs in coda position and voiceless stops are unaspirated (see, for example the discussion on Javanese pronunciation in Horne 1961). This distribution is not predicted by the analysis that we offer here since the coda is not a position of salience. We think that the key to understanding the Javanese pattern is to note that the glottal stop in Javanese is also restricted to coda position. Thus, in Javanese the two glottal sounds pattern the same. This suggests that there may be languages in which /h/ does not pattern at all with aspirated segments but with other glottal sounds. We could analyze Javanese as having an active constraint that restricts glottal segments to coda position and this would outrank any of the alignment constraints involving [s.g.]. Thus, while our alignment analysis of [s.g.] does not on its own predict a pattern like that found in Javanese, such a pattern can come about due to high-ranking constraints that pertain to glottal segments more generally.29

Conclusion

In summary, in this paper we have offered a detailed optimality-theoretic analysis of the distribution of aspirated stops and /h/ for both American English and Korean. Our work is different from previous work in that for each of these languages we delineate the close parallel in their distribution and show how an optimality-theoretic analysis can account for it.
Our analysis of the distribution is an alignment analysis that make reference to constraints requiring the feature [spread glottis] to be realized in various positions of salience. We further demonstrated how the alignment analysis predicts a typology of patterning of aspirated stops and [h]. Crucially, the patterning of these sounds is not always predicted to be closely parallel as in English and Korean, but as we show, a range of patterns is predicted and instantiated in various languages. In reality, our paper only scratches the surface of an interesting issue for phonological analysis. Nonetheless, we believe we have offered a particular approach to the issue that researchers working on other languages will find insightful.

Received 27 June 2000 Indiana University
Revised version received Pukyong National University
3 May 2002

Notes

* We wish to thank Julie Auger, Karen Baertsch, Kenneth de Jong, Daniel Dinnsen, John Harris, Beth Hume, Jong-Kyoo Kim, Paul Kiparcky, Minkyung Lee, Shinsook Lee, Yongsun Lee, John McCarthy, Renate Raffelsiefen, Catherine Ringen, Jerzy Rubach, Toshiyuki Tabata, Mark Van Dam, and the anonymous reviewers for discussion on different aspects of this paper. We also wish to thank audiences at the 4th and 7th Midcontinental Workshop in Phonology, HILP4, Osaka University of Foreign Studies, Stanford University, and University of California at Santa Cruz for their input. The current paper builds on the earlier works of Cho (1998) and Davis (1999a, 1999b). The usual disclaimers apply. Correspondence address: Stuart Davis, Department of Linguistics, Memorial Hall 322, Indiana University, Bloomington, IN 47405, USA. E-mail: davis@indiana.edu.

1. We are unaware of previous work by others that details the parallel environments of the appearance of aspirated stops and /h/ in American English. The pattern of American English aspiration distribution is well known (though not completely uncontroversial). The distribution of aspiration that we lay out in this section is virtually identical to that given in Iverson and Salmons (1995: 374–375), Selkirk (1982), Kreidler (1989), and Jensen (2000), though only the latter discusses data like that in (4a). There has been much less discussion in the phonological literature on the pattern of /h/ distribution in American English. The pattern that we lay out in this section is in agreement with Borowsky (1984, 1986) and Harris (1994, 1997).

2. Kreidler (1989: 76) refers to the /p/ of the initial stressless syllable in Patricia as being unaspirated. However, Kreidler (1989: 116) clearly states that /p, t, k/ are aspirated word-initially before a stressless vowel, though the aspiration is weaker. Jensen (2000), Iverson and Salmons (1995), and Selkirk (1982) all indicate aspiration on a word-initial voiceless stop before a stressless vowel. Moreover, Ken de Jong (personal communication) points out that the fact that the stressless vowel in the first syllable of Patricia can be partially voiceless indicates that the initial /p/ is indeed aspirated. Along
these lines, it is important to recall the distinction between aspiration noise and burst noise so as to eliminate the possible issue that the noise immediately following the initial stop in (3a) consists only of the burst noise and not aspiration. Johnson (1997: 132) is very clear at distinguishing between the two. “Burst noise is produced at the consonant place of articulation (like fricative noise), whereas aspiration noise is produced at the glottis. Thus, the vocal tract filter for the two types of sound sources is different. Also, the burst is very short in duration, whereas aspiration noise may be quite long. For a few milliseconds after a stop closure is released, the constriction is too narrow to allow the amount of airflow needed to produce aspiration at the glottis. Thus, immediately after the release, conditions are right for the burst (high-pressure buildup, very narrow opening) but not for the aspiration; while later, as the constriction is opened further, conditions are right for aspiration (when the constriction is open enough for a high volume of airflow).” Given this, the partial devoicing of the stressless vowel in the first syllable of Patricia reflects the aspiration of the initial /p/ and not the burst. This should be compared with a word like bequeath where the stressless vowel of the first syllable clearly cannot be devoiced.

3. There seems to be a controversy as to whether the initial voiceless stop in the third syllable in words like that in (4a) is actually aspirated. One of the anonymous reviewers of this paper as well as Steriade (2000) imply that it is not. On the other hand, both Jensen (2000: 209) and Pater (2000: 270) explicitly say that such stops are aspirated. We are unaware of any published phonetic work that addresses this question. However, preliminary work done with naive speakers in the phonetics laboratory at Indiana University strongly supports the view that the third syllable in such words is aspirated. Given this, one complication noted by Pater (2000) with the pattern in (4a) concerns complex words like capitalistic where the first /t/ is not aspirated, but flapped. Pater (2000) relates this to the fact the /t/ is flapped in the base word capital and suggests a possible output-to-output correspondence account in an optimality-theoretic framework. Note that all the words in (4) are monomorphemic. This is important because the data in (4a) show that aspiration is to be expected in the environment indicated. This is contrary to the following statement in Steriade (2000: 334) about the word Mediterranean: “I attribute the unflapped [t] in this unique form to the orthographic geminate ‘rr’, which is interpreted by speakers as an indication of secondary stress on the preceding vowel.” Steriade’s explanation, though, would fail to account for the unflapped (aspirated) [t] in Návratilova and Mánitová as well as the fact that the vowel of the third syllable in Mediterranean is reduced. Consequently, we maintain, contrary to Steriade (2000), that the aspiration on the /t/ in Mediterranean, as well as that on the other relevant stops in the data in (4a), reflects a general pattern.

4. Both Selkirk (1982) and Kreidler (1989) show optionality of aspiration of a word-final (postvocalic) voiceless stop. Thus, the word night can be pronounced with either an aspirated or an unaspirated [t]. However, this is probably only true when the word is said carefully in isolation or at the end of a phrase; the more natural tendency is to pronounce it as unreleased preglottalized. As Iverson and Salmons (1995) indicate, in a context like night owl the /t/ of night would not be aspirated, nor would it be aspirated in a phrasal context such as the night when we played. We follow Iverson and Salmons in not indicating a word-final stop in this context as being aspirated.

5. Working within government phonology, Harris (1994, 1997) implicitly notes the parallelism in the distribution of /h/ and aspiration. However, as will be discussed in section 3, the analysis that Harris offers for /h/ is problematic when extended to the aspiration data.
6. The distribution between aspirated stops and /h/ in American English is closely parallel, not exact. An important difference between them is that aspirated stops can occur before the liquids /l, r/ while [h] fails to do so (although in older stages of English, [h] did surface in such position). That is, aspirated stops can appear as a first member of a complex onset, as in the words play and cry, but [h] does not. We suggest that this difference can be explained in terms of the patterning of American English /h/ as a segment of high sonority. Thus it would not surface as the first member of a complex onset. Such a view raises the issue of the sonority value of laryngeal consonants. It has been noted in the literature that laryngeals display variable patterning with respect to the sonority hierarchy (see, for example, Churma and Shi 1995 for a cross-linguistic survey and de Lacy 2001 for specific examples of laryngeals patterning as high-sonority segments with respect to the phonology). Clements (1990: 322) states the following: ‘Laryngeals tend to behave arbitrarily in terms of the way they class with other sounds … patterning now with obstruents, now with sonorants in a way often better explained by their historical origin in any given language than by their inherent phonological properties.’

With respect to the appearance of /h/ before glides in American English, many speakers no longer have the /hw/ sequence in words like what and where (and even for those that do, it is unclear as to whether it should be analyzed as a sequence or a single sound, namely as a voiceless labiovelar glide). Some speakers of American English have a pronounced [h] before the palatal glide in words like huge, [hyu] where the [y] occurs immediately before [u]. However, Davis and Hammond (1995) have argued that the [y] in a word like huge in American English is actually part of the nucleus forming an on-glide of a diphthong /y+v/, and so the initial [h] in huge [hyu] would not be part of a complex onset. Thus, the lack of /h/ as the first member of a complex onset may be due to its patterning as a high-sonority segment.

A natural question that emerges from the above discussion is why specifically laryngeal consonants show variable cross-linguistic behavior as to whether they pattern like segments of low sonority or high sonority. We suggest that it is because articulation at the larynx is ambiguous between reflecting a place of articulation in the vocal tract or reflecting a state of the glottis. In the former case, the laryngeal sound would be interpreted as being of low sonority since there is an obstruction of air flow in the vocal tract (at the larynx); in the latter case the laryngeal would be of high sonority since there would be a free flow of air through the vocal tract. Laryngeals, then, may be phonologically interpreted differently in different languages. American English interprets /h/ as a segment of high sonority.

There can also be a difference in the patterning between aspiration and /h/ in slow, careful speech. In such speech almost any stop can be aspirated, even a syllable-final one (e.g. the /t/ in sit), whereas /h/ in syllable-final position (as in brahmin) is not pronounced. We do not have any clear explanation for this, but we do not consider this to be a major problem since out paper focuses on casual speech. Relatedly, Kreidler (1989: 116) says obligatory aspiration occurs with a word-final voiceless stop when after /s/. This is an environment that is not considered by most other researchers. Some examples include test, wasp, risk, and breakfast. [h] does not occur in this environment. However, it should be noted that word-final position after an /s/ is an environment shown to favor the deletion of a voiceless stop (cf. Guy 1980). This can be seen by the common plural form of breakfast as breakfasses. In any case, /h/ would not be expected to surface in a parallel position (i.e. word-finally after an [s]), given its patterning as a segment of high sonority as discussed above, since English does not allow a coda cluster of rising sonority to consist of an obstruent followed by a sonorant.
7. This is clearly seen in (11c), where the /t/ in charity is flapped. This points to a fundamental difference between a voiceless stop at the beginning of a final stranded syllable, as in (11), versus a voiceless stop at the beginning of a word-internal stranded syllable, as in (9b). It is only the latter that can be incorporated as the initial syllable of a superfoot and thus can be aspirated. Relatedly, with respect to a final stranded syllable, there do not seem to be any words where a final stranded syllable begins with a pronounced [h]. Words like O'mahà and Ïdaho tend to carry a secondary stress on the final syllable. The somewhat obscure pair, Élohim and Êlohist is interesting since it shows the deletion of the /h/ at the beginning of a word-final unparsed syllable. If one were to pronounce Êlohist with an [h] then that syllable would almost certainly have secondary stress. Similarly, when the word véhicule in (6b) is pronounced with a distinct [h] at the beginning of the second syllable, as it can be in some nonstandard American dialects, stress is also noticeable on that syllable.

8. For a word like lolapalooza McCarthy (1982) posits the following foot structure that differs from (12b) in that the first three syllables form a superfoot rather than the last three.

```
(i)   F
     /       /
  F       F
       /     /
  σ₃ σ₄ σ₅ σ₆ σ₇ σ₈
     lо   lа   pʰә   lυ   zә
```

We follow Jensen (2000) in positing the structure in (12b) for a word like lolapalooza. One argument for the structure in (12b) as opposed to the one above in (i) is that (12b) captures the parallel with words that begin with an initial stressless syllable such as potato in (3a). In both (12a) and (12b), the first syllable of the superfoot is stressless. If we adopt (i), we would still need a superfoot with an initial stressless syllable for words like potato.

9. Jensen (2000: 215), who is ambivalent regarding the utility of an OT analysis for English aspiration, briefly considers and rejects a constraint similar to the one we give in (14) when he says, “we cannot require that all feet begin with an aspirated stop, since other segment types must be permitted in that position.” The constraint in (14) requires that the foot begin with the feature [s.g.]. However, despite Jensen’s claim, the inclusion of (14) does not mean that all foot-initial segments will have the feature [s.g.]. This is because (14) is dominated by the higher-ranked constraint in (15) that militates against voiced aspirated sounds. As we will detail in our analysis, if a voiced sound is in foot-initial position it will surface as such without the feature [s.g.] because of the constraint in (15). Consequently, other segments besides aspirated ones can occur in foot-initial position, contrary to what Jensen implies.

10. We leave open the question of whether voiceless fricatives are made with the feature [spread glottis] in English (especially in foot-initial position). If not, then a constraint like *[s.g., +continuant] would play a role preventing the feature [spread glottis] from being realized on fricatives. See Vaux (1998) for interesting discussion suggesting that voiceless fricatives can have the feature [spread glottis].
Aspirated stops and /h/

11. In the tableaux, we will not usually consider candidates that violate the undominated constraints *[s.g., + voice] and DEP. Also, for a tableau like (24) we assume a low-ranked constraint DEP-sg to account for the addition of [s.g.]. This constraint will not be indicated. However, it will play a role in our analysis of Korean in section 5. Finally, we do not account for stress or vowel reduction; for convenience, we assume that stress is part of the input.

12. To reiterate from note 6, the distribution of aspirated stops and [h] is closely parallel, but not exact, the main difference being in word-initial position before a sonorant consonant where aspirated stops can occur (e.g. play, cry), but [h] does not. Also, Kreidler (1989: 116) mentions that aspiration obligatorily occurs in word-final position after an [s] (e.g. wasp, test). While we do not agree with Kreidler’s view of the obligatory nature of aspiration in this position (it can be unreleased or unpronounced), clearly, [h] cannot surface in this position. As mentioned in note 6, it is possible to account for the lack of [h] in these positions if [h] patterns as a segment of high sonority and so would not surface as the first member of an onset cluster or the second member of a coda by the regular phonotactics of English. One additional environment that should be mentioned where there seems to be a dispute as to whether aspiration occurs concerns data like that in (i), which according to Selkirk (1982) and Y. Lee (1998) show optionality.

(i) a. filter [fb] or [t]
   b. wimpy [ph] or [p]
   c. falcon [kh] or [k]

The aspirated stop is in an onset following a coda sonorant of a stressed syllable. Interestingly, what has not been noted is that in the same environment /h/ can be optionally deleted, as shown in (ii), thus reflecting parallel behavior with the aspirated stops.

(ii) a. philharmonic [h] or h.
   b. Amherst [h] or h.

Impressionistically, the /h/ in (ii) and the aspirated stops in (i) surface when the syllable that they are in is pronounced with secondary stress, though the appearance of secondary stress seems more probable in (ii) than in (i).

13. The constraint MAX-sg requires that the feature [spread glottis] in the input be realized in the output. If one were to develop the analysis along these lines, it could be maintained that MAX-sg would also play a role in the analysis of (5b), (6b), and (7b), where /h/ does not surface. The winning candidates would violate this constraint. Since /h/ only has the feature [spread glottis] as shown in (8a), when that feature does not surface on /h/ then the result would be the deletion of the entire phoneme. In our discussion of aspirated stops and /h/ in Korean in sections 4 and 5, we do make use of MAX-sg, given that aspirated stops are phonemes in the language.

14. We say ‘normally’ because, as an anonymous reviewer points out, a word-internal, stem-initial /h/ in onset position can be pronounced, though it would usually delete in casual speech. An example would be /i-ha/- → [iha] or [ia] ‘below’. This should be compared with the stem-final /h/ in words like (54), where it obligatorily deletes. Since our focus is on casual speech, we will not be concerned with accounting for the potential lack of deletion of stem-initial /h/ in forms like /i-ha/.

15. The underlying forms in (50) and (51) can be justified based on morphophonemic alternations such as nkp ‘swamp’-nkp-sio ‘swamp (locative)’ for (51a) and cokho ‘like (stative)’-cokho ‘like (and)’ for (50c). It should be noted that the /h/ in cokho deletes,
but its effect can be seen in cok'o, where it triggers aspiration of the /h/. Relatedly, the effect of the underlying /h/ in the monomorphic forms of (50a) and (50e) can be seen in its triggering of aspiration in (50b) and (50f), respectively.

16. We are not aware of any previous work on Korean phonology that specifically tries to account for the distribution of aspiration and /h/ in a unified way. Within optimality theory, works such as S. Lee (1998) and Cho and Lee (1999) deal with aspects of /h/ distribution but do not connect it to aspiration.

17. The forms in (51c) and (51d) reflect the independent process in Korean of consonant tensification: when two obstruents come together over a syllable boundary, the second one is tensified. It should be noted that in the Korean phonemic inventory, there is a well-known three-way laryngeal contrast in the stop series. These include the aspirated stops /pʰ, tʰ, kʰ/, the tense (fortis) stops /p, t, k/, and the plain (unaspirated) stops /p, t, k/. Additionally, the plain stops are realized as voiced intervocically, but we do not indicate this in the transcribed data.

18. The phonetic form in (51f) reflects the Korean palatalization process, which has the effect of palatalizing coronals before the high front vowel.

19. In very rapid speech it is possible to reduce the secondary stress on a word like “uphill” as in the phrase “an uphill battle.” Impressionistically, in such a phrase the word “uphill” could be pronounced as [v´pul] without aspiration.

20. Only the voiceless stops /p/, /t/, /k/, and the voiceless affricate /c/ can be aspirated in Korean.

21. Given the role of AlignL(Ft,[sg]) in the analysis of American English presented in section 3, the constraint in (58), AlignL(Word,[sg]) would be vacuous in American English since word-initial position is also a foot-initial position. The *h constraint in (59) does not play an independent role in the analysis of American English. We assume that it would be low-ranked.

22. In note 11, we mentioned that the constraint Dep-sg is low-ranked for English. That is, given the common assumption that English voiceless stops are not specified as having the feature [s.g.] in underlying representation, the feature is added when voiceless stops are in foot-initial position. Since aspiration is allophonic in English, this does not result in any neutralization of stop consonants. In Korean, on the other hand, aspiration is phonemic, as evidenced by minimal pairs like [pʰul] ‘grass’ vs. [pul] ‘fire’. This means that the feature [s.g.] is crucially present in the underlying representation of certain voiceless stops, such as in the initial voiceless labial in [pʰul] ‘grass’. The Dep-sg constraint is high-ranking in Korean, thus preventing [s.g.] from being realized on voiceless stops where it is not underlingly present. Thus, the initial labial of [pul] ‘fire’ does not have [s.g.] added to it. Despite the difference between English and Korean with respect to the phonemic status of aspiration, there is a similarity in the patterning of [s.g.] in the two languages in that when [s.g.] does surface it is always in a position that is syllable-initial.

Further, an anonymous reviewer raises the issue as to whether the constraint in (60) should be termed Ident-sg rather than Dep-sg. The use of Dep feature constraints is appropriate for features like [s.g.] that are considered as monovalent because such constraints militate against feature insertion. The Ident feature constraints are appropriate for features that are understood to be binary such as [+ sonorant] since Ident constraints militate against a change in the feature value.

23. In the tableaux we show no difference in the ranking between Max-sg and MAX (indicated by the dotted line) since we are not aware of data that show a crucial ranking between them. Also, while the winning candidate shown in (67c) violates both Max-sg and MAX, data like that in (56) with aspiration merger would involve forms that
violate MAX without violating Max-sg. In (56), the phoneme (root node) \(/h\) deletes, but the [spread glottis] feature surfaces on the neighboring stop.

24. We leave open the question of whether voiceless continuant sounds in Korean can take the feature [s.g.]. Typically, fricatives like [s] are not described in Korean as having the feature [s.g.], but the work of Vaux (1998) raises the possibility that they may, though he does not specifically discuss Korean. Relatedly, it should be noted that Korean does have the aspirated palatoalveolar affricate \(\text{/ch/}\). Given this, an interesting candidate for the input /c/oha/ in (57c) is [\(\text{c}^{-}\text{hoa}\)] where the aspiration is preserved on the initial phoneme. That is, in comparing data with and without aspiration merger in (56) and (57), one notes that the [s.g.] feature of the /h/ can only surface on an adjacent consonant and is never “thrown back” to some other consonant, as in the hypothetical [\(\text{c}^{-}\text{hoa}\)] from /c/oha/. However, given the constraint ranking reflected by the tableau in (74), the hypothetical candidate [\(\text{c}^{-}\text{hoa}\)] would be selected over the actual candidate [coa]. In order to eliminate [\(\text{c}^{-}\text{hoa}\)] as a winning candidate, one can split the constraint *MC into two types, one that militates against the coalescence of adjacent elements and one that militates against the coalescence of nonadjacent elements. We assume that the latter is undominated in Korean, preventing [\(\text{c}^{-}\text{hoa}\)] from surfacing.

25. See Kim-Renaud (1986: 20–21) for the phonetic motivation behind the tensification process. It is interesting to note that tense consonants have the same distribution as aspirated stops. Under the view that tense consonants have the laryngeal feature [constricted glottis] (e.g. Cho and Inkelas 1994), the alignment constraint in (58) involving [s.g.] can be considered as pertaining to a laryngeal alignment constraint more generally.

26. The ranking in (80) predicts that tensification should occur with a suffix-initial aspirated stop that follows a root-final obstruent so that the hypothetical /no\(\text{p}^{-}\text{t}\)-\(\text{a}/ would be realized as [no\(\text{p}^{-}\text{t}\)-\(\text{a}/. Korean, however, lacks suffixes beginning with underlying aspirated stops. Along these lines, it should be noted that in compound words like /cak + \(\text{t}\)-\(\text{o}/ ‘red dirt’, aspiration is preserved (\(\text{cak}^{-}\text{t}\)-\(\text{o}/); but this could be due to high-ranking AlignL\(\text{Word,}\text{[s.g]}\), and so may not be predictive for suffixes.

27. Beckman (1997) develops a positional faithfulness account of prominent positions, while Zoll (1997) develops a licensing account. It is beyond the scope of the present paper to address our alignment analysis in light of these works.

28. An alignment analysis involving [s.g.], somewhat similar to ours though not as developed, is briefly sketched out by Vijayakrishnan (1999) as part of a paper that was to be presented as a poster paper at the HILP 4 meeting in Leiden. Our work is independent of his.

29. Along similar lines, there are languages such as the Cariban language Tiriyo (Parker 2001; Meira 2001) where the only coda consonants allowed are nasals homorganic to a following onset and /h/ which only can surface as a coda. Here, we can understand the distribution of /h/ more in terms of its lack of place features than of any relevant alignment constraint. That is, the consonants that appear in the coda must lack any independent place features. This situation, not uncommon, can be analyzed by a constraint permitting only onsets to license place features, perhaps along the lines of Goldsmith (1990) or Ito et al. (1995).
References


